Preface

We are satisfied by doing real work. Software is like a plant that grows: You can't predict its exact shape, or how big it will grow; you can control its growth only to a limited degree. There are no rules for this kind of thing—it's never been done before.

- Charlie Anderson, Architect, Borland Quattro Pro for Windows.

You will find no books on the bookshelf here that tell you how to start up a new discipline. Software has been seeking its own way as a relatively young discipline for the past 40 years. Every new discipline struggles to find practices suitable to its survival and growth. Sometimes this struggle is incremental. Sometimes disciplines undergo more substantial shifts in process, structure and values that break more with the past to explore new ground. What Charlie Anderson said above about the Borland Quattro Pro for Windows effort in particular applies to the rhythms of software development in general. Get ready for change, for it will come tomorrow.

The most exciting advances in science go hand in hand with radical social change. The move from classic physics to quantum physics precipitated from a crisis in physics. We talk about the software crisis, yet no individual crisis in software — let alone *the* Software Crisis, whatever that might be — has precipitated the same kinds of change that we associate with great advances in science. Software development has perhaps yet to face its first true crisis that leads to the first true industry-wide systemic change.

But that doesn't mean that software is static. We can identify different faces of change in software development over the past five decades. Our interest in this book is what software development has learned about itself from an organizational and social perspective. Software development is perhaps working in its fourth *social* style of system development. Yet what is *really* interesting about these social styles is their ties to technical advances in the art. The first style of software development goes back to the first computers that were programmed manually with console switches. The second style came with the advent of programming languages that allowed scientists to work individually or in small teams, interacting with the machine through a language. In the third style, what we learned from hardware design and manufacturing carried over into software. Formal processes drove development, management was visible and explicit, and both the system and the organizations that worked on the system were highly hierarchical. Now we are in the fourth style: one that breaks down hierarchy, that features dynamic social structures and communication paths, and that values immediacy. This fourth style often bears the label "agile," but that is just one of many characterizations of a broad new way of developing software that has emerged over the past decade.

Yet human endeavors tend to take the same shape century after century, and the fact that human endeavors all have the common element of human nature bounds the range of human undertakings. For example, most organizations have leaders, and cliques, and their own little rituals, their own nuances of meaning for terms of the trade, a correspondence between physical space and organizational structure, and hundreds more. The organization of any major human endeavor follows basic laws of efficiency of communication, span of control, xenophobia, specialization, and other sociological forces that drive most large-scale projects to similar practices and structures. Much has been made of the similarity between vernacular housing architecture and the construction of software systems. [CoplienDevos2000]. The same may be true for the organization of any social animals, but we leave verification of that claim to readers better tooled in those disciplines than we are.

Going deeper yet, the systems of nature have common rhythms and trends that underlie their emergent complexity. These properties come from the *structure* of the organization: the deeply held relationships that define the organization as a social entity. Senge [Senge1990] popularized this aspect of social behavior in a discipline he called *systems thinking*, a discipline that goes beyond our everyday disciplines that are based on a simplistic relationship between cause and effect. Many early attempts at software process improvement relied on this simplistic cause-and-effect relationship, particularly as the third paradigm of software development started to take hold in the industry. Most ISO 9000 process improvement efforts were run this way: find what we're doing wrong, find the place in the process that's wrong, and make it right. There was rarely any notion that the process as a whole might be wrong and that, for example, a step-by-step process should be replaced by a more reactive, agile process. And it was heresy to conjecture that process itself might be the wrong formalism to capture the crucial properties of efficient, effective systems.

When we started this work in the early 1990s, we started with documented research that showed serious shortcomings in process-based approaches such as ISO 9000. We asked: if process isn't the answer, then what is? We chose organizational structure—and, in particular, the structure of relationships between roles—as the basis for system understanding. All systems are about relationships, and most disciplines that study systems study the relationships in those systems. The idea worked. What's better, the technique didn't displace the process-based approaches in existing organizations (it's always hard to tell an organization to stop doing something they think is helpful, anyhow), but complemented them by adding insight into deep structure that explained behavior at the process level. So if you already have a process improvement program in place, this book can add an enriching dimension that builds on your own culture and helps develop your peoples' insights into that culture.

Patterns provide a way to capture both the broad, invariant practices of socially built artifacts as well as the specialized practices of individual disciplines, along with an understanding of how those practices build on each other. Long before Alexander started using patterns for the field of architecture, anthropologists were using them to describe human social structures [Kroeber1948]. The pattern languages in this book combine the timeless human structures that transcend disciplines with the best practices of contemporary software development. These patterns are all empirical: they capture the major rhythms and structures of successful software-intensive organizations today. Many of the patterns come from our own research, but we also incorporated patterns from other authors working in the same field. This is a collected work and in many ways reflects a community-wide effort.

There are two equally valid views of this book: as a guide to organizational improvement, and as a record of the “best typical” software development structures of the fourth social paradigm of software development. Most readers will use the book in the first sense. However, it is our hope that this book reflects a well-enough grounded view of contemporary software development to serve as a touchstone that records what life was like in software development organizations in the late twentieth and early twenty-first centuries. Fifty years from now, will this book be a sobering admonishment to the industry? Will we just chuckle at how things used to be? Or will time leave this fourth-generation culmination of software progress largely untouched? In that spirit, we greet the rare reader who finds an archival copy of this tome on a dusty bookshelf in the middle of the twenty-first century, and we salute your efforts to use this understanding to further improve the lot of the organizations of your time and place.

Our sense of history extends in the other direction as well. Christopher Alexander’s book includes a picture at the beginning of every pattern [Alexander1977]. Each picture sets a broad tone for the pattern that follows. We wanted that same feeling for this book, and we strove to include a picture for each pattern. We initially felt that the social network diagrams would suffice as pictures, but that gave the book an “academic” feel that left a bad taste in our mouths. Paul Bramble turned us on to the prints and photographs division of the Library of Congress (http://lcweb.loc.gov/rr/print/catalog.html), which provided a wealth of vintage photos. Most come from a collection of depression-era photographs sponsored by the Farm Services Administration. Some of the photos are strikingly poignant or relevant to the patterns; that was a surprise, since they come from an era that predates the software culture that is such a large part of this book. But we feel that the age and human element of the photos lends an overall charm to the book that totally would be lacking in the social network diagrams. They also give us a feel of the timelessness of the basic human issues facing organizations of any culture, era, or ideology. This is not a book about ideology, but about human nature. Last, the pictures might help make the patterns more memorable for you: pictures are powerful association tools.

Many of the pictures have a military theme. Please remember that the purpose of patterns is human quality of life and comfort, and that patterns help us capture as much learning from history's tragedies as from its moments of peak culture. Also remember that the earliest patterns of human organizations (such as [Clavell1989]) have roots in military organizational structure.

Acknowledgments

In doing this book we view ourselves as editors and chroniclers of others' work and ideas. There are literally thousands of people who contributed to this book through their participation in the empirical studies from which we mined the patterns. We don't have all of their names here, but we appreciate all of them for their time and energy. Especially noteworthy were the Borland QPW Group, coordinated by David Intersimone, a remarkably productive project at AT&T led by Judy Tschirgi, highly effective projects at Schlumberger in Oslo, where we were hosted by Lise Hvatum, and the group managed by Richard Gabriel at ParcPlace Systems that was undergoing a sobering restructuring at the time we visited Richard.

There are other people who put even more of their own energy into this book by building things for us and doing things with us. Brendan Cain was one of the original members of the Pasteur research effort at Bell Laboratories, and he wrote many of the original analysis tools. Anthropologist Peter B¸rgi was another early member of the research team; he contributed many of the insights on schismogenesis and on other direct parallels between the corporate world and the more "traditional" world of cultural anthropology. Tom Burrows' early work on the GIL and Romana environments at Bell Labs provided a platform for many of the early tools. We are grateful to Steve North for the **dot** tool that not only provides good supporting visuals that map out the pattern languages, but which was a key research tool in its own right.

We are particularly indebted to authors who let us reproduce their patterns here. Pieces of the patterns of Alistair Cockburn, Ward Cunningham, Bruce Whitenack and Steve Berczuk have all made their way into this collection. Thanks for sharing, folks. Gerard Meszaros wrote several patterns, including ARTIFACT OWNERSHIP, ARCHITECTURE DEFINITION TEAM, and ARCHITECTURE ORGANIZATION, whose contents filtered into many patterns in these pattern languages.

Other people steered us in the right direction. Diane Grinnell pointed us to the references on organizational incest and its parallels to dysfunctional constellations in family therapy. Tom Stone, then at Addison-Wesley, pointed us to some dynamite references on organizational learning, and in particular the studies that came out of Royal Dutch Shell. Bindu Rama Rao of Lucent pointed us to the work by Kroeber, which gave us strong ties from patterns back to the world of anthropology. Urvashi Kaul of Allstate developed pattern taxonomies that shaped how we organized these patterns into pattern languages. But most of all, we're grateful to Moody Ahmad, who first gave us a hint back in the mid-1980s that software development research should be investigating not just the technical issues, but the human issues as well.

Dozens of people reviewed these patterns in writers workshops at pattern conferences and local pattern groups. Additionally, we enjoyed the feedback of a team of focused and thorough reviewers who weren't afraid to give us the benefit of their opinion in places where they felt we were misguided, and they were usually right. Gerhard Ackermann at Siemens in Vienna offered a wealth of first-hand insights in organizational growth and repair. Paul Bramble and Ian Graham were our two main manuscript reviewers for the late versions of the manuscript, but they offered a lot of useful advice on the organizational of the book. Joshua Kerievsky pioneered the conversion of these patterns to Alexandrian form with his outstanding editorial efforts on SOLO VIRTUOSO, SIZE THE ORGANIZATION, and SELF SELECTING TEAM. And many thanks to our favorite Mercenary Analyst, Betsy Hanes Perry, for her contributions to PUBLIC CHARACTER. Other key early reviewers included Jay Stagnone, ...

There are others who worked with us as partners along the way, and whose editorial feedback and suggestions were fundamental to the shape of the book. Martine Devos (then of Argo in Belgium, and currently of Avaya Labs) and Steve Berczuk invested much of themselves in this work, and we are grateful for their energy and dedication.

We enjoyed a good technical and organizational infrastructure to support out work. At Bell Labs, the research organizations managed by Eric Sumner, Mary Zajac, and David Weiss actively supported this work over a decade. That is a long time not only in Internet years but even by research project standards. We honor their vision, patience, and forbearance. David Weiss continued to support this work in a similar capacity at Avaya Labs. Many thanks to UNIVERSIT‰T Karlsruhe for the Wiki that we used to develop the book manuscript, and in particular to Dr. Helmut Goos. The support came in part under the auspices of the IST 1999-14191 EasyComp joint research project of the European Community, and we are grateful for that support. Research Chair John Roddick and fellow professor Paul Calder sponsored the infrastructure and time for this work while Jim Coplien spent a summer (or was it winter?) at Flinders University in Adelaide, Australia.

And of course, where would we be without our editorial support? Alan Apt has always been there in the wings, but not bugging us too much, supporting us in mighty ways. It’s been a joy working with him.

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PART I. History And Introduction

This book is about people — people who write software. No, this isn't a Dilbertesque look at our profession or an analysis of the minds of cult figures in the profession. It is about teams of real people who write real software. You see, over the last ten years or so, we have studied how people work together to create software. And we have seen that these organizations have a lot in common, whether they are writing software for telephone systems, banks, or oil exploration. The people issues shine through whatever application they are developing. And that is comforting, in a way.

At the same time, though, it is disconcerting. For while organizations are inanimate, they take on a life of their own. We see that organizations grow, learn, and sometimes even get sick! Yet they can heal themselves, and can become healthy again. Of course, we are most interested in the characteristics of the healthy organizations; perhaps other organizations can learn from those experiences.

It is this notion of healing, repair and growth that are the foundations of Agile development. O.K., we'll be frank: we chose "Agile" for the title out of marketing concerns. It seems to be the current term of choice for the kinds of things we describe in this book. It is a term that rolls off the tongue more easily that other clever names that clamor for your attention on today's bookshelves. This manuscript has been evolving piecemeal for over a decade, and the early pre-publication manuscripts have been a foundation and source of inspiration for many contemporary popular approaches. For example, Jeff Sutherland notes that an early publication on this work, related to one of the major case studies in this book, was one early influence on SCRUM [Sutherland2003]. Ken Schwaber notes that the early background of these pattern languages "were the genesis of some of the agile processes" [Schwaber2003]. Gabriel's early article [Gabriel1994] and later book [Gabriel1996] discuss the successful application of these techniques at ParcPlace Systems as a key part of a broader effort that transformed the organization. And these patterns have the dubious distinction of earning the criticism of one notable software person who was the primary reviewer of the first published version of these patterns. He noted that anyone who worked on organizational issues was avoiding doing real work (which by his own admission was limited to anything directly related to Smalltalk programming). He would later go on to be one of the founders of Extreme Programming—a discipline that builds in part on the patterns that have been in this language (such as Developing In Pairs (4.2.28)) for almost a decade.

Yet this book is broader than so-called agile development. We are really concerned with effective software development — the ability to produce good software efficiently, time after time. Many of the organizations we studied and learned from would not be considered "agile", but they were highly effective. The 5ESS development in AT&T, for example, would fit nobody's definition of agile. But year after year, they produced software for a system that was not only one of the largest software systems in the world, but among the world's most reliable. Yes, many of these patterns contribute to agility, but our chief aim is effectiveness.

We have captured the good things organizations do and have written them down as patterns. We hope these patterns will be as interesting and useful to you as they have been to us. Many others have found them useful: at conferences, we find that these patterns are the foundation of improvement programs in many companies worldwide.

We have divided this book into four parts:

- Part I: History and Introduction, the section you are reading
- Part II: The patterns themselves
- Part III: Foundations and History

- Part IV: Case Studies
- Part V: Appendices

Here in the introduction, we provide background material that will help you better understand the core of the book, which is the patterns themselves. It is an ideal goal that each pattern should convey everything you need to know to touch the resources within you that will allow you to apply it. But more practically, experience has shown that a knowledge of the history behind the gathering and publication of patterns can help the reader better understand their scope and applicability. For example, John Vlissides' book "Pattern Hatching," [Vlissides1998] a reflection on the seminal Gang of Four book, offers commentary that takes the pattern practitioner to a new level of depth in understanding both the strengths and limitations of the techniques. Here, we package both parts into the same book. And furthermore, we present the ideas up front as a foundation for what follows.

After you read the patterns, the case studies follow to revisit and reinforce the principles and practices that the patterns offer. The appendices include miscellaneous supporting material.

CHAPTER 1 *An Overview Of Patterns And Organizational Patterns*

The authors of this book all know that you really wanted to first open the book to HOW TO USE THIS BOOK (CHAPTER 3), but we thought it would be good to introduce the topic a bit before taking you there. Having a bit of terminology at hand will help provide context for the most powerful application of the patterns in this book. We kindly urge you to read all of Part I before moving into the patterns in the following sections, for the same reason.

1.1 What Are Patterns?

A *pattern* is an element of design that is most commonly ascribed to the architect Christopher Alexander, who uses a pattern-based approach to the construction of towns, neighborhoods and buildings ([Alexander1977], [Alexander1979]). Each pattern solves a problem by adding structure to a system. The main tenets of the pattern approach to system construction include incremental repair and piecemeal growth, building on experience, and an attentiveness to quality of life.

Alexander's ideas were adopted by the software community, and in particular by the object-oriented programming community, in the early 1990s.

The concept of pattern is difficult; it is plagued by more misunderstanding than were ever suffered even by terms like "object" and "function" of the 1970's and 1980's. There are aspects of the definition that are intuitive—"a solution to a problem in a context"—yet a pattern is much more than that. In this book, your intuition about what the term "patterns" means will take you far as you build and repair your organization. But a deeper knowledge of patterns will make it easier for you to extend the pattern language with your own patterns, and to experience the joy that comes with the freedom of playful and insightful organizational design.

To fully understand what a pattern is, you must first understand what a pattern language is. A pattern doesn't exist apart from a pattern language; its first purpose is to establish connections to other patterns in the language ([Alexander1977], p. xii). But to understand pattern languages, you must first understand what a pattern is. We know this is recursive, and to understand recursion, you must first understand recursion. We must start somewhere, and we start here: with patterns.

Here is a short and necessarily incomplete definition of a pattern:

> A recurring structural configuration that solves a problem in a context, contributing to the wholeness of some whole, or system, that reflects some aesthetic or cultural value.

Some of these aspects of pattern don't come out in the popular literature, and you may not find them all in the same place in Alexander's definitions. But they are the key elements of what makes a pattern a pattern, and what makes it different from a simple rule. A pattern *is* a rule: the word *configuration* should be read as "a rule to configure." But it is more than just a rule; it is a special kind of rule that contributes to the overall structure of a system, that works together with other patterns to create emergent structure and behavior.

Let's jump into an example. Consider the pattern TEAM PER TASK (4.1.21). Let's discuss each section of the pattern in turn interleaved with explanatory commentary.

> TEAM PER TASK**

That's the *name* of the pattern. We try to make pattern names descriptive, and sometimes even evocative. The name is a shorthand by which we'll refer to the structure, forces, solution, and so forth of the pattern as a whole, and it's important that patterns have good names to support good communication between you and your colleagues as you evolve your organization. The two stars after the name are a confidence level for the pattern; there can be zero, one, or two stars depending on how often we have seen the pattern applied and depending on our sense of confidence about the pattern's value.

> ... a big diversion hits the team, threatening to disrupt the ongoing work, and temporarily halt progress.

This is the *context* in which we find the problem. The context tells us something about the current structure of the system and may give us a hint about what other patterns already have been applied. After this prologue is the following delimiter, which leads into a discussion of the *forces*, or trade-offs, behind the pattern:

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> **Large distractions (usually called crises) must not be allowed to stop a project, even for a short time.** Crises are inevitable, and they are legion. If the project takes time to respond to each, its members will soon find themselves spending so much time responding to each crisis that the real work doesn't get done.
>
> Of course the diversions are real. A previous release needs an emergency bug fix. New people must be trained. The ISO audit will happen. But they must be handled in a way that the project still moves forward.

At this point we have a sense that this is a tough problem! These "forces" draw out the considerations that must be balanced in the solution. They point to the nub of the problem and, in summary, are a statement of the problem itself. In this pattern form—called Alexandrian form, after Christopher Alexander—there is no real separate problem statement. We can interpret the emboldened part of the forces to summarize the problem, but it is *all* the forces together that cause the problem.

The problem isn't context-free; it is not a law of nature, but arises in a cultural context. Each culture has its own aesthetics about what is acceptable and what is gauche, what is constructive and what is unacceptable. Patterns honor this human element of design.

Next, we present the solution after a ceremonious "Therefore":

> Therefore:
>
> **Let a sub-team handle the diversion, which allows the main team to keep working.**
>
> One approach is to split the team. Sort the activities so that each team has a primary task with additional, sympathetic activities. Sitting in meetings, answering phone calls, writing reports, for example, are non-sympathetic to designing software. Arrange it so that each team can focus on its primary task, and each task has a dedicated team member.

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We close off the solution with another set of stars, and then go into some discussion about why the pattern works: how it balances the forces, what the strengths and liabilities of the pattern might be, and so on:

> The result is that the important distractions are handled pretty much entirely by specialized teams, thus allowing the main team to continue uninterrupted.
>
> However, one must be careful not to overdo it. Carried to extremes, it results in single-person teams. In addition, while solving a crisis is important, be careful not to heap praise too lavishly on the crisis teams. Otherwise, addressing crises becomes the glamor job, and the focus of the team becomes putting out fires rather than building the building. (See COMPENSATE SUCCESS (4.2.25)).

Aha! And there is a link to another pattern. We can also add sections to make these links explicit:

Related Patterns:

This pattern treats each task both as an activity and as a deliverable. Therefore:

OWNER PER DELIVERABLE (10.5.19) - the general form of ownership and accountability

FUNCTION OWNER AND COMPONENT OWNER - team for each artifact, as well as the task of designing it

. . . .

And so forth. For the full pattern, see TEAM PER TASK (4.1.21).

A good pattern takes the reader on an emotional journey. We want you to feel what it might be like to be on such a team, focused on one task. One goal of the forces is to touch those experiences within you that cause you to say “Aha!” and identify with the pattern.

Patterns tend to be small, local things. There is no “organization structure” pattern or anything like that. Patterns work together in rich and complex ways to generate emergent structure and behavior. An individual pattern captures local related concerns; a pattern is an encapsulation of related forces. When we apply patterns, we can do so without undue concern for other patterns in the language. In application, they are decoupled—but in the broader scheme of things, they are always part of some whole that gives them context. Patterns are like the cells in a plant; the resulting organization is like the tree or the forest that results as the cells grow, divide, and specialize. The structure for putting the patterns together in this way is called a *pattern language.*

1.2 What Are Pattern Languages?

Patterns come from pattern languages. We use the term “language” as an analogy. English is a language: as a language, it comprises words and the rules to put words together in meaningful ways. A pattern language is a language that comprises patterns and the rules to put patterns together in meaningful ways, in a certain sequence. It tells how to build a *whole,* a *system*. Patterns encapsulate related forces so you can focus on local trade-offs using local thinking; pattern languages are about emergent behavior in systems.

Actually, a pattern language is an outline of many ways that patterns *may* be put together. How they are put together depends on *context*. When we apply a pattern, the context changes. When someone joins the organization, or when the organization decides to build a new product line, the context may change. Depending on the context at any given time, different patterns might or might not apply.

So while a pattern language is a roadmap, there are paths to organizational growth. The exact path one takes depends on circumstances and on progress—and, of course, on the choices that people make in shaping the organization along the way. Sometimes people make bad choices, and that may mean backing up a bit or taking a detour on the journey. And bad choices sometimes result in insights that lead to new patterns and to new structures in the pattern language.

Consider that you are working in the PROJECT MANAGEMENT PATTERN LANGUAGE. You already have PROGRAMMING EPISODES (4.1.19) in place, and that you've decided that you need the pattern SOMEONE ALWAYS MAKES PROGRESS (4.1.20) to keep the project from getting "stuck" or distracted, particularly by diversions. SOMEONE ALWAYS MAKES PROGRESS seems like the right idea; you have many tasks that go awry. But now the question is how to tailor SOMEONE ALWAYS MAKES PROGRESS to the particular situation. You could derail the entire team to address the problem, but that would be overkill.

So you look at SOMEONE ALWAYS MAKES PROGRESS where you find this:

> You can employ one of a broad range of particular solutions and tactics depending on the exact forces to be resolved. The following specializations are example refinements of this pattern:
>
> - DEVELOPING IN PAIRS (4.2.28) - one person can always take the keyboard.
> - TEAM PER TASK (4.1.21) - separate tasks into sympathetic sets.
> - SACRIFICE ONE PERSON (4.1.22) - assign only one person to the distraction.

- DAY CARE (4.1.23) - separate the training task from that of producing software.

You home in on TEAM PER TASK as being a good response to the concerns raised by trying to fit SOMEONE ALWAYS MAKES PROGRESS (4.1.20) into the organization. So you design a team into your organization to address the problem.

How do you staff the team? You move onward in the language and find that SACRIFICE ONE PERSON (4.1.22) or DEVELOPING IN PAIRS (4.2.28) might be suitable solutions to the problem. Or you might look at INTERRUPTS UNJAM BLOCKING (4.1.25) as another refinement of TEAM PER TASK: connect the team with a manager who can get the team off top dead center if the team becomes stuck on the problem too long.

Each of these pattern selections follows a natural progression through the pattern language. Most patterns can be applied one at a time. However, it pays to know the patterns in advance, and it pays to explore several patterns in your mind to provoke your instinct to the right action. Good advice from peers and, even more so, from the stakeholders in the decision, can also help guide the decision. Having the patterns at hand provides a foundation for discussion and analysis of the problem and its potential solutions.

There are four pattern languages in this book that build four “wholes”. These languages are a Project Management Pattern Language, a Piecemeal Growth Pattern Language for growing the organization incrementally, an Organizational Style Pattern Language, and a People and Code Pattern Language. Note, though, that the “wholes” aren’t distinct, but are different views of the same organization. In other words, a healthy organization exhibits patterns from all four of these pattern languages, simultaneously!

1.3 Organizational Pattern Languages

1.3.1 The Structure of Social Systems

An organization is a system and, like most systems, it has structure. In particular, it is a social system. What does it mean for a social system to have structure?

The study of human organizations goes back thousands of years, and many of the schools of this nascent organizational science looked at structure. The Chinese classics like *The Art of War* [SunTzu1989] talk much about organization structure—the organization of armies, some of the earliest large groups of people that needed guidance from organizational principles. The primary structure in a classic militia is one of hierarchy, authority, and top down control; most other structures respond to that.

These structures are part of culture (see ANTHROPOLOGICAL FOUNDATIONS (CHAPTER 7)). A friend of ours in Siemens-Nixdorf claims to be able to trace the hierarchical structure of the company back to its founders, who were military officers in the Bismarck era in Prussia—a very hierarchical culture. One finds such overt hierarchy in much of German culture and in its companies.

But there are other kinds of culture that reflect different kinds of structure, and that structure comes about from the patterns that generate it. Another extreme is the contemporary Linux culture in software. It is an extremely shallow and broad hierarchy; that structure in turn leads to different processes (see BEYOND PROCESS TO STRUCTURE AND VALUES (7.2)).

Culture is important. While engineering organizations traditionally seek technical missteps in their postmortem analyses, the contributions of culture are usually ignored. If you are *in* a culture, it's hard to *see* the culture, and that causes us to miss the important cultural roots of failed projects again and again. But we are getting better at it. The Columbia Accident Investigation Board lays blame for the Challenger disaster on the NASA 'culture.' Elements of that culture included its value system of funding, schedule, and safety [Recer2003]. We don't need to wait for disaster to strike to take proactive steps to grow and repair corporate culture. That's what organizational pattern languages do.

1.3.2 The Multiple Structures of Social Systems

Organizations are complex; we might define complexity as proportional to the number of distinct, meaningful views of a system. In software, we sometimes use the word *architecture* to describe the articulation of system structure. We can also talk about the organization as a system, a system that can be described by architecture, where an architecture comprises the structures in the organization and the relationships between them. The “structures” are patterns, and each pattern documents its relationships to the other patterns in the language. In this book we talk about four interrelated architectures of an organization. Each one has its own pattern language:

- PROJECT MANAGEMENT PATTERN LANGUAGE (4.1): This pattern language has to do with the work of the organization and how to structure it. It focuses on schedule, process, tasks, and in particular the structures to support good work progress.
- PIECEMEAL GROWTH PATTERN LANGUAGE (4.2): This pattern language describes how to grow the organization and process together; it is reminiscent of concurrent engineering approaches that grow the process and product together.
- ORGANIZATIONAL STYLE PATTERN LANGUAGE (5.1): This pattern language looks at the structure of role relationships in the organization and what they portend for different organizational styles.
- PEOPLE AND CODE PATTERN LANGUAGE (5.2): This pattern language is an expansion of the famous Conway’s Law, that states that there is a close relationship between the structure of an organization and of the artifacts it builds. The pattern language offers further insight on organizational structuring in light of growing insight into the system architecture.

Each of the pattern languages reflects a domain. These domains came from our analysis of the patterns. We grouped the patterns according to how they worked together in sequences and, modulo a small number of pattern duplications, we just ended up with four groupings. There’s nothing magic about the number “four,” but it’s nice and manageably small.

In practice, one uses all of these pattern languages in parallel. Each one describes a different architecture of the organization. Each of these architectures must be tended to. There are of course relationships between the pattern languages; in particular, some patterns are common to more than one pattern language. In this book we present each pattern only once, in the pattern language where it best seems to belong, and the other pattern languages make reference to that presentation of the pattern.

These patterns come from a wide variety of organizations, large and small. We feel that most of the patterns can be considered for most organizations, large and small. Large organizations almost always comprise a composition of several smaller organizations; almost all of these patterns were collected from identifiable groups that were cohesive in their own right, though they all had effective coupling to external agencies, organizations, and individuals. The PEOPLE AND CODE PATTERN LANGUAGE (5.2) is particularly applicable to small organizations, and those readers who have a particular interest in small team dynamics might find that chapter particularly useful. (However, neither of us believe in "large teams;" we don't believe they exist! The word *team* means something, and the spirit and effectiveness that come with the word *team* can't be sustained across large populations.)

1.3.3 Pattern Languages and Sequences

With each pattern language we provide a story—from real life—that illustrates how patterns from the pattern language might fit together to achieve organizational growth, improvement, or maturity. These stories are a form of what we call *sequences*. A sequence is an architect's tour through the structure about to be built. It is a path through the pattern language; when you use the patterns in a given order, that is a sequence. For example, one may begin a new project by appointing an architect design the overall product (ARCHITECT CONTROLS PRODUCT (5.2.3)). Because it is a big project, the architect gets help (ARCHITECTURE TEAM (5.2.4)), and then they sequester themselves to come up with the initial architecture (LOCK 'EM UP TOGETHER (5.2.5)). This shows a small piece of a typical sequence of a new project. A given path, or sequence of patterns, results in a particular system, or whole. At the end of each of the four languages, we give a story that illustrates a sequence through the pattern language.

These sequences should help you get a feel for what the language is trying to build; what it's trying to achieve. They should give you a better feel for what pattern languages in general are about. They should help you see how the patterns tie together, depend on each other. As you read the pattern languages and consider your own experiences, you will be able to see sequences through the pattern language—your own stories.

Of course, all the possible sequences are implicit in the structure of the pattern language. You can and should generate your own sequence by going from pattern to pattern, working your way through the language. The pattern language diagrams presented at the beginning of each pattern language can be a guide. And sometimes you may find a place to apply a pattern in a way that's a bit out of sequence; as long as the context is suitable for the new pattern, let common sense rule and try the pattern if your instinct leads in that direction.

Near the end of the book we also present some case studies. These are like the sequences in the stories we present with each pattern language, only they are less structured. The case studies come from organizations we have studied and modeled, so we have less insight into their process of growth than we do for the examples given with the pattern languages. But one can still imagine what process might have taken place, and one can still see the interworking of the patterns in those stories.

CHAPTER 2 *How The Patterns Came To Us*

We didn't make up these patterns. No one invents a pattern (or if they do, they shouldn't). Patterns are out there waiting to be discovered and documented. We took it upon ourselves to find the latent patterns of the domain of organizational maintenance and to document them. This book is the result.

This section briefly looks at the techniques we used to find and organize the patterns. You should read this chapter if you are interested in the methodology behind the patterns as much as you are interested in the patterns themselves. However, the section on HOW TO USE THIS BOOK (CHAPTER 3) provides a summary of what you'll need to know to understand most of the patterns that follow.

We can summarize our research approach as follows:

1. Gather data from identifiable teams, using team interviews.
2. Analyze the data using social network techniques, to build organizational models.
3. Present the analysis results to the team, note team reactions, and adjust the model as necessary
4. Catalog the analysis results and look for common patterns, identifying the problem, forces and solution for each pattern

5. Capture the patterns in pattern form.
6. Look for links between the patterns that form meaningful sequences for applying the patterns.
7. Organize the sequences into pattern languages.

We started with team interviews, and largely used social network analysis tools to look for patterns in the data from around 100 organizations. Those organizations ranged in size from 5 people to 100 people, but most of them were organizations of 20 to 40 people working on a common software project. By "organization" here, we mean a social unit such as a department or project or sometimes a work location where the people depend on each other and work together. That sense of organization may (or may not) be independent of what is on the corporate organizational chart. Often, each organization would be responsible for one or more *processes* in the sense that the term is used in ISO 9000 certification.

We studied organizations in Europe, America, the Middle East, and Australia. Our models unfortunately do not build on any substantial data from Japan, China, Singapore, or other countries of the Pacific Rim. It is possible that the cultural differences (in the vernacular sense) might limit the application of some of these patterns in Pacific Rim settings. But we have found remarkable commonality across organizations in Western Europe, the Nordic countries, the United States, and the Middle East.

Given that background, here's a more in-depth description of how we gathered and analyzed the organizational data.

2.1 Gathering Organizational Data

This work draws on data gathered as part of the Pasteur process research program at AT&T Bell Laboratories. In the Pasteur program, we studied software development organizations in many companies worldwide, covering a wide spectrum of development cultures. The Pasteur analysis techniques are based in part on organizational visualization. Many of the patterns in this pattern language have visual analogues in the Pasteur analyses. We sometimes use visualizations to illustrate a pattern.

There are two kinds of pictures used in the Pasteur studies. The first is a social network diagram, also called an adjacency diagram. Each diagram is a network of roles and the communication paths between them. The roles are placed according to their coupling relationships: closely coupling roles are close together, and de-coupled roles are far apart. Roles at the center of these pictures tend to be the most active roles in these organizations, while those nearer the edges have a more distant relationship with the organization as a whole.

The second kind of picture is an interaction grid. The interaction grid is a communication matrix for the organization, structured in a way that makes it easier to find clusters of communication, of engaged and disengaged roles, and of other patterns in the communication network. We present an overview of these tools in READING THE PATTERNS (3.1), and describe them in more detail in the section SOCIAL NETWORK ANALYSIS (7.4).

The pattern texts in this book often make reference to documents or projects that typify the pattern, particularly in the Design Rationale section of the patterns. One of our most important case studies was a 1993 evaluation of Borland's QuattroPro for Windows development, also called "QPW" in the text. This research is further discussed in the proceedings of BIC/94 [Coplien1994], in a column by Richard Gabriel [Gabriel1994], and in an article in Dr. Dobb's Journal [Coplien1994b]. The case study appears in this book as BORLAND QUATTRO PRO FOR WINDOWS (CHAPTER 8).

2.1.1 Introspection In And Analysis Of Organizations

We launched our work on process and organization as ISO 9000, STD 2167a and other standards broadened their influence on software development in the late 1980s and early 1990s. These standards focused on process reproducibility, striving to reduce organizational performance variation more than on raising the mean. Such baselining is important to the quality techniques popularized by W. Edwards Deming [Deming1986] based on statistical process control. A process can be improved if it can be understood; it can be understood only if it has a consistent structure [Senge1990]; its structure can be consistent only after the first steps of process improvement have reduced process variability. We found that the process culture in most contemporary organizations has a strong focus on process documentation, but what is documented is often distant from day-to-day practice. The process cultures often ignored important variations in organizational behavior that are key to dealing with market uncertainties, or the uncertainties that arise in any process rooted in human intellect and instinct.

2.1.2 Shortcomings Of State Of The Art

Most process-intensive organizations look to a process specification document as the final word on development activities. We noted three problems with this approach in practice: lack of empirical conformance between practice and process specifications; incompleteness of process models; and inability to capture long-term stable process abstractions. Many processes exhibited such broad variation in behavior that it was difficult for process specifiers to agree on a process that represented the *typical* scenario. Many organizations informally built process specifications from anecdotal process experience instead of driving the baseline process model with empirical models and data. Many organizations we studied created an *ideal* specification instead of capturing empirical practices [Archibald1993]; organizations used those specifications as a baseline for improvement despite this mismatch. Because many process specification models were divorced from empirical practice, nothing forced development practice into statistical control.

Second, process models were often incomplete and inconsistent. Most process models focused on the task and event perspective, leaving artifacts, roles, actors and agents as secondary abstractions. Much of this task perspective was driven by a preoccupation with interval prediction and reduction on one hand (one manages overall interval by focusing on individual intervals) and quality on the other (methodical reviews form obvious task / event benchmarks). Task models fit well the waterfall-based development model that is predominate in most development cultures. Furthermore, task models held up the promise of process automation (e.g., [KrishnamurthyRosenblum1991]). We note that the disconnect between process tasks and the artifacts they produce continues to plague most of the organizations we work with today.

Third, many organizations built their process improvement programs around the task or event dimension of process. Well-understood processes (like bug report flow) often can be regularized, but the core processes of architecture, design, implementation and validation are poorly understood from a task perspective. We have found that task ordering changes rapidly in a high-technology development organization, so it can't be counted on as a stable component of process structure. One large organization we studied surveyed its developers and found that 80% of them were working under officially granted process waivers instead of the official common process, largely because the project's process standard didn't capture the essential, stable structure of the process. One reason that task chain models don't capture the stable structure is because of the high degree of concurrency present in modern software development. It is interesting to note that iterative and incremental design cultures were demonstrating success at about the same time that process consciousness was growing. Project managers still find it difficult to reconcile iterative and incremental techniques with process standards that prescribed process steps [Archibald1993]. Many organizations we studied exhibited concurrent engineering practices, where requirements, design, and implementation activities proceeded in parallel [Hartley1992]. Few organizations intentionally applied concurrent engineering. In fact, many organizations using concurrent engineering (as we discovered empirically) remained stalwart about the accuracy of their waterfall design methods (as stipulated in project process documents). We felt that a role-based model would be a better match for these concurrent engineering organizations than would models based on tasks and events.

There is growing recognition that even if process models could represent interesting aspects of an organization, they aren't terribly useful as a guide for carrying out the work of the business. In *Contextual Design* ([BeyerHoltzblatt1998], p. 41), Beyer and Holtzblatt note:

> In Contextual Design, we always try to build on natural human ways of interacting. It is easier to act, not out of a long list of rules, but out of a simple, familiar model of relationship. A list of rules says, "Do all these things"—you have to concentrate so much on following the rules you can't relate to the customer. It's too much to remember. A *relationship model* says, "Be like this"—stay in the appropriate relationship, and you will naturally act appropriately.

And this position in turn builds on longstanding observations of human behaviour; Beyer and Holtzblatt cite Goffman's work from almost a half-century ago as foundation for this position ([Goffman1959]). We sought to counter the problems of an explicitly process-based approach to organizational improvement with an explicitly role-based modeling approach.

We wanted to adopt process formalisms that would allow us to compare iterative processes with traditional waterfall models; this meant going beyond task and event models. While many aspects of process might be automatable, we found that productive processes emphasized the creative value added by the people in the process. In general, this suggested that we should study many dimensions of process: artifacts, organizational roles and structure, personal skill sets, and many other factors. Together, these diverse properties define a process architecture. Architecture is a partitioning of a system that results from applying a set of partitioning principles, together with the relationship between the parts resulting from that partitioning. Our resources didn't allow us to study all of these at once, we decided to focus on organizational structure, to balance the investment most organizations had made in task models. The industry has a fascination with the relationship between development organizations and the software they create (see [Fraser1994a] and [Fraser1994b]) so we felt there would be interest in such research.

The organizations we studied didn't necessarily correspond to formal organizational structures, but arose as communities of interest develop within a project. The "real" organizations in any culture can be defined in terms of coupling between actors or roles, brought together by a common interest or objective. Such organizations are called *instrumental organizations* and should be distinguished from the formal organization structure. An instrumental organization is the "instrument which regulates organizational behaviour." ([SwieringaWierdsma1992], page 10). These two structures line up in some organizations; see the studies by Swieringa and Wierdsma [SwieringaWierdsma1992].

2.1.3 The CRC- Card Methodology

The Pasteur research program was an empirical research program based on real-world experience. Research on human subjects is notoriously difficult. We were wary of any results that would simply reduce people to numbers. We wanted results that were intuitive. We wanted to build on the insight of our subjects as much or more as on the insights that we as researchers would develop. One of the few constraints we wanted to apply to the data we collected is that it be based on roles, and we felt that roles were a general enough representation to not interfere with gathering insights from the study subjects. This section describes how we used CRC cards to capture the data about organizational roles that would serve as input to our analyses.

We set out to build instrumental organizational models from first-hand accounts [CainCoplien1993]. Since process works at the level of the engineers doing the day-to-day design, coding, and fire-fighting, why not build the models from their perspective? We chose CRC cards as the tool we would use to analyze organizations. CRC cards (which stands for classes, responsibilities, and collaborators) had been developed as a software design tool by Beck and Cunningham to support their work on software architecture and implementation in the mid-1980s [Beck1991]. In CRC design each index card represents an object in the system. The card is used to note and track a *c* lass's set of *r* esponsibilities and *c* ollaborations (hence the name: CRC) in a role-playng exercise.

Subsystem Coord.	
Validate MR lists	Subsystem coord.
Build group products	Change committee
Administer ENVY	Designers
Resolve physical deps.	system test
	Tool vendors

A CRC Card

In our organizational analysis, each index card represents a role. We also captured responsibilities and helping relationships in our role play, but the resulting model captures the structure not of an object-oriented program, but of an organization.

CRC cards fit our needs in several respects. First, they support a highly participatory information gathering technique—something that would help us get at empirical behavior. This level of participation allowed people to act out a faithful memory of day-to-day events.

Second, they made it possible to gather data in a group setting. Role-play is a powerful technique to help people recall past events, particularly in the company of the original players. There is something about acting out one's memories that makes the memories almost tactile, drawing out further detail and recalling context that helps keep the data faithful to actual practice. Sociometric research by Bernard, Killworth et al. has shown that informant accuracy is less than 50%

when people report individually on their interactions ([Wasserman1994], p. 57). This enactment unfolds in a *sociodrama*: a kind of play that recalls the reality of life in the organization. Our subjects were the actors; we were the audience. Of course, the subjects were also unwitting members of the audience, and the technique owes much of its power to that fact. Bringing group members together helps recall corporate memory. It is also an opportunity to plant the seeds of group learning [Senge1990], as we will discuss later.

Third, CRC cards were a good “fit” for the domain we were studying. Each card could be used to model an organizational role; the “responsibilities” captured the responsibilities of each role to the organization; the “collaborations” captured the dependency relationships. At this early juncture, we were naive about social network theory and sociometric diagrams, but we would find that the CRC model would serve us well to support social network formalisms.

Fourth, CRC cards balanced important aspects of several techniques commonly used in social network data gathering ([Wasserman1994], p. 19; p. 44). There are many different flavors of modeling units. Examples of modeling units include actors, dyads, triads, and others. Our primary modeling unit was *roles*, a generalization of related actor responsibilities. In dyadic data gathering, each actor is asked about their interactions with other actors. In triadic data gathering, one actor offers an opinion on how a second actor interacts with a third. The CRC modeling technique focuses on dyadic data by helping role actors focus on their interactions with others. However, group discussions led to the collection of triadic data, particularly for controversial or problematic interactions. It was possible to gather data from an entire organization in one or two sessions of a few hours each.

We have used CRC cards to gather data from about forty organizations, almost all of which serve the software industry. We focused on large system development efforts, including development organizations in AT&T and other telecommunications companies, companies producing software development environment products, aerospace organizations, and medical software development. We also have data points from areas as diverse as government administration projects and consumer software. Most of these have been “software development organizations”: the folks who design, implement, and test software. We have a smaller sampling of organizations that interface the market to the development organization, and which perform other assorted functions

You can read more details about the CRC technique, particularly from the perspective of research methodology, in CRC CARDS AND ROLES (7.5.1).

2.1.4 Analyzing Roles And Relationships

We analyzed the data from the CRC cards and from notes taken during the role plays in various ways. We analyzed the data on the CRC cards quantitatively. Over time, three meaningful quantitative measures emerged. They are:

Number of Roles: This is simply the number of roles in the organization. It is not the number of people.

Communication Saturation: Each role has the potential to communicate with every other role. The communication saturation is the percentage of the potential communication paths that are actually used.

Communication Intensity Ratio: Not every role has the same number of communication paths to other roles. In many organizations, one role has the lion's share of the communication paths. The communication intensity ratio is the ratio of the number of communication paths of the 'busiest" role to the average number of communication paths in an organization. It measures how much the communication is concentrated in a single role.

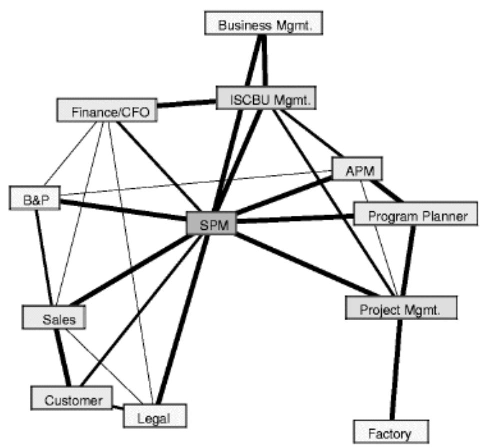
These measures helped form some of the patterns; you will see them mentioned later in the patterns themselves. The patterns will explain the implications of the measures.

Visual Analysis

Besides the quantitative analysis, we found that *looking* at the data from the CRC cards yielded some interesting — and sometimes surprising — insights.

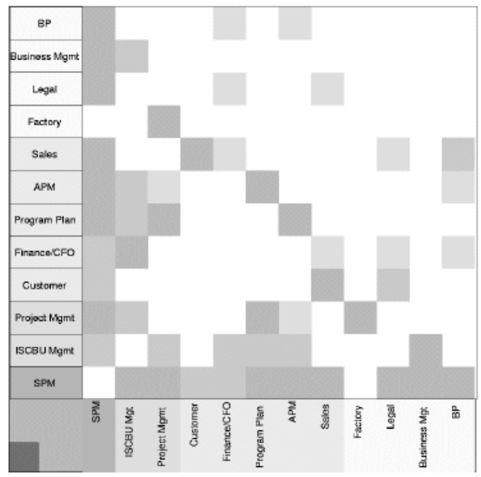
The first "picture" of the data we use is called a sociogram. It is best explained by a metaphor. At the conclusion of a session with an organization, we have a deck of cards, one for each role. We take the cards back home to our laboratory. We begin by rubbing each card through our hair, thus imparting a weak positive charge to the cards (and a negative charge to our hair.) We then deal the cards out on a frictionless table (we have one of those in our lab.) Then we reach for our jar of protons, and very carefully place one proton in the middle of the table (we have a jar of protons.) This causes all the cards to move away from the center, and away from each other. But then we hook the cards that communicate with each other together with rubber bands. In fact, we have three strengths of rubber bands, representing the strength of communication. They show up as lines of different thickness. We have noticed that the more rubber bands that a card gets, the darker it is shaded.

Finally, we step back and let the cards settle down, and view the resulting patterns. As you can imagine, cards that communicate strongly with each other clump together. And some cards are left pretty much alone. The cards with the most communication end up in the middle. In the following sociodiagram, for example, you can see that a role called “SPM” is central to the entire organization. On the other hand, the factory role is isolated from the rest of the organization.



With practice, we were able to learn many things about an organization, literally at a glance. These diagrams led to other patterns; the above pattern is representative of the HUB SPOKE AND RIM (5.1.17) pattern.

The second diagram we use is called an interaction grid. Here is a simple interaction grid for the same organization as depicted in the sociogram above:



This diagram shows both communication and direction — which roles initiate communication to other roles. The roles shown along the left of the grid (the y axis) initiate communication to the (same) roles along the bottom of the grid (the x axis). The shading represents the intensity of the communication, just as in the sociogram.

These visualizations have their roots in social network theory. For those of you who are interested, we explore their origins in SOCIAL NETWORK THEORY FOUNDATIONS (7.5.2), as well as the tools used to create the pictures, after we present the patterns.

2.2 Creating Sequences

2.2.1 Why Sequences Are Important

The pattern languages themselves in this book are static. Organizations are always changing, and the way they change isn't always predictable. Where do the dynamics come from?

The dynamics come in the application of the patterns, and the order in which one applies them. What is the right order, then? One might speculate that one follows the structural relationships between the patterns (as in the sections PROJECT MANAGEMENT PATTERN LANGUAGE (4.1), PIECEMEAL GROWTH PATTERN LANGUAGE (4.2), ORGANIZATIONAL STYLE PAT-

TERN LANGUAGE (5.1), and PEOPLE AND CODE PATTERN LANGUAGE (5.2), where the relationships are shown graphically). But it doesn't always work that way.

Alexander believes that order in any system fundamentally depends on the process used to build the system. This is why the fundamental process is important (see the section PIECEMEAL GROWTH (6.2)). It is important that each step preserves structure and gradually adds local symmetries, and the organization unfolds over time. It is step-by-step adaptation with feedback. Simply following the pattern language doesn't give you a clue about how to handle the feedback. So that's why the fundamental process exists: to give complete freedom to the design process to attack the weakest part of the system, wherever it may be.

However, the fundamental process cannot work on a human scale without some kind of cognitive guide that is built on experience and which can foresee some of the centers that must be built. That's what patterns are: essential centers.

If unfolding is important, how do you know what order to unfold things? The sequence is crucial. You want a smooth, structure-preserving unfolding. It shouldn't feel like "organizational design."

So, what a sequence does is:

- Preserves structure;
- Keeps you doing one thing at a time;
- Takes the whole organization into account at each step;
- May be repeated tens of thousands of times.

Sequences take you into unpredictability, and into circumstances you handle with feedback, always in the context of the whole organization. Sequences are where generativity comes from.

2.2.2 Our Sequences

We have created sequences for each pattern language here. Each of these sequences is one of millions of sequences one could hypothesize for each pattern language: there are many meaningful paths through the pattern language graph.

Sequences unfold as stories, and so that's how we present them. These "stories" are sanity checks on the set of patterns they refer to. If these patterns really do belong together, then we should be able to come up with a “story” that flows through the patterns. (And note that this is not necessarily a temporal flow through the patterns.) It may point out patterns that don’t quite fit where they are, or don’t fit well in the group at all. We might also use the story in the book as an illustration of how the patterns work together. Look at these sequences in the book:

- A Story About Project Management (in Project Management Pattern Language (4.1))
- A Story About Piecemeal Growth (in Piecemeal Growth Pattern Language (4.2))
- A Story About Organizational Style (in Organizational Style Pattern Language (5.1))
- A Story About People And Code (in People And Code Pattern Language (5.2))

These sequences are real; they come from our experience, and we thought they typified the rich ways in which patterns build on each other, and the way in which the language can become alive.

Of course, each of the Case Studies could also have a sequence written for it. Each sequence selects patterns which themselves form a small language. That language describes the culture of the organization.

2.3 History And Related Work

The bulk of the organizational patterns in this book draw on the Pasteur research project at Bell Laboratories. The earliest work on that project sought alternatives to ISO 9000 series approaches as a means to baselining organizational quality. That work dates back to about 1991; the first paper published from that work was [CainCoplien1993]. The key idea of using *roles* dates back to that work.

That research program first used started using patterns to capture organizational structures in late 1993. This body of patterns grew, and the first draft of those patterns was presented for review at the first conference on Pattern Languages of Programs in 1994. The organizational pattern language that was eventually published in the first book in the PLoPD series [Coplien1995] was one of the first pattern languages in software. That pattern language dealt with recurring structures—configurations of roles—in software development organizations, as a reaction against the predominate organizational literature of the era that was based on development process and ISO 9000 series standards and the CMM.

A contemporary language that dealt closely with process and organizational issues was Bruce Whitenack's RAPPeL pattern language [Whitenack1995]. Bruce's pattern language focused largely on the requirements process, "to build systems that do the right things." His view of prototyping contributed heavily to the BUILD PROTOTYPES (4.1.7) pattern in this book. It is perhaps regrettable that few of Bruce's other patterns appear here, but we decided they are a good pattern collection in their own right with loose enough coupling to other organizational issues that it would be best to keep the two as separate works.

Another contemporary pattern language was Norm Kerth's "Caterpillar's Fate" [Kerth1995] which also appeared at the first pattern conference and is published in the first PLoP book. It looks at the transition from analysis into design, and there are many good organizational insights in his patterns, borne on years of consulting and experience. Like RAPPeL, the patterns look at organizational structure as a secondary concern, and so we elected not to incorporate them into the patterns here.

Since then several other efforts have come on the scene and have matured over the years. Steve Berczuk wrote patterns about developing software with distributed teams that are strongly technical, but have interesting organizational overtones [Berczuk1996]. Some of these ideas have evolved into the excellent book by Steve and his coauthor, Brad Appleton [BerczukAppleton2002].

Another follow-on was Ward Cunningham's *Episodes* pattern language. Episodes reflected long-standing experience in the Smalltalk community on small projects that extended all the way back to Ward's experience at Wyatt Software. His work included patterns such as PROGRAMMING EPISODE (4.1.19) and its subtending patterns. *Episodes* was first published in the PLoPD-2 book [Cunningham1996].

Other follow-on work in this vein came from Alistair Cockburn in 1998 and showed up in his book *Surviving Object-Oriented Projects: A Manager's Guide* [Cockburn1998]. His patterns include DAY CARE (4.1.23), SACRIFICE ONE PERSON (4.1.22), and many other practical project management patterns.

Joseph Morabi and colleagues studied the design of organizations [MorabitoSackBhate1999].

Scott Ambler wrote some patterns of developing software from the process perspective[Ambler1999].

You can find more research foundations and related work in ANTHROPOLOGICAL FOUNDATIONS (CHAPTER 7), and particularly in PATLETS FROM OTHER PATTERN LANGUAGES (10.5).

CHAPTER 3 *How To Use This Book*

How should you use this book? Just read the patterns and apply them in your organization! But of course, it isn't that easy. In fact, it isn't easy at all. But right now, the big question for you is how to get started. Here is what we recommend.

3.1 Reading The Patterns

First, read the patterns. We have attempted to put them in a logical order; in the order of a typical sequence through each of the languages. So begin by reading them in order.

3.1.1 The Form

We use Alexandrian form for our patterns: a stylized format for organizing the important components of a pattern. The body of each pattern starts with a statement of the context in which that pattern applies. A problem may arise in that context; the problem description comes next in the pattern. Then the pattern elaborates the problem with a description of the forces that define the problem. Last, the pattern presents a solution that we have validated across a spectrum of development organizations, followed by a rationale that describes why you might believe the pattern should be successful.

3.1.2 Understanding the Models Behind the Patterns

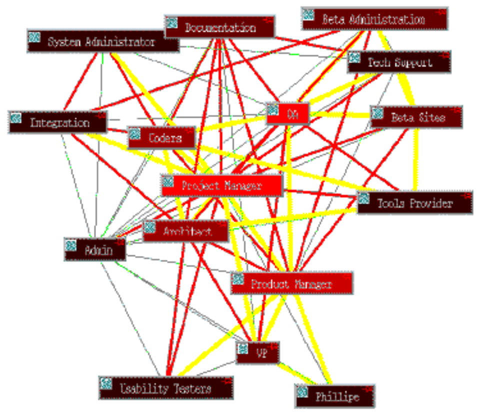
In How The Patterns Came To Us (Chapter 2), we gave a detailed description of the methodology and research technique behind the pattern. We told you that section was optional reading. Nevertheless, it's important to go into the rest of the book with some level of understanding of the source of the patterns, so we give you a summary here.

All of these patterns came out of empirical research. Most of the patterns were distilled from observations gleaned from organizational analysis exercises we conducted on dozens of organizations worldwide. These exercises were used to build organizational models. The *role* is the basic building block of these models. Every organization has roles: developer, manager, systems engineer, tester, and many more. Roles get their work done by interacting with other roles, and much of the success of an organization owes to how effectively roles can exchange information and work together. Each model attempts to capture these interactions between roles.

We gathered the data for the models in a role-playing exercise where each participant tracked the interactions between their role and other roles in the model as the role-play progressed. We used CRC cards — a technique borrowed from object-oriented design — as the tool for capturing these interactions.

These data were fed into a tool to visualize the interaction structure of a given organization. We discovered many of these patterns by looking at diagrams of the communication structures between roles or individuals in the organizations. It was easy for us to notice important features and anomalies in these pictures, and it will be easy for you to do so as well.

For example, consider the following organizational model (called a *sociogram*) that we cite frequently in this book:

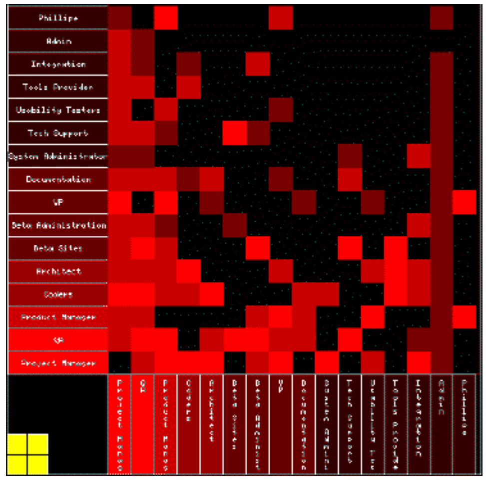


The roles near the center are more closely coupled to the organization as a whole than are those nearer the outer edge. Roles that are near each other are more closely coupled to each other than they are to more distant roles. And roles with more coloring are more coupled to other roles than the ones with less coloring.

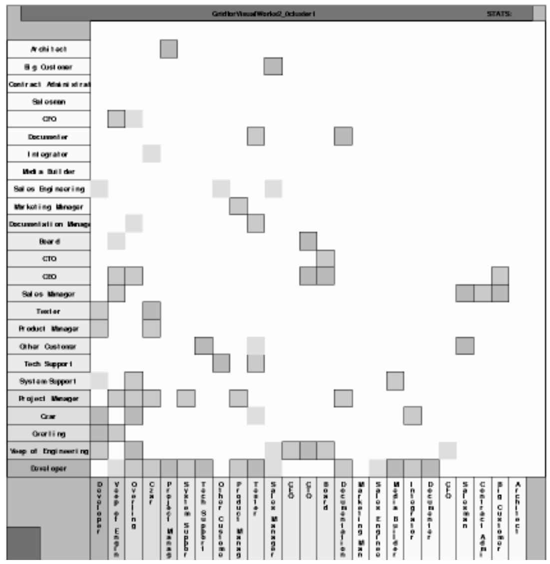
We can see many patterns in this picture. We can see that the roles in this organization Distribute Work Evenly, since the amount of work — reflected by the shading of the roles — is spread around rather than being centralized in a handful of roles. We can see that the Architect Controls Product, being central to the organization. We can validate that the Architect Also Implements because of the proximity to the Coder role. Of course, when we wrote the patterns, we had additional information that led us to these conclusions, information that came from the organization's process sequences. But these diagrams serve to substantiate and illustrate those observations.

(Don't worry that you don't yet understand these patterns; we'll get to them later on.)

That is just one kind of visual model that we can build. Here is another model of the same organization:



The axes of the interaction grid span the roles in the organization, ordered according to their coupling to the organization as a whole. If a role at ordinate position *p* initiates an interaction with a role at coordinate position *q*, we put a point at the position (*p*, *q*). The point is shaded according to the strength of the interaction. In the above model we can see that there is a dense network of communication between roles. There aren't very many large "holes" in the communication structure of the organization. Compare the above grid with this grid:



This picture tells a tale of a much different management style, one where a few core managers initiate interactions across the rest of the organization. Barring those management-initiated interactions, there just *isn't* much interaction between roles.

Many of the patterns in this book use these pictures as aids to understanding the context and forces described in the pattern. We describe the diagrams in more detail in the section SOCIAL NETWORK THEORY FOUNDATIONS (7.5.2), and we recommend you take a quick look at that section before exploring the patterns in depth. For more on our research techniques, you can read the entire section HOW THE PATTERNS CAME TO US (CHAPTER 2).

3.1.3 Stories and Pictures in the Patterns

Many of these patterns come from stories we have picked up on our travels — stories of real problems in real organizations and the real solutions they applied. Many of our patterns start with what we believe to be a particularly poignant or appropriate selection from among such stories.

Each pattern starts with a picture. The pictures are sometimes fun, sometimes somber, and sometimes thought-provoking. Each one strives to underscore the human dimension of the pattern and to serve as a tool to help remember the pattern.

3.1.4 Finding your Way

You will soon see that patterns point to other patterns, not necessarily in the same sequence. One would expect this, since there are many paths through a language. So you may find it more useful to read the patterns in a different order; feel free to do so.

Each pattern is designed to be understandable and applicable in isolation, even though each pattern gains much of its power by reinforcing the patterns around it in the pattern language. When you read the patterns, focus on understanding each on individually: don't worry unduly about the sequence. Allow yourself to get lost, to explore, to play. Of course, if you're a more linear thinker, you may want to follow a specific sequence to order your thoughts; do what is comfortable for you. There are many paths to understanding these patterns.

If you need to get a quick overview of a pattern, just read the text. That gives you the name, the problem it solves, and the solution. For convenience, there is a quick reference summary of the patterns at the end of the book; they are called "patlets." In the patlets, the problem and solution are distilled into a single sentence. Therefore, they are best used as a reference; as a reminder of what each pattern is about.

Whatever order you read the patterns in, you will find some patterns that seem particularly relevant to your organization. Some will jump out at you, and you will say to yourself, "Now here's a pattern that our organization can really use." So mark them with a little yellow sticky note. One or more of these will probably become your organization's entry into the pattern language. Note the wording above: the patterns you mark must be not only helpful, but feasible in your situation.

3.2 *Applying The Patterns*

Now for the hard part: getting the organization to actually use any of the patterns. That means changing the culture of the organization, and cultural change is tricky, difficult, sometimes painful, and sometimes even dangerous. We cover this topic in more detail in Organizational Principles (Chapter 6), and it is important to read that chapter before actually trying out these patterns in your organization. The section Piecemeal Growth (6.2) gives particularly important advice that can be boiled down to: *apply one pattern at a time, and if it doesn't feel right, back out*. Until you read Organizational Principles, here are some tips to get started.

3.2.1 Sequences

You should apply the patterns in a *sequence*. Though you can *understand* the patterns individually in almost any sequence, they gain much of their power by building on each other in the right order. Each particular organization is built from a sequence of patterns whose order is suggested by the succession of unbalanced forces each pattern leaves for the ensuing one. At the beginning of each pattern language chapter we offer some example sequences.

For more on sequences, see the section Creating Sequences (2.2).

3.2.2 Which patterns?

There is no prize for using the most patterns. With the sequences as a guide, choose the patterns that solve problems that you actually have. Do you feel the pattern's forces in your organization? Then the pattern is worth considering. Otherwise, don't oblige yourself to use the pattern. *There is nothing intrinsically good about any pattern in isolation; each one is good only to the extent that it resolves the forces that actually exist in your organization.* Pay specific attention to the patterns you marked with yellow stickies when you were reading them. Don't be afraid to follow your nose. Remember: patterns aren't about us telling you what to do, they're about helping you discover what you knew how to do all along.

3.2.3 Human Concerns

Organizations comprise people, so it should be no surprise that you will need to deal with "people issues" as you unfold a pattern language in an organization. Let common sense and sensitivity be your guide; here are a few tips to guide you.

First, remember that nearly every organization has some awareness of its own failings. People may not be able to put their finger on a particular problem, but they know that they have troubles. But we tend to be our own worst critics: we usually think that things are worse than they are. So build on this self-awareness and self-criticism. You may wish to begin with patterns that the organization already does well, and then introduce the patterns they can easily adopt.

Language and conversation are keys to successful change. In other words, people need to learn what the patterns are, and then begin to use the names of the patterns in their conversations. So teach people about the patterns you have selected. Naturally, we think it would be grand if everyone in the organization had their own copy of this book to refer to!

Finally, recognize that no matter who your are, *you* can't change the organization. The people must change themselves. So enlist allies. Make sure you read the following patterns: GATE KEEPER (4.2.10), PATRON ROLE (4.2.15), PUBLIC CHARACTER (4.2.17), LEGEND ROLE (4.2.20), and WISE FOOL (4.2.21). These patterns describe some of the key movers and shakers in an organization. Identify them in your organization, and go to them first. Once they get excited about these patterns, it is likely the rest of the organization will come along. By the way, which of those patterns fits *you*?

3.3 Updating The Patterns

We certainly didn't foresee all possible details of organizational structure in this book! Your business almost certainly has detailed needs that beg for new patterns or for different versions of the patterns here. Make the patterns your own. That's O.K., we won't mind—really! Until you make a subset of these patterns yours you won't really be in control of your organization. Take control by letting your instinct guide you into a tailoring of these patterns.

By the way, we are interested in your updates, if you care to share them with us. It is your experiences that expand, correct, or substantiate these patterns. In a very real sense, these patterns do not belong to us, but to the software development community as a whole. So write us—we would love to hear from you!

3.4 *Who Should Use This Book?*

Let us say a few words about the intended audience for this book. What kind of organization can use these patterns? Who should be responsible for applying the patterns in these organizations?

These patterns come from studies of a wide range of organizations, most of which are software development organizations. These organizations ranged from small individual companies of a couple dozen people to organizations embedded in companies with hundreds of thousands of employees. We have turned around and used these patterns in improvement efforts in a similar range of organizations. While a few of the patterns may be particularly suitable to teams of a particular size, almost all of them are generic.

While the patterns often exhibit ties to software development, they apply far beyond software developers. Project managers, testers, marketing people, secretaries and clerks, business planners, and a host of other roles figure as strongly or more strongly than the designer and coder in software development. There is something in this book for every member of a software enterprise. And many of the patterns generalize into other businesses if applied with insight and taste.

Many of the patterns require some authority to implement, so first or second level managers would be a natural audience for this book. But the funny thing is that we predict that many of the people who read this book will not be managers, but developers. So we think there is a good chance that you, dear reader, are a developer. But not just any developer. You probably feel an extra concern for the function of your organization. In fact, you are probably a key person; one of the roles we mentioned above: GATE KEEPER, PATRON ROLE, PUBLIC CHARACTER, LEGEND ROLE, or WISE FOOL. You may have more influence than you think you do.

So what is a GATE KEEPER or a WISE FOOL? We've talked enough *about* the patterns; it's now time to read the patterns themselves.

PART II. The Pattern Languages

Finally, the patterns themselves! Thank you for patiently reading the introductory material; it will help you use the patterns.

We have divided the patterns into four interrelated pattern languages:

1. Project Management: the organizational aspects of managing projects.
2. Piecemeal Growth of the Organization: how an organization grows and develops over time.
3. Organizational Style: the general approach the way the organization works.
4. People and Code: how the people affect the code — and how the design of the code affects the people!

Each pattern language presents patterns in a sequence that allows the patterns to build on each other. Sometimes a pattern recurs in multiple pattern languages, but we present the pattern only in the first pattern language where it occurs, and we substitute a reference to that first appearance in subsequent pattern appearances. In practice, you will use all four of these pattern languages together, weaving patterns together to solve problems and to strengthen your organization one pattern at a time.

The first two pattern languages are design pattern languages; the second two are construction pattern languages. The two following chapters are dedicated to these two kinds of patterns, respectively. Alexander makes the same distinction in his pattern language, separating the act of design from the engineering considerations of construction.

Design patterns are those that lay the foundation of the entity to be built — buildings and towns for Alexander; software development organizations for us.

Construction patterns deal with the nuts and bolts of creating the thing. Organizations need to be built just as surely as buildings need to be built.

A pattern may appear in several of these pattern languages. If so, we include its description in the pattern language with which it is most strongly connected. Other pattern languages cross-reference that text.

The appendix SUMMARY PATLETS (CHAPTER 10) presents summaries of all the patterns in *patlet* form. A patlet is a terse summary of the pattern's problem and solution. You may find this useful as a reference as you set about putting the patterns to practice.

CHAPTER 4 *Organization Design Patterns*

The term *Design Patterns* has unfortunately come to mean the collection of 23 patterns that appear in the book *Design Patterns: Elements of Reusable Object-Oriented Software*, by Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides [GOF1995]. Here we use the term in the same sense Alexander does in his classic, *A Pattern Language* [Alexander1977]. In Alexander's sense, a design pattern is something you use to understand the geometry of a building; to understand the major relationships between parts. It is a definition that most of us we recognize as similar to the word *architecture* in software.

Once you design an organization, the organization comes to life through organizational *construction patterns.* Construction patterns discuss the "materials" and processes to reduce the conceptual design to practice.

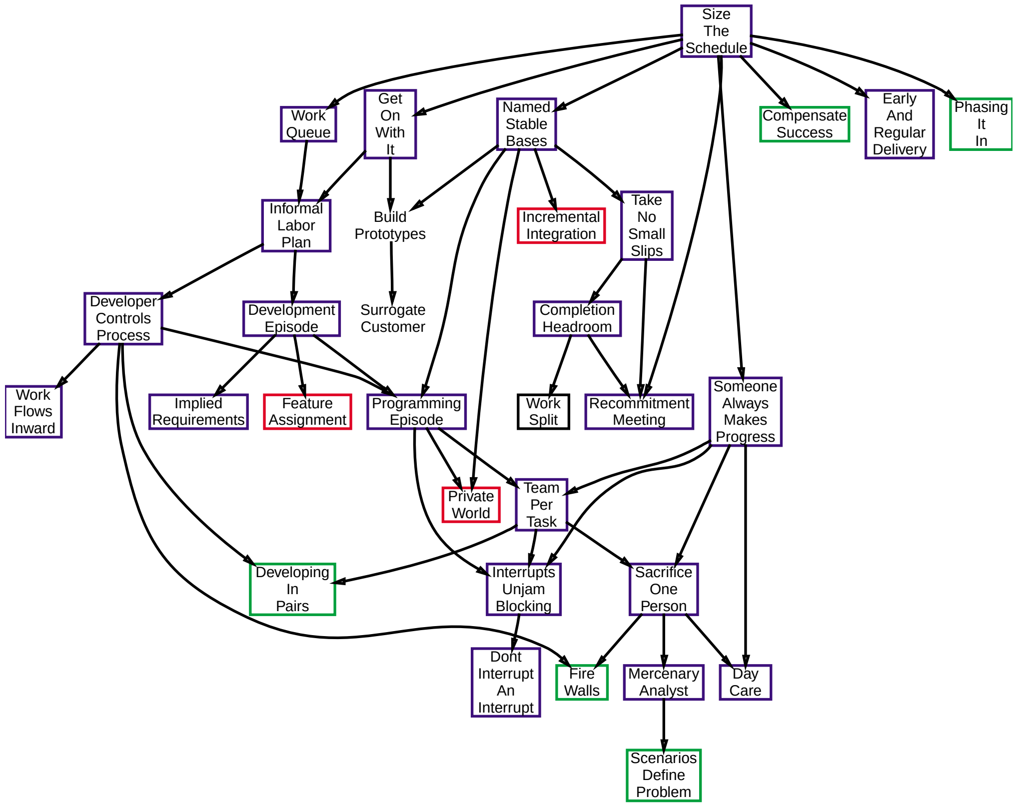
The distinction between these two kinds of patterns isn't as clear in organizational design as in the design of buildings, and even there the difference isn't formal or clean. We separated the two kinds of patterns based less on their characterization as "design" or "construction" patterns than according to their affinity for each other. The so-called "construction patterns" can be found in the chapter ORGANIZATION CONSTRUCTION PATTERNS (CHAPTER 5).

4.1 *Project Management Pattern Language*

Project Management is a crucial part of organizational design. Many organizations have a project manager role, but in fact project management is a much broader function—so broad that it covers almost a quarter of the patterns in this book.

The patterns here do concern themselves with all the things a project manager worries about. We start out with SIZE THE SCHEDULE (4.1.2). In today's markets, time to market is everything. In the classic view of project management that suggests that there are three resources one can trade off against each other—staff, functionality, and schedule—it is schedule that is most often the strongest invariant. Past years have seen functionality fall from this first place position as software development enterprises have come to realize the difficulty in both capturing and meeting detailed requirements. Customers have come to the realization that it's better to get *something* that works in a finite amount of time than to spend a seeming eternity "getting it right the first time." Instead, we tend to defer correctness to the later releases.

The Pattern Language



The above figure depicts the patterns in the pattern language and the connections between them. The connections themselves are as much part of the language as the patterns themselves. Each pattern provides a possible context for the patterns below it. They depict the dependencies between the patterns that govern the order in which they are to be applied: you start at the top and work your way toward the bottom. If a pattern has several subtending patterns you can apply as few or as many of them as you like, and in any order.

The pattern language is based in empirical study of organizations that do software, most of whom deliver some software artifact to a customer. However, the pattern language has little to do with software per se. We believe these patterns reflect management principles that are deeper and broader than software alone. Software development organizations can learn from these broader principles.

Here is a real story about a real project that features many of the patterns in this pattern language. Think of this story as a sequence of application of the patterns.

A Story About Project Management

In the mid 1980s my group embarked on an ambitious project. We took a successful product and adapted it to new technology. We began by testing the concepts in prototypes (Build Prototypes (4.1.7)), and their success gave us the confidence to Size The Schedule (4.1.2).

Because we were building on an existing product, it was easy to have Named Stable Bases (4.1.4) of code; we continued them throughout the project. This made it possible — and necessary — to provide developers a way to have their own view of the system, a Private World (4.1.6). There was ample tool support for these views.

Although the project was large, the project was basically centered on the developers. For example, we decided on our own coding standards (Developer Controls Process (4.1.17)). It certainly had a feel of Work Flows Inward (4.1.18). Developers had some latitude about how to organize their work; Work Queue (4.1.13), Informal Labor Plan (4.1.14), and Programming Episodes (4.1.19) were common.

Unfortunately, we had problems. One of the biggest was that we did not allow Completion Headroom (4.1.10). As the technical difficulties intensified, the schedule became tighter. Finally, the head of the project called everyone together and announced a single large schedule slip (Take No Small Slips (4.1.9)), and asked everyone to commit to the new schedule (Recommitment Meeting (4.1.12)).

We continued to struggle with technical challenges, and some became crises. We created teams to deal with them (Team Per Task (4.1.21)), and even had to Sacrifice One Person (4.1.22) on at least one occasion. However, no crisis stopped everyone (Someone Always Makes Progress (4.1.20)); this was in part because the architecture of the system allowed it.

In the end, we met the slipped date. But the technology was moving in such a direction that it made no sense to deploy it. However, pieces of that project were used in later projects for years to come.

4.1.1 Community Of Trust **

In high school, I went to music camp one year. During one orchestra rehearsal, my section was struggling with a particularly difficult passage. The conductor asked about it, and I said, "Don't worry. We will have it tomorrow." He said, "Ok," and continued with the rehearsal. By the next day, we had indeed learned the passage.

... once an organization has been established, interpersonal relationships have a significant positive or negative impact on the effectiveness of the team.

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It is essential that the people in a team trust each other, otherwise, it will be difficult to get anything done.

Communication is essential to the smooth working of any team; for example, software developers must constantly talk to each other to coordinate interfaces, builds, and tests. If individuals do not trust each other, communication will not be smooth.

If people do not trust each other, they will spend time in defensive mode. For example, if I don't believe you will provide me a certain interface on time, I might go to great lengths to code around it, costing extra work and time.

Design reviews can foment distrust. All too often, design reviews are contests among the reviewers to show who is more clever, and thus do not provide helpful suggestions to the designer. One alternative is for people to put on their best social behavior in reviews, but that dampens the energetic discussions that lead to the best insights in group discussions.

The organization might have policies that smell of distrust: one may have to jump through hoops to be allowed to submit code to the project base.

The perception of trust or mistrust is the reality, regardless of the intention.

Therefore:

Do things that explicitly demonstrate trust, so it is obvious. Managers, for example, should make it overtly obvious that they are at the side of the organization, rather than playing a central role that controls people to do what must be done. Take visible actions to give developers control over the process.

The key here is that the actions must be visible and obvious, particularly if they are removing onerous rules and processes. Shortly before I went to work at a certain company, the company dispensed with time clocks for research and development personnel. My co-workers spoke fondly of the time clock smashing ceremony they had.

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This is different from the oft-cited "empowerment" strategy. Empowerment is a conscious abdication of control to lower levels (see The Open Closed Principle Of Teams (6.1.4)). In a Community Of Trust, progress is more often made by bilateral agreement than by unilateral directions. If people feel they have a voice and have influence over decisions, they are more likely to trust those who make the decisions. By the same token, they are likely to be more responsive in carrying out responsibilities they have committed to themselves over responsibilities that have been "given" to them. In fact, you can't give someone responsibility; you can only give someone accountability. Responsibility is taken, not given. One of the most demoralizing things a manager can do is to give accountability in the absence of responsibility.

You need trust between the customer and all team members to lay out project plans that extend from Size The Schedule (4.1.2) in the Project Management Pattern Language (4.1). The same is true for role differentiation; giving everyone pride and individuality can contribute to trust, as in Size The Organization (4.2.2) and its subtending patterns in the PIECEMEAL GROWTH PATTERN LANGUAGE (4.2). Start building trust by starting small with FEW ROLES (5.1.2), and let this principle guide the ORGANIZATIONAL STYLE PATTERN LANGUAGE (5.1). To keep people from working defensively, one needs a team spirit; this is true ARCHITECT CONTROLS PRODUCT (5.2.3) and subtending patterns relating to PEOPLE AND CODE PATTERN LANGUAGE (5.2).

COMMUNITY OF TRUST provides a foundation for many other patterns, such as UNITY OF PURPOSE (4.2.12), PATRON ROLE (4.2.15), FIRE WALLS (4.2.9), DEVELOPER CONTROLS PROCESS (4.1.17), RESPONSIBILITIES ENGAGE (5.1.14), and more.

So why is this a separate pattern? It has a specific structural impact: it is about nurturing communication paths, and has some positional impact (in particular, it encourages manager roles away from the center.) Second, the visible nature of the actions is important; we haven't captured that in any of the other patterns.

Trust is contagious, and spreads most effectively through an organization from the top down.

4.1.2 Size The Schedule **

Software engineers determining the next schedule.

... the product is understood and the project size has been estimated.

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Both overly ambitious schedules and overly generous schedules have their pains, either for the developers or the customers.

If you make the schedule too generous, developers become complacent, and you miss market windows. But if the schedule is too ambitious, developers become burned out, and you miss market windows. And if the schedule is too ambitious, product quality suffers, and compromised architectural principles establish a poor foundation for future maintenance.

Common wisdom says that you can trade off staff, schedule, and functionality. While principles such as Brooks' "adding people to a late project makes it later" [Brooks1995] cast doubt on the place of staff in this equation, it's clear that schedule and functionality trade off against each other. Ward Cunningham says in his pattern Comparable Work, "Every project must commit to delivery on a few hard and fast dates. This is actually fortunate because it is about the only way to get out of work that is going poorly." [Cunningham1996] In a reasonable business climate, it is much smarter to hold the schedule constant and to negotiate functionality than it is to extend the schedule. The customer believes you can cut functionality, but a promise of having the yet unattained functionality at some future date leaves the customer much less comfortable. And projects without schedule motivation tend to go on forever, or spend too much time polishing details that are either irrelevant or don't serve customer needs.

Therefore:

Reward developers for negotiating a schedule they prove to meet, with financial bonuses (or at-risk compensation; see COMPENSATE SUCCESS (4.2.25)), or with extra time off. Keep two sets of schedules: one for the market, and one for the developers.

The external schedule is negotiated with the customer; the internal schedule, with development staff. The internal schedule should be shorter than the external schedule by two or three weeks for a moderate project (this figure comes from a senior staff member at a well-known software consulting firm). If the two schedules can't be reconciled, customer needs or the organization's resources—or the schedule itself—must be re-negotiated (RECOMMITMENT MEETING (4.1.12)).

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Help delineate the schedule with NAMED STABLE BASES (4.1.4). Grow as needed with PHASING IT IN (4.2.3). Define initial targets with WORK QUEUE (4.1.13). Make sure SOMEONE ALWAYS MAKES PROGRESS (4.1.20).

The forces come from the MIT project management simulation and from studies as projects such as Borland Quattro Pro for Windows. Another manager suggested that the skew between the internal and external schedules be closer to two months than two weeks because, if you slip, it usually reflects a major oversight that costs two or three months.

De Marco talks about rewarding people for accuracy of schedules; see [DeMarcoBoehm1986]. Verify this reference... Also, read about the place of promptness in [ZuckermanAndHatala1992].

You don't need a full schedule—perhaps no schedule at all—to get started. See GET ON WITH IT (4.1.3) and BUILD PROTOTYPES (4.1.7).

4.1.3 Get On With It **

Alias: Partial Evaluation

Get ready...

Go!!!!!

During one study, I asked the organization to describe how they develop software. "Well," they said, "project management gives us a list of features they want estimates for. So we start working on the features we think are the most important. Over time, they ask for more detailed estimates, and the features we are working on have smaller estimates, because they are underway. Those features generally make the cut. By the time we get official approval to begin development, we are nearly finished."

....you have a good idea of a market need and, furthermore, a good idea of how to get started on parts of the project. You're eager to get started but want to proceed deliberately and by the path that will be both expedient and productive.

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You can't wait until you have every last requirement to get started.

Team members are sitting idle because their upstream tasks have not been completed. On the one hand, you want requirements to be done carefully. On the other hand, you have some information, and people sitting idle.

Therefore:

As soon as you have confidence about some project direction, start developing areas in which you have high confidence. These may lie in the area of hardware development (or procurement), algorithm development, database schema development, etc. Let each subgroup work according to an INFORMAL LABOR PLAN (4.1.14) as if they were in full-swing development.

Note that "high confidence" refers to project direction and requirements, not technology. It's perfectly all right, and in fact desirable, to work on the technologically risky areas first (see BUILD PROTOTYPES (4.1.7).)

Give yourself some room to retrench later as requirements become more clear.

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In many projects, behavioral requirements are one of the last things that the designers get right. Many projects ship their first release with only basic requirements met, with economically more significant requirements met in subsequent releases. Telecommunications systems often follow this pattern, offering basic communications systems in early releases and more advanced features later. In fact, behavioral requirements are often overrated in their impact on the overall structure of the system; the code that meets behavioral requirements often lives in application code that is added very late to a robust stable base.

The base reflects deep domain knowledge more than it reflects behavioral requirements. There is much common code that can be done early on with high confidence: code that supports common domain functionality that is part of most systems for a given market. This code can often be started or acquired before requirements are firm.

This pattern can increase rework, but it is more in the spirit of piecemeal growth architecture than would be a master-planned system that precipitates from "complete" requirements. It is likely that any false starts will also be educational at the enterprise level. In fact, as a risk management measure one can consciously decide to not commit to the results of such an activity. On the enterprise level, this becomes the pattern SKUNK WORKS (4.2.14); with a project, it is BUILD PROTOTYPES (4.1.7).

There are two occasions in which you cannot tolerate that rework. First, if the task is the process bottleneck, it must work at peak efficiency, and rework should be minimized. Very occasionally, the rework will take longer than the original task, and so this pattern should not be used.

Teams need good communication with their upstream counterparts through patterns like HALLWAY CHATTER (5.1.15) and RESPONSIBILITIES ENGAGE (5.1.14) to make this work.

The principle involved is that a process not constraining the overall system can afford to be done inefficiently and in parallel. It is often the case that the analysts, designers and programmers can get started right away, without having finalized requirements. Serializing their work will take longer than doing 10-20% rework. In one group we studied, the database group constrained the process. They could not afford rework, and had to work in the most efficient way possible. Therefore, they did not start early, but waited until their requirements were stable. The designer / programmers had enough extra time that they could afford to prototype some test databases for themselves, which were thrown away when the database designers did their final design.

See [GoldrattCox1986].

Examples:

Each team had 1 requirements & analysis person, and 2-3 designer / programmers. Database design was understaffed and constraining the process, so it was made a special service group given final requirements only (the counterforce). A first cut at the requirements had been done earlier, so a rough set of requirements were available. Much of the system was similar.

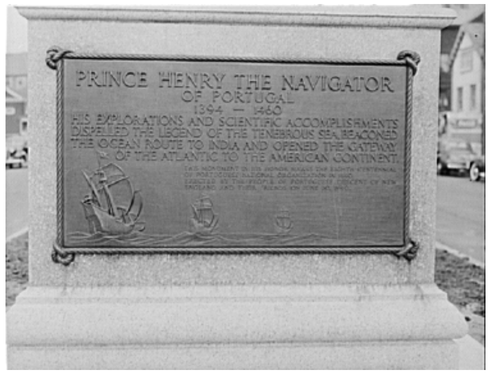
The designer / programmers quickly got ahead of the requirements people, who were busy in meetings trying to nail down details of the requirements. If they waited until the requirements were solid, they would not have enough time for to do their work. They were able to guess quite closely what the requirements would be like, without knowing final details, so they started design and programming right away. The requirements person gave them course corrections after each meeting. The amount of time it took to incorporate those mid-course alterations was small compared to the total design time.

This pattern comes from Alistair Cockburn's original pattern ALL AT ONCE (10.5.3) [Cockburn1996], which was later modified and renamed GOLD RUSH [Cockburn1998]. The alias name "PARTIAL EVALUATION" comes from the inspiration that this is a temporal form of DIVIDE AND CONQUER (5.1.6). The name "GET ON WITH IT (4.1.3)" arose when we discovered that the name the pattern bore at that time—JUST DO IT--CONFLICTED with another pattern written by Jeff Garland. Jeff suggested the current name.

Shalom Reich writes:

> The "ALL AT ONCE (10.5.3)" pattern appears to be a typical Project Management "crash project" approach. In a "crash project" one must be careful to identify true predecessors for each task with the goal of reducing the "critical path". This allows parallel efforts to proceed which will all "come together" at the last possible moment. I have found that project plans often contain *false* linkages between tasks. For example, in one large project we had a "specification" phase. I was able to break the project into several smaller projects which each had its own specification phase. This allowed me to juggle my limited resources and have coders working on the part that went first through the specification phase at the same time that the analysts were working on the specifications for the second sub-project.

4.1.4 NAMED STABLE BASES *



A stable base with a name on it...

... the project schedule has been laid out and development has started.

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It is important to integrate software frequently enough so that the base doesn't become stale, but not so frequently that you damage a shared understanding of what functionality is sound and trusted in an evolving software base.

If you try continuous integration, developers struggle to follow a moving target and there is no shared sense of quanta of functionality at any given time, or quanta of progress from week to week. But if it's too long between integrations, developers become blocked from making progress beyond the limits of the last base.

So while stability is a good thing, the project must always make progress — and, more importantly, the stakeholders must *perceive* that progress is being made.

Therefore:

Stabilize system interfaces—the architecture—about once a week. Give the stable system a name of some kind by which developers can identify their shared understanding of that version's functionality.

The names need not be elaborate; they can simply be a load number. The names should, however, be easy to remember, to identify with the correct version of software, and to distinguish from each other. The idea is to provide some sort of handle that people can use to communicate about a stable base.

Other software can be changed (and even integrated) more frequently.

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A prototype can be an expedient for one of the NAMED STABLE BASES; see BUILD PROTOTYPES (4.1.7).

The project has targets to shoot for and benchmarks whose accomplishments can be trumpeted to customers. This affects the Customer view of the process, and has strong ramifications for the Architect as well.

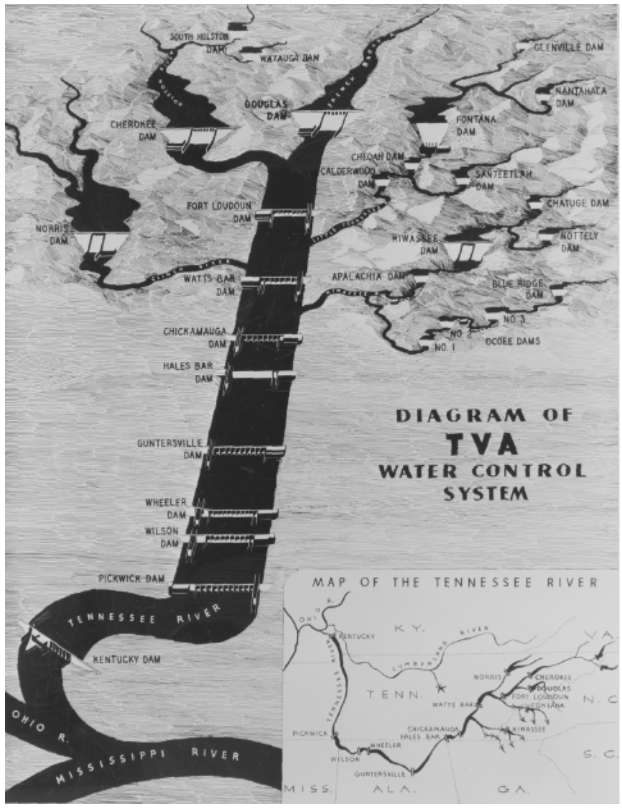
The pattern was initially pointed out by Dennis DeBruler at AT&T.

The main point of the pattern is that a project should schedule change introduction so the effects of changes can be anticipated. It is less important to publish the content of a change (which will go unheeded under high change volume) than for the development community to understand that change is taking place. It is important not to violate "the rule of least surprise."

It can be helpful to have, simultaneously, various bases at different levels of stability. For example, one AT&T project had a nightly build (which is guaranteed only to have compiled), a weekly integration test build (which is guaranteed to have passed system-wide sanity tests), and a (roughly biweekly) service test build (that is considered stable enough for QA's system test).

PROGRAMMING EPISODE (4.1.19) is an example of this pattern in the small.

4.1.5 Incremental Integration **



Contribute to software one piece at a time, gradually, avoiding waterfall and other precipitous changes.

...some organizations have infrequent integrations which reflect large changes. This can make it difficult for the integration release to work as expected, complicate the process of work integration and make Named Stable Bases (4.1.4) difficult to achieve when modules do not work together. Because we often develop with one Owner Per Deliverable (10.5.19) there will be occasional mismatches between units.

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For iterative development to work well, it is necessary to make sure that components work together.

Subsystems get developed at different rates. Developers work in a PRIVATE WORLD (4.1.6). We need to find a way to make it possible to integrate without surprises.

Therefore:

Provide a mechanism to allow developers to build all the current software periodically. Developers should be discouraged from maintaining long intervals between check-ins. Developers should also be able to build against any of the NAMED STABLE BASES (4.1.4), or the newest checked in software, at will.

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Assign the task of building the entire software system periodically: NAMED STABLE BASES (4.1.4) suggests intervals no more frequent than a week. This periodic build should be checked for interface compatibility (does it compile?) and testing (does it still work?)

Encourage developers to build from files that are likely to be in the release (for example, perhaps the newest code in the revision control system is trunk) to anticipate, and allow time to correct for, incompatibilities. The goal is to avoid a "big bang" integration and allow the developmental build to proceed smoothly.

This can be combined with PRIVATE WORLD to ensure that the changes integrate with a copy of the current development system. There are issues relating to the size of the software system (some systems take quite a while to build, making frequent integrations difficult). Balance this with PRIVATE VERSIONING (5.2.16) to allow the developer some leeway on deciding when to integrate their new code into their environment, but do not put it off for too long.

Example:

The developer's work space could be updated (at the developer's request) to a named stable base from the project repository approximately weekly. The developer will also retrieve the current files from the repository to anticipate how the current changes in the work space will work with files that may later be in the baseline.

4.1.6 Private World **

... an organization is creating Named Stable Bases (4.1.4), and developers can build against these versions, integrating their own code with the latest of other code (Incremental Integration (4.1.5)).

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How can we balance the need for developers to use current revisions, based on periodic baselines, with the desire to avoid undue grief by having development dependencies change from underneath them?

It is important for developers to work with current versions of software subsystems to keep up with the latest enhancements, avoid running into already fixed bugs fixed elsewhere, and to avoid getting out of synch with interface changes.

Introducing new software into an environment while debugging may cause grief by introducing new behavior, and providing distractions because of the time spent resolving integration issues in some cases, code may no longer compile due to interface changes.

However, we must balance these needs: the need to keep up to date with the need of developers to maintain a stable environment for feature development / bug fixing.

Some organizations, to facilitate Incremental Integration, will have a shared baseline of code, libraries, etc. Unfortunately changing a code base, even in a different subsystem, can cause problems when there are interface changes, for example. You want to avoid hearing stories about developers leaving a problem at night to view it in the morning with a clear head, only to find that one's test environment does not compile.

Therefore:

Provide a mechanism where developers can maintain a Private World development environment. In their Private World they can control the rate of integration. This allows them to avoid having an integration step interrupt work in progress. The environment should represent a snapshot of all the software being developed in a system, not just the code the developer is modifying. Try to ensure that the private development area is not used as a means of avoiding integration issues.

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A starting point for the independent development area would be one of the Named Stable Bases which have been previously released. Developers then build their software and any related software that depends on their software. Alternatively, you can provide the ability to do a private system build from source code (and other artifacts).

While allowing developers the freedom to decide when to allow changes into their space you need to make sure that the developers update their code as often as possible to avoid integration surprises. So encourage developers to integrate their code frequently, perhaps by providing a mechanism for easily backing out of a difficult change.

Depending on details of implementation, one consequence of this pattern might be that project disk space requirements may grow quickly as *N* developers will have their own copies of the source code. But the costs of personnel almost always exceed the cost of an extra disk. A modification to this approach is that stable and distantly related subsystems can be used by reference, but one should be made aware of when changes are imminent. In this case the configuration management system should provide access to prior Named Stable Bases as well.

Developers can simply defer advancing to a new instance of the NAMED STABLE BASES until the current problem is solved.

A variation of a PRIVATE WORLD is a shared integration machine. In this case the developers move their new code to a system that has a current version of the system.

The pattern *simulates* SOLO VIRTUOSO (4.2.5). See also PRIVATE VERSIONING (5.2.16).

Example:

A developer is working on a problem. The developer work space is self-contained with all of the files needed to build the system. The developer work space is updated only at the developer's request, after the problem is solved in the context of the current NAMED STABLE BASES.

Notes:

Brad Appleton points out:

> Sun's NSE (Network Software Environment) had this type of thing built into it. I think that the more recent TEAM WARE product may also have preserved some of these concepts. NSE let you create work spaces that it called "environments". There were three kinds of environments you could create:
>
> - Independent Development Environments: for Independent Development.
> - Independent Integration Environments: for integrating (importing and merging) and reconciling changes and integration building and testing.
> - Independent Release Environments: for release builds, system test, and other release engineering and software product deployment activities.

PRIVATE WORLD captures the spirit of all these environments.

An environment would insulate developers but would *not* isolate them. There was an event notification and registration mechanism for broadcasting events in one or more other environments to interested parties (maybe this is a more general configuration management event notification pattern of which things like baseline publishing and change publishing are concrete variants).

4.1.7 Build Prototypes **

...you are trying to gather requirements necessary for test planning, as in the pattern Application Design Is Bounded By Test Design (4.2.30), and for the architecture, as for the pattern Architect Also Implements (5.2.10). Some of these requirements come from the customer, but some are design decisions that come from the structure of the solution itself. For example, you may be building a user interface, some new technology such as database or network technology, or you are working on a new, critical algorithm, or don't understand your project domain.

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A project must test requirements and design decisions to reduce the risk of wasted cost and missed expectations.

You need knowledge to proceed on development, and you must move forward; yet, requirements (or your understanding of them) are always changing.

You're missing information about the product (not the process), and you have a best guess you can use to move forward, and you want some way to evaluate the result of your best guess.

Written requirements that are gathered once at the beginning of a development cycle with the hope that they can drive development are usually too ambiguous.

You want to get requirements changes as early as possible, and you want requirements understanding to lead deployment by as far as possible.

Designers and implementors must understand requirements directly — that the requirements have been captured in a document isn't enough. And for designers and developers to understand requirements implies that they must understand the implementation ramifications.

Therefore:

Build an isolated prototype solution whose purposes are:

- **to understand requirements, including latent needs,**
- **to validate requirements with customers as in ENGAGE CUSTOMERS (4.2.6)**;
- **to explore human/computer interactions for the system**;
- **to explore the cost and benefits of design decisions**.

The prototype is a small system that explores a small number of issues in isolation using best current knowledge. By examining that small system you can learn whether your current knowledge is correct and sufficient. Prototypes are particularly useful for external interfaces.

Throw the prototype away when you're done. This is more important than it may sound. Since the purpose of prototyping is to gain knowledge, prototypes can (and should) ignore details necessary in production software. Yet such details (such as scale, performance, robustness, etc.) cannot be incorporated into prototype-based software without the result resembling the proverbial bowl of pasta.

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You will decide that your current knowledge is or is not sufficient. If it is, adapt that small system's design (not code!) to your larger system (incorporate it entirely if it was built to production specifications). If not, decide whether you now have enough information to safely proceed, or whether you need to do another Prototype.

It's good to use Developing In Pairs (4.2.28), particularly if one of the pair represents the customer interests or is a customer per se.

Prototypes are a good supplement to use cases to help more thoroughly to assess requirements. For one thing, prototypes help bring unstated requirements into the open. This pattern nicely complements Engage Customers (4.2.6) and Scenarios Define Problem (4.2.8).

The processes of the visualizations used for Developer Controls Process (4.1.17), and the pattern Engage Quality Assurance (4.2.29), are based largely on prototyping.

Continued prototyping without convergence means that the design is constantly shifting, and the team is not learning enough to reach a conclusion. If other teams that depend on the prototyping team do not get the stable interface they need, it is time to get out of prototyping and either implement *or* Engage Customers (4.2.6) (Recommitment Meeting (4.1.12)) to evaluate current project directions and priorities.

There are subtle organizational overtones to building prototypes. It is important that the Architect Controls Product (5.2.3), and not the prototype control the product. Therefore, the prototyping team should be kept separate from the Architect and Architecture Team (5.2.4). Instead, the prototyping activity helps enhance the Domain Expertise In Roles (4.2.22). And one of the positive effects of building a prototype is to reduce the risk of the unknown. The prototype helps to define the scope of the problem as well as a possible solution.

Related patterns:

- Early And Regular Delivery (10.5.11) - adds knowledge about your development process.
- Microcosm (10.5.18) - returns measurable data about process and technology.

Another related pattern is Alistair Cockburn's Clear The Fog (10.5.7) [Cockburn1998], which one might view as a generic version of this pattern. In that pattern, Alistair recommends "Do something (almost anything) that is a best initial attempt to deliver some part of the system in a short period of time" in the interest of Someone Always Makes Progress (4.1.20). He gives as rationale, "The difficulty is that you don't know what it is that you don't know. Only by making some movement can you detect what it is you don't know. Once you come to know what it is you don't know, you can pursue that information directly." And he adds an interesting admonition: "If you only 'clear the fog' and 'clear the fog' and 'clear the fog', you will not make real progress. You will have lots of little experiments and no deliverable results."

Bruce Whitenack's RAPPeL pattern language also presents a PROTOTYPES (10.5.23) pattern ([Whitenack1995], p. 288). He adds the admonition:

> The dark side to prototyping is that solutions can be hacked together with the software inadequately robust and not well designed. It takes maturity, discipline and a very good programming / design environment to reengineer quality back into a product. Without rigor and discipline a product is in serious risk of failure when features are continually added. As more prototyping and evaluating are done, there will be the need to modify the requirements. Iteration between prototyping and use-case modeling occurs during requirements analysis. In addition, user expectations have to kept realistic as a prototype is not a product. Customers must realize that what they are seeing is a product simulation — not the product itself.

He also distinguishes between *lo-fidelity prototypes* and *hi-fidelity prototypes*:

> Work with the customer to build (initially) low-fidelity prototypes... using paper widgets, drawings, self-stick notes, and index cards. (These are true throwaway prototypes). Or, if the necessary skills and tools are available, build high-fidelity prototypes. (You do not want to spend more that 10 percent of your time on how to use the tool instead of focusing on the actual prototype, however). Alternate between prototyping and use-case modeling. Prototyping provides more user involvement, and use case modeling provides rigorous analysis. Augment the use case documentation with references to prototype versions (product simulations).

The high fidelity prototypes that are developed with a tool capable of generating useful code may be used for evolutionary development. It may not be a throwaway prototype but should be developed with the spirit that it will be thrown away. This means making sure that all on the project — especially managers — understand that the prototype *may* be thrown away. It has been my experience with Smalltalk development that if the developer has a good design in mind and if he is experienced, the prototype will probably contain code that is very usable for a production version. Be sure to plan for training of beta users and for doing a number of prototypes for perspective users.

Building and demonstrating prototypes is an art in itself. See the excellent pattern language, "DEMO PREP (10.5.9)," by Todd Coram [Coram1996] for guidance on the building, administration, and demonstration of prototypes. See also an earlier work by Ian Graham [Graham1991].

The risk to your project of a small, throw-away effort is a small schedule delay. The risk of making a poor technical choice is a poor product, or perhaps committing to a technology that simply will not work.

Be careful not to be seduced by the siren song of a successful prototype. Prototypes almost never can demonstrate capacity, reliability, or performance. But these are often the most troublesome issues in development. The danger is that we see a prototype working, and naturally assume that it will scale gracefully, will run for weeks without rebooting, or will perform nimbly under a typical customer's load. A working prototype does not imply that these problems are solved.

Contrast this pattern with SKUNK WORKS (4.2.14), which many think of as prototyping on a larger scale, but which is actually a little bit different in its forces and intent.

"The best friend of the architect is the pencil in the drafting room, and the sledgehammer on the job." — Frank Lloyd Wright, quoted in [Jacobs1978].

4.1.8 Surrogate Customer

See Section XXX.

4.1.9 Take No Small Slips **

Boarding house, Washington, D.C., 1942, morning bathroom line. Small slips in the bathroom schedule build up, causing unfulfilled expectations downstream, and leading to discomfort and dissatisfaction on the part of others.

Our project was in trouble. Everybody knew it. And then our project manager left the company. When our new project manager arrived, he called us all together. "I believe in taking one schedule slip," he said. Then he announced a three month slip. We all returned to work, and redoubled our efforts. It was a challenge to meet the revised schedule, but he (and we) stuck to it, and ultimately completed our development without incurring another slip.

...development is under way and progress must be tracked, avoiding major surprises to both the customer and the enterprise.

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It's difficult to know how long a project should take, and even more difficult to recover when one guesses wrong.

If you guess pessimistically, developers become complacent, and you miss market windows. If you guess optimistically, developers become burned out, and you miss market windows. Projects without schedule motivation tend to go on forever, or spend too much time polishing details that are either irrelevant or don't serve customer needs.

Therefore:

Prefer a single large slip to several small slips. ([Brooks1995], page 24.)

"We found a good way to live by 'Take no small slips' from... *The Mythical Man Month.* **Every week, measure how close the critical path (at least) of the schedule is doing. If it's three days beyond schedule, track a 'delusion index' of three days. When the delusion index gets too ludicrous, then slip the schedule.** This helps avoid churning the schedule." — Personal discussion with Paul Chisholm, June, 1994.

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This helps support a project with a flexible target date.

Dates are always difficult to estimate; De Marco notes that one of the most serious signs of an organization in trouble is a schedule worked backward from an end date [DeMarco1993].

A single large slip is important for the morale of the team. If you continually take small slips, nobody believes the schedule any more. This hurts morale, the sense of urgency fades, and people stop caring. On the other hand, a single large slip preserves at least some of the believability of the schedule, and people are more willing to work toward the revised schedule.

Much of the rationale is supported in the MIT project management simulation; the Borland Quattro Pro for Windows case study; and from Brooks' seminal work [Brooks1995].

Most sane projects manage this way.

See also RECOMMITMENT MEETING (4.1.12).

4.1.10 Completion Headroom **

Speaking of headroom...

...work is progressing as the software unfolds and the team learns more about the system from the customer and from the behavior of the system itself. Things are far enough along to start thinking about delivery, and about delivering what can be delivered to the customer on the agreed delivery date.

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Every project must commit to delivery on a few hard and fast dates. This is actually fortunate because it is about the only way to get out of work that is going poorly. It's also important because it's usually more important to deliver *something* on a specified date even than to deliver everything that was anticipated: *when* is often more important than *what*. A Work Split (4.1.11) provides the graceful exit by allowing one to defer the portion of work that is not understood or going poorly while saving the part that does work or will save face. A Work Split does require some advance notice since some portion of the work must still be completed before deadline.

Therefore:

Project work group completion dates from remaining effort estimates in the WORK QUEUE REPORT [Cunningham1996]. Take the largest of the earliest completion dates for each work group and compare it to any hard delivery date that may apply. The difference is your COMPLETION HEADROOM.

Any group has an obligation to make their efforts visible through what becomes the ultimate trouble signal, low COMPLETION HEADROOM (4.1.10). Headroom disappears when developmental activities fail to match those of COMPARABLE WORK [Cunningham1996].

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In order for COMPLETION HEADROOM to work, it is vital to calculate it from the beginning, and recalculate it often, at least weekly. Watch for trends. Headroom will often jitter plus or minus a day or two from week to week. But steady evaporation of headroom for any WORK GROUP is a sure indicator for management attention. You have at your disposal reordering the WORK QUEUE (4.1.13), possibly deferring whole items to later release, the WORK SPLIT already mentioned, or the public embarrassment of a RECOMMITMENT MEETING (4.1.12).

A common problem is the well-meaning escalation of requirements by people too close to a problem. If you track COMPLETION HEADROOM (4.1.10), you are better in a position to assess the impact of adding these requirements to the project.

See also TAKE NO SMALL SLIPS (4.1.9).

A version of this pattern first appeared in [Cunningham1996].

4.1.11 Work Split *

... a Work Group commits to resolve and deliver Implied Requirements (4.1.16) in the most timely and satisfactory way they can find. They are not committed to specific dates.

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A work group has an obligation to make its efforts visible through what becomes the ultimate trouble signal, low Completion Headroom (4.1.10). Headroom disappears when developmental activities fail to match those of Comparable Work. A common problem is the well-meaning escalation of requirements by people too close to a problem.

Therefore:

Divide a task into an urgent and deferred component such that no more than half of the developmental work is in the urgent half. Defer more if required to acquire sufficient Completion Headroom (4.1.10). Defer analysis and design of parts that won't be implemented. This advise runs counter to conventional wisdom.

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Often a split is just a way to get back to the basic work that had been originally planned. Trust Architectural Substitution to cover for omissions and inconveniences caused by incomplete "up-front" work. Both halves of the split will appear in the Work Queue (4.1.13) with distinctly different urgency.

The split should be based on clear business priorities or should otherwise be rooted in agreed values. Ian Graham has written patterns that combine to form a small pattern language (drawn from a larger pattern language) to address this issue. See the patlets for ESTABLISH THE BUSINESS OBJECTIVES (10.5.12), BUSINESS PROCESS MODEL (10.5.6), and GRADUAL STIFFENING (10.5.14).

A version of this pattern first appeared in [Cunningham1996].

4.1.12 RECOMMITMENT MEETING *

...each development group is managing its schedule using WORK SPLIT (4.1.11), but additional scheduling problems seem to keep coming up.

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If a Product Initiative is in jeopardy because IMPLIED REQUIREMENTS (4.1.16) cannot be met through schedule and WORK QUEUE (4.1.13) adjustments, then it is unlikely any other development initiated activity will help. Management up to at least the level that began the initiative will suddenly take interest in all circumstances leading up to the current situation. Some of this is natural and appropriate. But it won't be a time of high productivity and shouldn't be allowed to continue too long.

Therefore:

Assemble a meeting of interested management and key development people. Allow the meeting to review history until all present agree simple adjustments (like working weekends, or adding staff) won't help. Eventually a solution appears, usually expressed as a question of the form: What is the least amount of work required to do X? X is one person's idea of the most important part of the initiative. The question should be answered quickly and confidently by consulting a recent WORK QUEUE REPORT [Cunningham1996].

The process may repeat for plans Y and Z. Ultimately a plan will be selected. Then the remainder of the meeting is devoted to talking through implications of the decision and getting all parties commitment to the new plan and / or schedule.

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This, of course, is another form of episode. The decisions are ones of allocating business resources and belong in upper management. However, all present can contribute, and should do so in a frank, honest, non-defensive and constructive way.

See also TAKE NO SMALL SLIPS (4.1.9).

A version of this pattern first appeared in [Cunningham1996].

4.1.13 Work Queue *

...Implied Requirements (4.1.16) suggest deliverable program enhancements which will have various necessities, dependencies, risks and rewards. Deliverables may be ill-defined, being represented more by a vision or desire than by anything concrete or measurable.

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It is difficult to do linear, monochronic scheduling in light of Implied Requirements.

If we were to work up a conventional schedule we would probably begin with a block of requirements analysis for each item. From these would be hung blocks of specification, design, implementation and eventually integration and testing. Add to this some wild guesses and a few ordering constraints and, presto, thirty feet of diagram saying what will be finished when and by whom. Such a document takes on a life of its own striking fear in developer's hearts and generally distracting everyone else from the real scheduling task which is to get better input, not larger output.

Therefore:

Produce a schedule that is simply a prioritized list of work. Use the list of IMPLIED REQUIREMENTS (4.1.16) (really just names) as a starting point and order them into a likely implementation order favoring the more urgent or higher priority items. When work can be factored from two or more entries, go ahead and do so giving the common element a name that establishes its worth and implies its implementation precedence.

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Example:

1. Settlement-Date Positions
2. Settlement-Date Based Tax Reports
3. Trade vs. Settlement Accounting Preference by Portfolio

Be prepared to reorder this list as unforeseen interactions surface or business realities demand new priorities. Remove work from the list as it is completed. Observed defects is not enough to return completed work to the list. However, independently scheduled repair activity may uncover omissions that are more appropriately removed from defect tracking and scheduled in competition with all of the other work on the WORK QUEUE (4.1.13).

A version of this pattern first appeared in [Cunningham1996]. The pattern is similar to the later SCRUM pattern “Backlog” [Beedle1999, 643-644], which is summarized in [Rising2000, 146]:

> To organize the work remaining on a project, maintain a prioritized list, the Backlog. The list is dynamic and updated at the end of each Sprint.

4.1.14 Informal Labor Plan **

Constructing an adobe building, Penasco, New Mexico. Workers using an informal labor plan.

We were discussing the introduction of new project management software. One project manager protested that it was too high level; it didn't provide the granularity she needed. It turned out that she wanted to track items that were fractions of days of effort.

... real development requires developers to work on several parallel tasks such as Development Episodes (4.1.15) that may have interdependent or even conflicting priorities and due dates.

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A schedule of developer work tasks can both assist workers in planning their time, and ensure stakeholders about scheduling expectations. The Development Episode presents an ideal that must be worked into the lives of people trying to get a big job done quickly. Developers will often find themselves obligated to more than one in-progress Development Episode at a time. The Work Queue (4.1.13) offers one prioritizing, though one that ignores the many small trade-offs possible when the work is at hand.

Therefore:

Let individuals devise their own short-term plans. Accept that much of the group activity implied in a DEVELOPMENT EPISODE will take place pair-wise between group members that find the time to tackle some issue together (DEVELOPING IN PAIRS (4.2.28)). Avoid the temptation to call a meeting where a developmental climax is intended to happen. It won't. Instead let individuals express interests and make commitments to each other. And let them revise these intentions on a moment's notice when the energy of some episode reaches an irresistible level.

Note that this means that there is a threshold of detail below which a project manager should not track. The threshold may vary depending on the project, but it is a safe bet that tasks smaller than a few days should not be formally tracked. One might get a sense of excess detail by the amount of complaining the developers do about the relevance of the tracking.

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This leads to an organization where the DEVELOPER CONTROLS PROCESS (4.1.17). Not only does the developer suggest the overall structure of commitments, but the developer becomes the focal point for day-to-day priority calls.

A DEVELOPMENT EPISODE is actually composed of a series of PROGRAMMING EPISODES (4.1.19), some of which must take place in (at least) pairs if any approximation of group consciousness is to form. An individual's labor plan is his tool to make these connections happen. Pair Programming Facilities [Beck1999] are configurations of the physical environment that can reduce this planning to an occasional HALLWAY CHATTER (5.1.15) promise.

A version of this pattern first appeared as [Cunningham1996].

4.1.15 Development Episode *

A baseball game is divided into separate episodes, called innings.

...members of a Work Group have been selected based on needs inferred from the Implied Requirements (4.1.16).

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It's important to build on the collective strength of an entire team and to build a true gestalt from the team members.

Each member brings specific skills which will be important at some point in the development. For this we can be thankful. However, if we overemphasize a member's specific strength, we diminish everyone's general abilities, unnecessarily narrow the members focus to applying just that specialty, risk creating ambiguity as to who is responsible for non-specialized tasks, and discourage the learning of new skills.

Therefore:

Approach all development as a group activity as if no one had anything else to do. Expect the activity to follow the usual course of an episode where energy builds to a decision-making climax and then dissipates. At the height of the episode, purpose should be clear, terminology well understood, knowns well explored and

unknowns identified. It is at exactly this point that individual strengths merge into a sort of common consciousness. Landmark decisions come easy. Breakthroughs are common. A creative act will have been shared.

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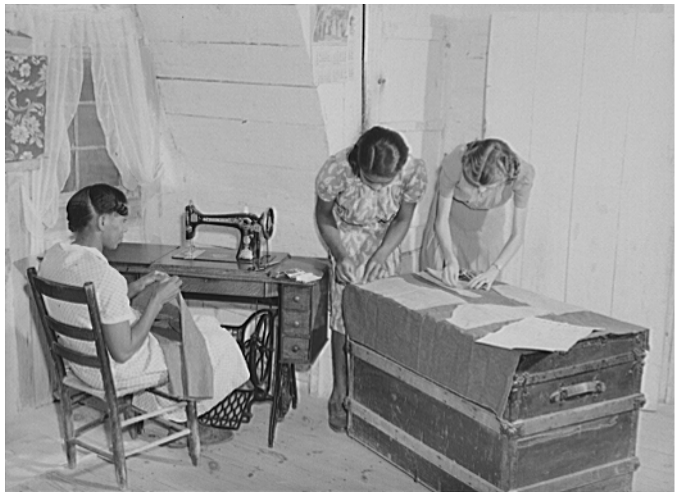
Besides yielding better decisions, the collective episode has very positive effects on the participants. Looking back, people often have trouble identifying the actual source of key ideas. Non-specialists gain invaluable insight into the thought processes of the specialist. A specialty is demystified, shared, spread throughout the group. A master of a specialty will realize that this sharing will not diminish one's own status within the group. As insight wells up in the master, he will delay slightly, expecting others to be close to the same insight, and knowing that their actual recognition experience will be of tremendous value to them and a small loss to himself. Seymour Papert called this an "Ah Ha" and admonished instructors not to "Steal the Ah Ha" [Papert1980].

A version of this pattern first appeared in [Cunningham1996].

4.1.16 Implied Requirements



FSA (Farm Security Administration) home supervisor Miss Harton helping one of borrowers' families cut patterns and make their own clothes. Caswell County, North Carolina. Pattern parts such as sleeves are named chunks of functionality, well understood by the customer.

...a Product Initiative (10.5.22) [Cunningham1996] has identified the direction for further development and a Market Walk-through (10.5.16) [Cunningham1996] has explored the customer motivation and developmental possibilities behind it. We expect positions and attitudes to be understood but have yet to make any commitments beyond everyone's general commitment to do a good job by the company.

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A commitment implies an agreement between people. Development commitments generally obligate developers to meet some customer need in a timely and satisfactory way. The tension here is to define a need in sufficient detail that commitments have meaning without exhausting up-front analysis or over constraining a solution.

Therefore:

Select and name chunks of functionality. Use names that would have meaning to customers consistent with the PRODUCT INITIATIVE (10.5.22). Allow these names to imply customer requirements without actually enumerating requirements in the traditional sense.

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Examples:

- Year-End Tax Reports
- Dollar Denominated Japanese Bonds
- High-Quality Printing
- Disconnected Operation on LAP- TOPS

These names will fill in the blank in the recurring questions like: Who's handling the programming (or specification, or customer contact, or manual update, or release notes) for _____.

A version of this pattern first appeared in [Cunningham1996].

4.1.17 DEVELOPER CONTROLS PROCESS **

A journeyman devises effective and efficient processes for manufacture of self-sealing fuel tanks, WW II.

...an organization has come together to build software for a new market in an immature domain, or in a domain which is unfamiliar to the development team. Progress will be marked by an INFORMAL LABOR PLAN (4.1.14). The necessary roles have been defined and initially staffed.

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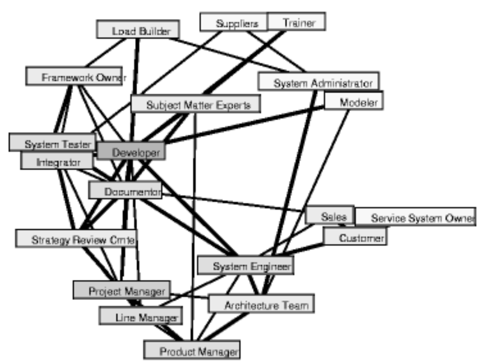
A development culture, like any culture, can benefit from recognizing a focal point of project direction and communication. Successful organizations work in an organic way with a minimum of centralized control. Yet there are important points of focus, embodied in roles, that tie together the ideas, requirements, and constraints into an artifact ready for testing, packaging, marketing, and delivery.

Totalitarian control is viewed by most development teams as a draconian measure. The right information must flow through the right roles. You need to support information flow across analysis, design, and implementation.

Because developers contribute directly to the end-user-visible artifact, they are in the best position to take accountability for the product. Of all roles, they have the largest stake in the largest number of phases of product development. And there should be no accountability without control. The MANAGER ROLE has some accountability as well, to the extent that it indirectly supports delivery of the user-visible artifacts. These are process issues.

Therefore:

Make the Developer the focal point of process information. Place the Developer role at a hub of the process for a given feature, in the spirit of ORGANIZATION FOLLOWS MARKET (5.1.9). A feature is a unit of system functionality (implemented largely in software) that can be separately marketed, and for which customers are willing to pay. Responsibilities of Developers include understanding requirements, reviewing the solution structure and algorithm with peers, building the implementation, and unit testing.



The developer is central to all activities of this end-to-end software development process.

Note that other hubs, such as the MANAGER ROLE, may exist as well, though they are less central than the Developer.

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The Developer who is at the hub of a particular feature may be accorded that position according to FUNCTION OWNER AND COMPONENT OWNER but, more generally, the developer should be at the communication hub of whatever process engages them in writing code for the customer. This pattern encourages a structure that supports its prime information consumer. The Developer can be moved toward the center of the process using patterns Work Flows Inward (4.1.18) and Move Responsibilities (5.1.18). Though Developer should be a key role, care must be taken not to overburden it. This pattern should be balanced with Mercenary Analyst (4.1.24), Fire Walls (4.2.9), Gate Keeper (4.2.10), and more general load-balancing patterns like Hallway Chatter (5.1.15), Responsibilities Engage (5.1.14), and Move Responsibilities (5.1.18). Conflicts can be escalated to the Patron Role (4.2.15) when consensus breaks down. and the Developer should enjoy particularly strong support from the Patron Role (4.2.15).

If the Developer controls the process, then it's possible to have Work Flows Inward (4.1.18).

Developers of course don't "control" the process unilaterally, but as a collective group, starting with Developing In Pairs (4.2.28).

We have no role called Designer because design is really the whole task. Managers fill a supporting role; empirically, they are rarely seen to control a process except during crises. While the Developer controls the process, the Architect controls the product. (In the figure, the Architect role is split across Framework Owner and Architecture Team (5.2.4).) This communication is particularly important in domains that are not well understood, so that iteration can take place to explore the domain with the customer.

In a mature domain, consider Hub Spoke And Rim (5.1.17) as an alternative.

You can still write down your process as part of a process improvement program. But keep the documentation light; many organizations have found that one page per process is good enough. And make sure each process step meets a need that you can tie to your organization's value proposition. Most often, this value is or should be tied to the product you are producing for a paying customer. If it isn't obvious how the process step helps achieve what you know the customer wants, the do the right thing instead.

4.1.18 Work Flows Inward **

Work (i.e. pears) flowing into a pear processing plant.

...an organization is in place and has been doing work long enough that it can introspect about its structure and workings. There is some management pecking order or hierarchical decision-making structure in the organizational network. Work instructions flow through this structure, with the possibility that each role makes decisions, adds constraints, or works to carry out decisions within some set of constraints.

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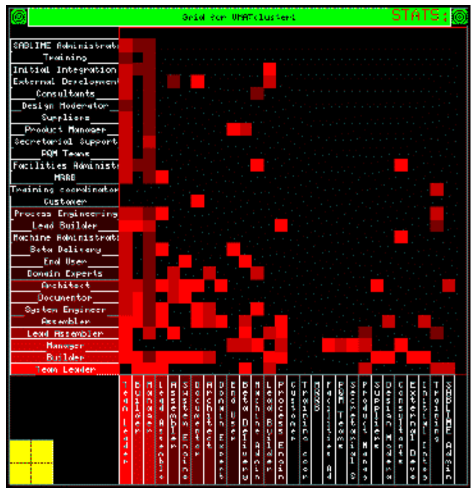
An organization must seek a structure that best insures that the most authoritative roles make the decisions and carry out the work that adds value directly to the product.

Some centralized control and direction are necessary. During software production, the work bottleneck of a system should be at the center of its communication and control structure. If the communication center of the organization generates work more than it does work, then organization performance can become unpredictable and sporadic. The developer is already sensitized to market needs through Fire Walls (4.2.9) and Gate Keeper (4.2.10) (no centralized role need fill this function).

Look at the following grid that depicts the directed flow of communication in an organization (see How The Patterns Came To Us

(CHAPTER 2)). In this organization, there is a core of roles at the center that initiate interactions across the spectrum of most of the other roles:



Yet this core receives very little input from the rest of the roles in the organization. And this core is rife with management roles (Team Leader, Manager, Lead Assembler). It has an overloaded center, and work requests flow outward from this center, diffusing across the other roles. Core roles *make* work.

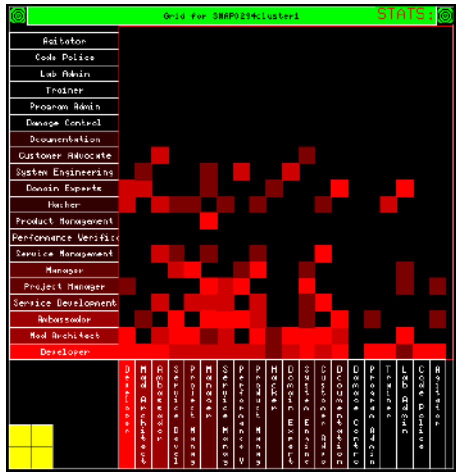
Katz & Kahn's analysis of organizations shows that the exercise of control is not a zero-sum game [KatzKahn1978, p. 314].

Therefore:

Work should flow in to developer from stakeholders, especially customers. Work should not flow out from managers.

You should not put managers at the center of the communication grid: they will become overloaded and make decisions that are less well-considered, and they will make decisions that don't take day-to-day dynamics into account.

Consider the following picture, where work flows from the roles across the organization to the roles at the center: Developer, Architect, Ambassador. There is a healthy distribution of inward-directed inputs. And in large part, the central roles *do* work, not *make* work.



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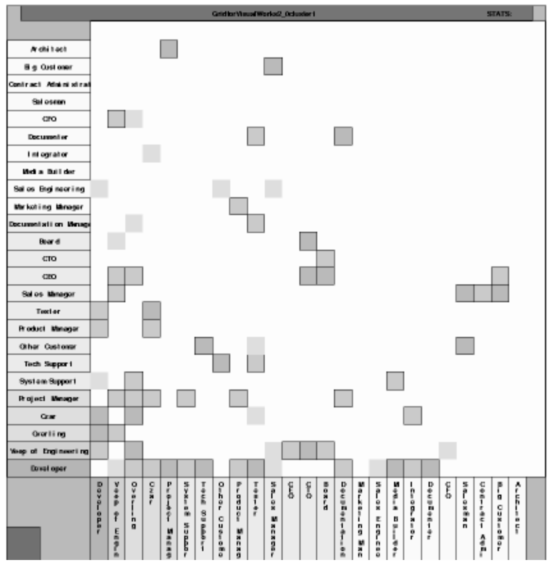
The result is an organization whose communication grid has more points below the diagonal than above it (as in the second figure above).

The work should focus at the center of the process; the center of the process should focus on value-added activities (Developer Controls Process (4.1.17)).

But consider this interaction grid:



Superficially, the graph appears to show a Work Flows Inward pattern. But in fact, most of the interactions directed from outlying roles to the developer were of an imperative nature rather than an informative nature. The developer role was being pulled in many directions, and the organization health suffered greatly.

Organizations run by professional managers tend to have repeatable business processes, but don't seem to reach the same productivity plateaus of organizations run by engineers. In programmer-centric organizations, the value-added roles are at the center of the process (Developer Controls Process (4.1.17); Architect Also Implements (5.2.10)). The manager should facilitate and support these roles and their work (Patron Role (4.2.15); Fire Walls (4.2.9)).

Mackenzie characterizes this pattern using *M-curves,* that model the percentage of task processes of each task process law level (planning, directing, and execution) as a function of the classification. [Mackenzie1986]

The rationale is supported with empirical observations from existing projects.

The broad goal of this pattern is to separate overhead work from central work; Day Care (4.1.23) is another pattern with a similar intent.

The MANAGER ROLE should still make day-to-day decisions for the business process, and pursuant to their responsibility to “keep the pests away” (FIRE WALLS (4.2.9)).

In his new work, *The Nature of Order,* Christopher Alexander speaks of *gradients* as one of the 15 structural properties of whole systems that emerge naturally in a process of local adaptation. In WORK FLOWS INWARD, there should be a natural gradient of information flow toward the developer: the “center” of the organization — both in the sense of the social network diagrams, and in the sense that Alexander uses the term “center” to describe a prominent feature of a system.

4.1.19 Programming Episode **

Making the possible decision now: what kind of candy can I buy with my nickel?

...you have a good idea on where to start and perhaps even some fledgling pieces of code. Now you need to get on to establishing a rhythm of productive development that can engage and fuel the team.

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Programming is the act of deciding now what will happen in the future, but it always seems like parts of the future don't happen soon enough and parts of it are always too far off and out of reach. A programming language offers an operationally precise way to encode decisions through a process called simply coding. Programmers reason about future behavior by interpreting previously coded decisions and integrating these with their own decisions and their interpretations of other sources like Technical Memos and domain experts. The depth, quality and value of programming decisions will be limited by the programmers ability to concentrate.

Therefore:

Develop a program in discrete episodes. Select appropriate deliverables for an episode and commit sufficient mind share to deliver them. Do this by making the possible decisions now, and coding those decisions. Be aware of the rise in concentration as the episode progresses. Consider each source (above) and consciously include or exclude its recommendations.

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Use the fear that often accompanies a decision not-yet-made as a motivation. Try to compare your position within an episode to similar points in previously successful episodes.

Example:

"I feel like we've been around twice now on the possible ways we can bind the six terms of this bond analytic to the four calculation classes we have in our library."

"Yeah, right now I'd be happy if we could place the four primary terms, look at the error cases, and see if that gives us a hint how to proceed after lunch."

Push for the decisions that can be made. Don't abandon an episode; that will leave you feeling defeated and unable to achieve even the same level of concentration at a future time. Make the decisions that seem possible. Code the decisions. Then review the code to be sure that the extent of your decisions and your confidence in them is apparent in the code. Coding occurs on the down-hill side of a programming episode. Coding is the most direct way to promulgate programming decisions.

A version of this pattern first appeared as [Cunningham1996].

4.1.20 Someone Always Makes Progress *

Room enough for everyone to work...

...non-primary tasks are dominating the team's time, keeping it from moving forward with their primary goal. There are common complaints of distraction.

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It is important to keep a team moving forward and to avoid getting stuck on the obstacles. You need to pay attention to every task, including small diverting ones. But you also need to complete the primary task by an important date.

Therefore:

Whatever you try, ensure that someone on the team is making progress on the primary task.

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If you do not complete your primary task, nothing else will matter. Therefore, complete that at all costs.

You can employ one of a broad range of particular solutions and tactics depending on the exact forces to be resolved. The following specializations are example refinements of this pattern:

- DEVELOPING IN PAIRS (4.2.28) - one person can always take the keyboard.
- TEAM PER TASK (4.1.21) - separate tasks into sympathetic sets.
- SACRIFICE ONE PERSON (4.1.22) - assign only one person to the distraction.
- DAY CARE (4.1.23) - separate the training task from that of producing software.

But, in any case, you will always be closer to your final goal — which is not always the case when dealing with distractions.

The psychological effect of this pattern should not be underestimated. If the project is hit with many distractions, it can be demoralizing to see work grind to a halt. However, any visible progress will help the entire team stay focused, and will encourage them to get through their particular crisis, so that they too can once again make progress.

Carried too far, this pattern might lead you into trouble for not adequately addressing the distractions. But too many distractions are usually a symptom of some other problem; see, for example, FIRE WALLS (4.2.9).

Sample situations:

A. Scylla and Charybdis, Atalanta. In the ancient Greek story, Odysseus had to get his ship past Scylla and Charybdis. Scylla was a six-headed monster guaranteed to eat six crew members, but the rest would survive. Charydbis was a whirlpool guaranteed to destroy the entire ship. In this paradigm of the dilemma, Odysseus chose to sacrifice six people so that the rest would get past Scylla's cave.

In the Greek story of Atalanta, Atalanta was assured by the gods that she would remain the fastest runner as long as she remained a virgin. So she told her father, the king that she would only marry the man who could beat her in a foot race. The losers were to be killed for wasting her time. The successful young man was aided by a god, who gave him 3 golden apples. Each time Atalanta pulled ahead, he tossed an apple in front of her. While she paused to pick up the golden apple, he raced ahead, and eventually won.

You could interpret this story as containing the moral that Atalanta should not have stopped to pick up the apples - that would also illustrate the point of this pattern. I choose to view it more metaphorically, that Atalanta represents distractions trying to beat you to your project's deadline. The apples are members of your team, whom you will separate from the main team one at a time to ensure success.

See [Csikszentmihalyi1990] and [DeMarcoLister1976].

A version of this pattern first appeared in [Cockburn1998].

4.1.21 Team Per Task **

... a big diversion hits the team, threatening to disrupt the ongoing work, and temporarily halt progress.

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Large distractions (usually called crises) must not be allowed to stop a project, even for a short time. Crises are inevitable, and they are legion. If the project takes time to respond to each, its members will soon find themselves spending so much time responding to each crisis that the real work doesn't get done.

Of course the diversions are real. A previous release needs an emergency bug fix. New people must be trained. The ISO audit will happen. But they must be handled in a way that the project still moves forward.

The temptation is to take this high-priority item and throw everything you have at it: let the whole team work the issue until it goes away. However, such an approach confuses urgency with amount of effort; some problems require only a small amount of attention, although it should be *immediate* attention. A stitch in time saves nine.

Therefore: **Let a sub-team handle the diversion, which allows the main team to keep working.**

One approach is to split the team. Sort the activities so that each team has a primary task with additional, sympathetic activities. Sitting in meetings, answering phone calls, writing reports, for example, are non-sympathetic to designing software. Arrange it so that each team can focus on its primary task, and each task has a dedicated team member.

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The result is that the important distractions are handled pretty much entirely by specialized teams, thus allowing the main team to continue uninterrupted.

However, one must be careful not to overdo it. Carried to extremes, it results in single-person teams. In addition, while solving a crisis is important, be careful not to heap praise too lavishly on the crisis teams. Otherwise, addressing crises becomes the glamor job, and the focus of the team becomes putting out fires rather than building the building. (See COMPENSATE SUCCESS (4.2.25))

Related patterns:

This pattern treats each task both as an activity and as a deliverable. *Therefore:*

> OWNER PER DELIVERABLE (10.5.19) - the general form of ownership and accountability.
>
> FUNCTION OWNER AND COMPONENT OWNER - team for each artifact, as well as the task of designing it.
>
> SOMEONE ALWAYS MAKES PROGRESS (4.1.20) - the general distraction management pattern.
>
> SACRIFICE ONE PERSON (4.1.22) - specialization to lose only one person.
>
> DAY CARE (4.1.23) - addresses training as a separate deliverable from the software.

Principles involved:

> Increase flow time and decrease distractions, thus trading personnel parallelism for time slicing. “Flow” is the quiet time in the brain when the problem flows through the designer ([Csikszentmihalyi1990], [DeMarcoLister1976]). It is when the design alternatives are weighed, and decisions are

made in rapid succession as mental doors open. The problem, the alternatives and the state of the decision process are all kept in the head. It is a not only a highly productive time, it is the only time when the designer feels comfortable making decisions.

It takes about 20 minutes to reach the internal state of flow, and only a minute to lose it. Beyond getting into flow, the designer must have time to make actually progress, which may be another 10 minutes. Any significant interruption within the half hour minute essentially causes the entire half hour to be lost. As it takes energy to get into the flow, a distraction costs energy as well as time.

To increase flow time, distractions have to be reduced. Certain pairs of activities are more mutually distracting that others. Fixing a bug requires flow in the old system, hence distracts from flow in the new system. Sitting in meetings, answering questions and time on the telephone are major distracters to design flow. Therefore the recommendation to group tasks into sympathetic sets. Requirements and analysis involve meetings, reading, and writing. Design and programming require concentration on the implementation technology and keeping a great number of details in the head.

Parallelism vs. time-slicing. Time-slicing can be more attractive in terms of job satisfaction - each person will do design some part of the time. The significant time to switch between tasks causes parallelism to be preferred in this case. Some of the people may adopt the new task as their profession (see SACRIFICE ONE PERSON (4.1.22), DAY CARE (4.1.23), and FIRE WALLS (4.2.9) for examples).

Sample situations:

A. Concurrently gathering requirements and designing software.

Project Winifred tried having each person do requirements, analysis, design and programming. We thought the developers would enjoy the change of activity, that this would reduce the meetings and bureaucratic documentation exchanged between people.

What happened was that the first two activities were so different from the latter two that people were unable to switch easily between them. After having attended and documented meetings for much of the day, it was difficult to start working on the design and programming. As with bug-fixing / new-development, every time a designer was pulled away from her or his work, it cost an additional hour to recover the train of thought.

We applied Team Per Task (4.1.21), and split the teams along task lines. Requirements gathering and analysis went with designated people in each team, and design and programming went with the others. The result was that the requirements / analysis people sat in meetings, read and wrote specs, examined interfaces and the like. They communicated their findings to the designer / programmers - orally, for the most part, since they were closely linked on the same team (Holistic Diversity (4.2.19)). The designer / programmers stayed in their train of thought, getting fresh input from their requirements colleagues. Some of the people put onto requirements really wanted to program, so this was quite a sacrifice for them (Sacrifice One Person (4.1.22)).

Two things we did not do. We did not put the requirements / analysis people into a separate team (Holistic Diversity (4.2.19) again). A team was jointly responsible for a section of the system, from requirements to delivery. The splitting was within each team. We also did not require the requirements group to document their decisions for the designers benefit (they did document for the project's benefit). The requirements and design people were in close contact at all times, and most information passed orally. There was, therefore, no "throw it over the wall" effect. These were both important teaming decisions made earlier, which we were intent on preserving.

B. Training is distracting the experts. See Day Care (4.1.23).

C. Other examples under Sacrifice One Person (4.1.22).

Reading:

See [Csikszentmihalyi1990] and [DeMarcoLister1976].

A version of this pattern first appeared in [Cockburn1998].

4.1.22 SACRIFICE ONE PERSON *

Other names: “Sacrificial Lamb”

... during a typical project, there are always a host of small distractions.

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Small distractions can add up, and sap the strength of the team.

Even small distractions must be handled. But they take time away from the primary task. In particular, any distraction, even a small one, disrupts “flow” time, which costs significant additional time to regain.

Many small distractions are less desirable jobs.

Therefore:

Assign just one person to it until it gets handled.

This is very much like TEAM PER TASK (4.1.21), except the distraction is smaller; it could seemingly be handled by one person half-time to full-time.

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The main group of the team moves forward distraction free. The person assigned to the distracting task may be unhappy, so try to get that person back on the team again as soon as possible. If you feel that one person is too much to sacrifice to this task and want to make it part time work, compute the loss of flow time that would result from trying to work this distraction and some other task.

If this keeps happening, you will have no one performing the primary task, and you ought to examine why you have so many distractions in the first place.

OWNER PER DELIVERABLE (10.5.19) is the general ownership and accountability pattern. SOMEONE ALWAYS MAKES PROGRESS (4.1.20) is the general distraction management pattern. TEAM PER TASK (4.1.21) is the general form of this pattern at the team level.

Several patterns refine this pattern for specific contexts. DAY CARE (4.1.23) addresses training as a separate deliverable from the software, and produces *mentor* as a profession. In FIRE WALLS (4.2.9), the distraction is a series of requests from outside the team, so one of the developers is sacrificed to act as project manager. That can produce *project manager* as a profession. The MERCENARY ANALYST (4.1.24) handles the distraction of documentation, usually a "hired gun" who takes care of it, leading to *technical writing* as a profession. And in GATE KEEPER (4.2.10), the constant inflow of technical information is the distraction, and one person is assigned managing that information as a distinct, part-time task. It is one of the major foundations for *manager* as a profession.

Don't forget the sacrificial lamb when it comes time to COMPENSATE SUCCESS (4.2.25).

Principles involved:

> As for TEAM PER TASK (4.1.21). The fact that handling the distraction looks less than a full-time job illustrates the significance of the time spent getting into mental flow.
>
> Maximum parallelism, profession, or sacrifice? If the people do not like the task, they consider it a sacrifice. If they like the task, it becomes their profession. Thus, FIRE WALLS gives rise to the profession of project management, DAY CARE gives rise to the profession of mentor.

Sample situations:

A. Updating the project schedule. On Project Winifred, the schedule was out of date. We thought it would be fair to let each person on each team evaluate their own work. That would spread the experience, discomfort and load. What really happened was that progress came to a total halt. When the design team got back to designing, a month had gone by with no design progress, and they had forgotten some of the design issues that had been in their head. One of the teams used SACRIFICE ONE PERSON (4.1.22). They drew lots, for one person to do the whole team's estimation while the others got on with the main task. At the end of several weeks of estimation, that team had moved forward while the other teams were at a standstill. Thereafter, every team applied the pattern. The person working on the schedule really felt sacrificed. This pattern was originally called "Scylla", as described in the story of Scylla and Charybdis.

B. Simultaneous release to QA and development of the next release.

Project Winifred had one increment entering test at the same time design was starting on the next. We optimistically thought the bug fixes would take a relatively small amount of time, and so assigned the whole team to both fixing bugs and doing new design.

Each fix broke a designer's train of thought for a period of time on the order of an hour, beyond just the fix. Three or four of these caused the designer to lose most of the day. Eventually, the designers gave up on the new release, because they knew the next bug fix would arrive before they would had recovered their thoughts and progressed on the new design.

We applied SACRIFICE ONE PERSON (4.1.22), and assigned one person to bug fixes. We originally planned it as a half-time job, but found there was not enough time left over for the person to do any useful design. The person rejoined the new design team as soon as the release went through test.

A version of this pattern first appeared in [Cockburn1998].

4.1.23 DAY CARE *

Alias: “Progress Team / Training Team”

... the project has just brought on several new people.

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Your experts are spending all their time mentoring novices.

You begin to hear things like “We are wasting our experts,” or “A few experts could do the whole project faster.” Indeed, the experts are not proceeding at the rate you or they would expect, because training the new people is draining their energy, time and concentration. But the new people must be trained, by experts, of course.

At the same time, you must make progress on the project itself.

Therefore:

Put one expert in charge of all the novices, let the others develop the system.

Separate an experts-only “progress” team from a training team under the tutelage of one or more mentors. Select the mentors for their ability to teach design and programming (object-oriented design and programming, for example) to novices. Let the progress team design 85-95% of the system, let the training team focus on quality training, delivering only 5-15% part of the system. Transfer people to the progress team as they become able to contribute meaningfully.

Make sure that the training team does not simply do training exercises, but actually contributes to the final system in an ever-increasing way.

If you have many people to train (more than, say, six), you will have to design a series of tasks for them to attempt. Otherwise you may give them a small, real part of the main system to design.

If the people in the training team are the ones who know the domain, you will have to make some further adjustment, or else the division may cause conflict.

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The result is that most of the experts can continue to make progress on the project. The novices contribute a small part of the project, that grows as they gain experience.

In extreme cases, though, you eventually have too few people to constitute a progress team.

How many people can one mentor train, if training results and not running software are his/her deliverable? A small, reasonable number is five. I have heard of one person mentoring 15 people on five concurrent mini-projects.

Related patterns:

> This pattern is a cross-specialization of several given in this chapter: OWNER PER DELIVERABLE (10.5.19), SOMEONE ALWAYS MAKES PROGRESS (4.1.20), TEAM PER TASK (4.1.21), SACRIFICE ONE PERSON (4.1.22).

Principles involved:

> The principles are synergy vs. distraction, the synergy of having a novice learn directly from an expert vs. the distraction to the expert. Experts having to answer novice questions are reduced to a fraction of their productivity, without particularly raising the productivity of the newcomers. Adding one novice to an expert may cut the expert's productivity in half, adding two may cut it to a third, adding three may prevent all productivity altogether.

Assume there are X experts who work at productivity 1 each, a larger number of N novices who work at n productivity each, with n much smaller than 1, on the order of 1/10. If the experts could work together, they would have, in this simple model, a total productivity of

(X) for the experts working together.

If one of them is sacrificed to train the novices, that person has zero productivity (except training novices), so the group's total productivity is

(X-1) + N*n for Day Care (upper curve in figure 8.1).

If they are all mixed together ("Even Mix"), m=N/X novices per expert, each expert's productivity falls from 1 to something like 1/(m+1). The group's total productivity is now

(X*X/ (N+1)) + N*n for Even Mix (lower curve in figure 8.1).

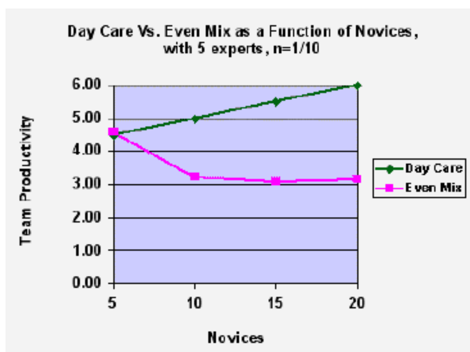
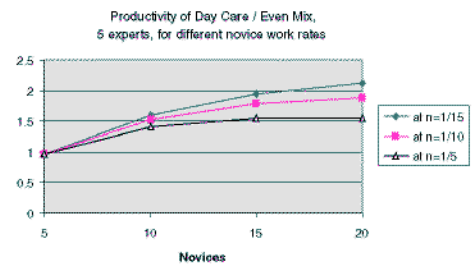


Figure 8.1 shows the productivity of Day Care (4.1.23) versus Even Mix, novices assumed to work at 1/10th the productivity of the experts. This shows the total productivity for the team in units of experienced people's productivity. As the number of novices increases, the Even Mix line shows the effect of training them. Let us check that the assumed productivity difference is not skewing the results. Figure 8.2 shows the ratio of Day Care (4.1.23) to Even Mix, for different productivity assumptions. Note that with five experts and five novices, the ratio is actually just below one, meaning that the

experts are absorbing and making use of the novices. By two novices per expert, DAY CARE (4.1.23) is already considerably more effective.



The nature of the training does not matter. Design and teaching are antagonistic tasks (as described in TEAM PER TASK (4.1.21)), and better split into separate teams.

Treating the delivery of trained people as separate from the delivery of running software gives you access to OWNER PER DELIVERABLE (10.5.19). SOMEONE ALWAYS MAKES PROGRESS (4.1.20) protects the delivery of running software.

Sample situations:

A. Mentoring. The standard recommendation in the industry is to put 1-5 novices under each trained expert. The consequence is that the experts spend the prime part of their energies training, halfheartedly. Besides being drained of energy for designing the system, the experts typically do not have the personality, background or inclination to actually teach the novices how to do design. They are caught between trying to get the maximum out of their trainees and trying to do the maximum development themselves. Thus, they neither develop the system, nor train the novices adequately.

Some companies have dedicated “Apprenticeship” programs, in which novices are put under the tutelage of a dedicated mentor for 2 weeks out of every 3 for 6 months.

B. Adding staff. Fred Brooks, in The Mythical Man-Month, talks about the training costs of adding people to a project. These new people drain productivity from the experts. The same suggestion applies: put the newcomers in a separate team to learn the system. Move them to the progress team as soon as they are up to speed.

Reading:

Brooks, F., *The Mythical Man-Month*, Addison-Wesley, 1995 [Brooks1995].

In *Situated Learning: Legitimate Peripheral Participation*, [Lave1991], Lave and Wenger describe the use of this sort of arrangement in apprentice-based work situations.

A version of this pattern first appeared in [Cockburn1998].

4.1.24 Mercenary Analyst *

On one of his many journeys in the Appalachian Mountains, the itinerant folk song collector John Jacob Niles heard a woman singing a particularly beautiful song. He persuaded her to repeat the now-famous Christmas song, "I Wonder as I Wander," until he had learned it himself. He later said, "I never saw her again."

... you are assembling the roles for the organization. The organization exists in a context where external reviewers, customers, and internal developers expect to use project documentation to understand the system architecture and its internal workings. (User documentation is considered separately). Supporting a design notation, and the related project documentation, is too tedious a job for people directly contributing to product artifacts.

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Technical documentation is the dirty work every project must do. It's important to create—and, more so, to maintain—good documentation for subsequent use by the project itself. Who writes these documents?

If developers do their own documentation, it hampers "real" work. Meeting software deadlines means money to the organization; technical documentation is one of those things we tell ourself can be deferred until there is time to do it. But “the time to do it” often never comes, and an organization without good internal technical documentation of its system has a serious handicap.

Documentation is often write-only.

Engineers often don’t have good communication skills.

Many projects use tools like Rose to do design, that produce pretty pictures. A good picture is not necessarily a good design, and architects can become victims of the elegance of their own drawings (see the rationale below).

Therefore:

Hire a technical writer, proficient in the necessary domains, but without a stake in the design itself.

This person will capture the design using a suitable notation, and will format and publish the design for reviews and for consumption by the organization itself.

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The documentation itself should be maintained on-line where ever possible. It must be kept up-to-date (therefore, MERCENARY ANALYST is a full-time job), and should relate to customer scenarios (SCENARIOS DEFINE PROBLEM (4.2.8)). Note, though, that all team members need to provide input to keep the documentation up to date. The AD- HOC CORRECTIONS (10.5.2) pattern [Weir1998] suggests that a master copy of the documentation be kept, and that team members write corrections in the margin. One team member is assigned to periodically update the document.

The success of this pattern depends on finding a suitably skilled agent to fill the role of mercenary analyst. If the pattern succeeds, the new context defines a project whose progress can be reviewed (the pattern STAND UP MEETING (5.2.7)) and monitored by community experts outside the project.

If the MERCENARY ANALYST really is a “mercenary” who “rides into town, gets the early stuff documented, kisses his horse, saddles up his girl, and rides off into the sunset” (Paul Chisholm), then it’s good to keep some of the expertise behind by combining MERCENARY ANALYST with DEVELOPING IN PAIRS (4.2.28).

This pattern is uncommon but empirically grounded and effective, found in Borland's Quattro Pro for Windows and many AT&T projects (a joint venture based in New Jersey, a formative organization in switching support, and others). It is difficult to find people with the skills to fill this role.

Rybczynski writes:

> Here is another liability: beautiful drawings can become ends in themselves. Often, if the drawing deceives, it is not only the viewer who is enchanted but also the maker, who is the victim of his own artifice. Alberti understood this danger and pointed out that architects should not try to imitate painters and produce lifelike drawings. The purpose of architectural drawings, according to him, was merely to illustrate the relationship of the various parts... Alberti understood, as many architects of today do not, that the rules of drawing and the rules of building are not one and the same, and mastery of the former does not ensure success in the latter. —[Rybczynski1989, p. 121].

A passage from Manzoni's *I Promessi Sposi* (*The Betrothed* [Manzoni1984]) might amuse the MERCENARY ANALYST.

> The peasant who knows not how to write, and who needs to write, applies to one who knows that art, choosing as far as he can one of his own station, for with others he is hesitant, or a little untrusting. He informs him, with more or less clarity and orderliness, of who his ancestors were, and in the same manner tells him what to set down on paper. The literate person understands part and guesses at the rest, gives a few pieces of advice, suggests a few changes, and says "Leave it to me."
>
> He picks up his pen, puts the other's thoughts as well as he can in literary form, corrects them, improves them, embellishes them, tones them down, or even omits them, according to how he thinks best, because—and there's nothing to be done about it—someone who knows better than others has no wish to be a mere tool in their hands, and when he is concerned with the business of others he wants it to go a little in his own way.

Richard Gabriel [Gabriel1995] notes the following are important traits of this role:

- good meeting facilitator
- likes things organized
- good attention to details
- has written instructional material (for software)
- has no ego to invest in the material being documented
- very smart, highly educated (Ph.D. in literature from Cornell in my case)

In exceptional cases, the MERCENARY ANALYST can actually take a stake in the design. Betsy Hanes Perry writes:

> When I fill this role, I most definitely have a stake in the design: I want to make sure it's elegant, consistent, and clean. The architect has primary responsibility, of course, but I also suggest places in which the design conflicts with itself or may lead to future misunderstandings. As I see it, a software architecture is an idea. The designer / implementors are responsible for expressing that idea (or those ideas) as code; I express it / them as prose. Both are projections of the idea into a particular plane. When there's a conflict, the code is probably correct.

Many projects put faith in tools and notations such as UML to improve quality. But, as Betsy points out, the tool largely provides the forum and opportunity for a human being to engage in the processes and convey the insights that contribute to quality. For documentation to have added value as a quality tool, the documentation process must proceed in the spirit of this admonition.

Paul Chisholm offers the following about the history and rationale of MERCENARY ANALYST:

> MERCENARY ANALYST came from two sources:
>
> (1) Borland's Quattro Pro for Windows, which Cope's identified as *the* most productive software development organization he's ever seen (average 1000 delivered non-commentary source lines of C++ per staff **week**), in large part due to the

fact that developers had people to write the development documentation for them).

Designer/coders have responsibilities that cannot be delegated. Some responsibilities, such as documentation, can be delegated. Besides, many excellent programmers and most average ones are less than stellar writers. (Richard [Gabriel] may disagree that this *is* the case, and will certainly disagree that this *should* be the case...

(2) A combination of two patterns. One, from Tony Hansen's group, is DISPOSABLE ANALYSIS: do analysis once, translate to design, throw away the analysis, keep only the design up to date with the code. The other is my observation that most CASE tools require significant experience in the method and the tool itself. If you have DISPOSABLE ANALYSIS (which few projects plan to do but many follow unintentionally), you should **not** develop local expertise in CASE tool operation.

It's bad enough learning Framemaker. CASE tools tend to have lousy user interfaces; it's a real pain to use them, or learn how to use them.

The "mercenary" in MERCENARY ANALYST. comes from the "hired gun" quality a MERCENARY ANALYST might have; rides into town, gets the early stuff documented, kisses his horse, saddles up his girl, and rides off into the sunset. That's the DISPOSABLE ANALYSIS model, not the Borland Quattro Pro for Windows model!

Mercenary Analyst plays well with DEVELOPING IN PAIRS (4.2.28).

Someone quoted by Jim Coplien wrote that "Mercenary Analyst is the professional technical writer who takes care of all the project diagrams and documentation so it doesn't get in the way of the architects."

Maybe not a "tech writer", and not " *all* the diagrams and documentation," but, yes, that's the idea.

What should be a Mercenary Analyst's education? Mastery of his or her tools (e.g., word processor, CASE tool) beyond that of most users. Experience (perhaps expertise) in the "method" behind the documentation (e.g., an ObjecTime Mercenary Analyst would have to know ROOM well, someone writing requirements would need systems engineering and / or software development experience).

What is the Mercenary Analyst's motivation? To get the *software* (**not** the documentation) out faster!

How can one paint CASE diagrams without knowledge of software? I had some naive hope that a CASE tool Mercenary Analyst could be a highly skilled clerk. I've given up on that. There may be some way of combining Mercenary Analyst with Developing In Pairs (4.2.28) (or a variant for triples) to make Mercenary Analyst some sort of entry-level or apprentice position.

Domain Knowledge. While knowledge of the domain is important for a project (Domain Expertise In Roles (4.2.22)) I don't think the Mercenary Analyst (4.1.24) needs it. (I hope not!)

Knowledge of software is important. Would you trust a driving instruction manual written by someone who'd never driven?

4.1.25 INTERRUPTS UNJAM BLOCKING **

During one project status meeting, it was reported that a critical piece of hardware was malfunctioning. Unfortunately, the expert on the hardware was on the other side of the country, and was involved in his own work. But he had the (mis)fortune to be on that conference call. So was the project director, who informed him in blunt terms that his services were required immediately. He was on the next plane out.

... you are fine-tuning scheduling in a high productivity design/implementation process or low-latency service process. The scheduling problem is to be addressed on a small scale (i.e., this is not scheduling entire departments, but the work of cooperating individuals). You want to use INFORMAL LABOR PLAN (4.1.14), but need additional criteria for individuals and small groups to plan their schedules. Local decisions may lack the scope necessary to avoid duplication of work, missed opportunities, and other sillinesses.

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A comprehensive scheduling plan is difficult if not impossible; yet, without some kind of plan, it becomes easy to fall into thrashing.

The events and tasks in a process are too complex to schedule development activities as a time-linear sequence.

Complete scheduling insight is impossible. Even if it were possible to capture the entire picture of the project for an instant, it would change very quickly. The dynamics of project development mean that the best we can hope for is a high-level, approximate schedule.

The programmers with the longest development schedules will benefit if more of others' code is done before they try integrating or testing later code, and their interval can't otherwise be shortened (see CODE OWNERSHIP (5.2.13)).

Therefore:

If a role is about to block on a critical resource, interrupt the role that provides that resource so they stop what they're doing to keep you unblocked.

The nature of the critical resource can vary. It may be a software module that is in the critical path. It could be the latest software integration. It is often critical knowledge, without which one cannot move forward. Whatever the resource is, the approach is to interrupt the provider of the resource.

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If the overhead is small enough, it doesn't affect throughput. It will always improve local latency.

The process should have a higher throughput, again, at the expense of higher coupling. Coupling may have already been facilitated by earlier patterns, such as WORK FLOWS INWARD (4.1.18), MOVE RESPONSIBILITIES (5.1.18), RESPONSIBILITIES ENGAGE (5.1.14), HALLWAY CHATTER (5.1.15), and COUPLING DECREASES LATENCY (5.1.22).

The intent is that this pattern will apply most frequently between cooperating developers working on a single project. This is supported empirically from a high productivity process in AT&T. There are strong software engineering (operating system) principles as well.

It may be useful to prioritize interrupts, and service the ones that would optimize the productivity of the organization as a whole. That is, it is better to unblock 4 people who are currently blocked than to unblock a single squeaky wheel. The decision-making process should be fast: Most of the time, it should be distributed. Where arbitration is needed, apply PATRON ROLE (4.2.15). The simplest resolution is the pattern DON'T INTERRUPT AN INTERRUPT (4.1.26).

The PATRON ROLE (4.2.15) and MANAGER ROLE can help the team audit the project for blocked progress, but should defer to the Developers (or other directly impacted roles) to resolve the blockage when ever possible. Management intervention can be effective, but may risk good will within the project.

Joe Maranzano notes a corollary to this pattern is another pattern: Don't put too many critical tasks on one person (which is related to MODERATE TRUCK NUMBER (4.2.24) and DISTRIBUTE WORK EVENLY (5.1.13)).

This pattern is much less effective if the provider of the resource is not in the same project as you are. In that case, the provider has little incentive to service your interrupt, and you risk alienating the provider if you engage in incessant pestering. This problem can be mitigated by adopting a policy of reciprocity, fair and proactive exchange of value among partners. [Dikel2001].

4.1.26 Don't Interrupt An Interrupt *

The original interruption device.

...you've applied Interrupts Unjam Blocking (4.1.25), but notice that the organization is now thrashing, particularly in the end game or under heavy churn.

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It's important to balance a desire that Someone Always Makes Progress (4.1.20) with the thrashing that can accompany short-term priority calls. One worker will inevitably be blocked on you—you can't do both things at once. Complete, omniscient foresight and scheduling are unreasonable to expect.

Therefore:

If a developer is already working in "interrupt mode" on a critical issue, don't put that work aside until it is complete or until that issue itself becomes hopelessly tangled.

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This prevents endless churn that can result from too much context switching. It helps ensure that Someone Always Makes Progress. And it provides some "back pressure" in the process that can help temper irresponsibly quick reversals of position in the front-end.

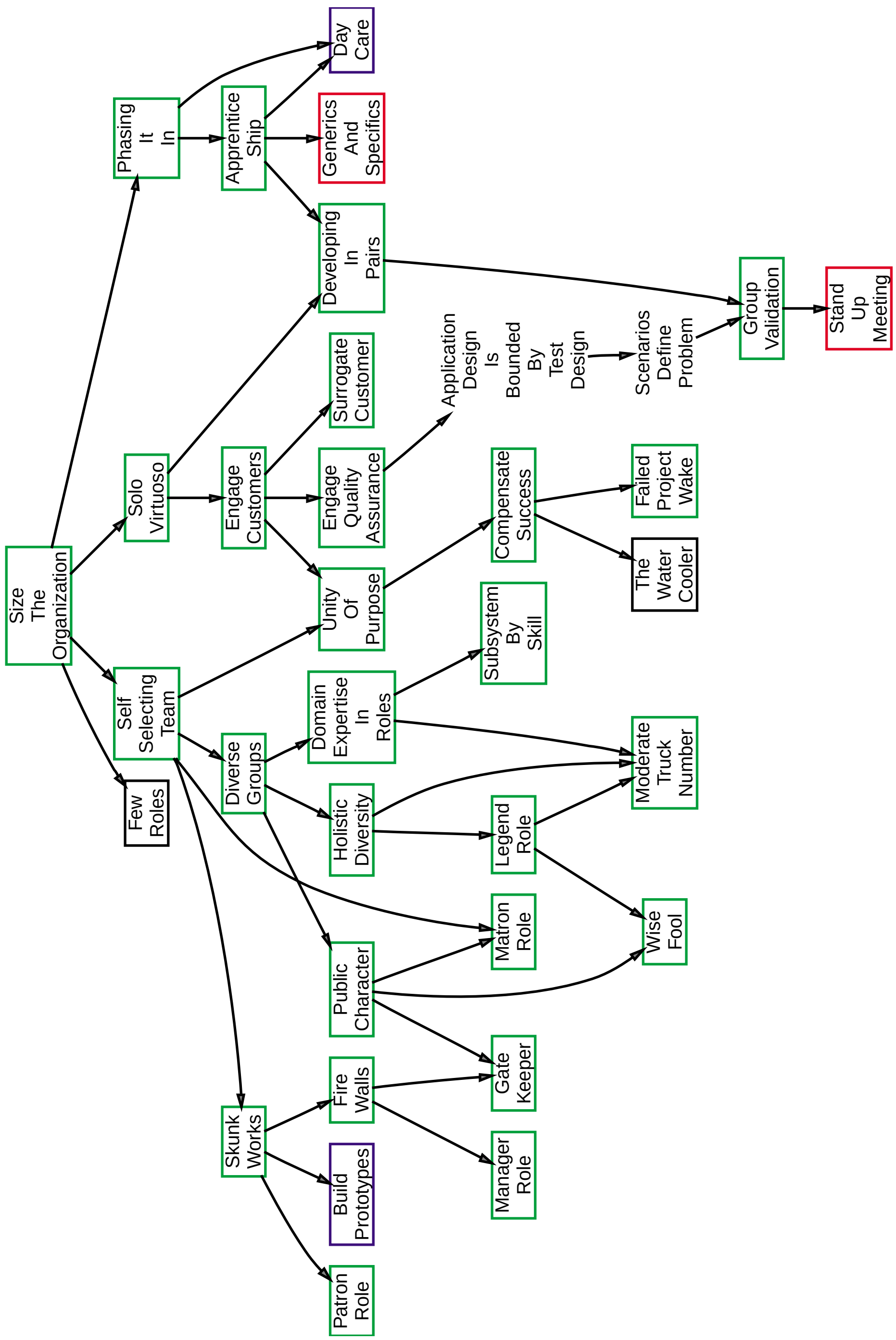
This is a simple, though somewhat arbitrary, rule to keep scheduling from becoming an elaborate ceremony.

This relates to the “red zone” from Linda McLyman’s analysis of the Satir change model [Satir1991], that suggests that if a foreign element (problem) arrives before the organization starts to learn its way out of the last foreign element, recovery is difficult.

4.2 Piecemeal Growth Pattern Language

The Pattern Language

This pattern language offers patterns to strengthen and tune an organization using feedback and insight. It is essentially a process of repair. Here are the patterns and their connections to each other:


Size The Organization
Phasing It In
Solo Virtuoso
Self Selecting Team
Few Roles
Apprentice Ship
Engage Customers
Diverse Groups
Skunk Works
Day Care
Generics And Specifics
Developing In Pairs
Surrogate Customer
Engage Quality Assurance
Unity Of Purpose
Domain Expertise In Roles
Holistic Diversity
Public Character
Fire Walls
Build Prototypes
Patron Role
Application Design Is Bounded By Test Design
Compensate Success
Subsystem By Skill
Legend Role
Matron Role
Gate Keeper
Manager Role
Scenarios Define Problem
Failed Project Wake
The Water Cooler
Moderate Truck Number
Wise Fool
Group Validation
Stand Up Meeting

Note, perhaps surprisingly, that *none* of these patterns have fundamental ties to software development. They are applicable to any design activity: any activity where a group of people is building something to solve a problem. They are equally applicable to software services as to building product; to hardware development as to software development. They are patterns about human nature and human organizations, about the ways that people come together to solve problems.

A Story About Piecemeal Growth

When I started to plan the Q project, I wanted small core team of architects, so I employed SIZE THE ORGANIZATION (4.2.2) with an eye to PHASING IT IN (4.2.3) through APPRENTICESHIP (4.2.4) with other staff later on. The project was too large for a SOLO VIRTUOSO (4.2.5) approach — though we would use that pattern later to flesh out a prototype. I put forward the opportunity and made it possible for people to sign up; there was no corporate or management compunction to join. Hence, it was a purely SELF SELECTING TEAM (4.2.11), started as a SKUNK WORKS (4.2.14) under management radar.

My main job as project coordinator was to put up the FIRE WALLS (4.2.9) to management until we had our act together. But my second job was to make sure we got a good group of people to the end of HOLISTIC DIVERSITY (4.2.19). We brought in Lalita for her work in scripting languages and their environments; Peter for his architectural expertise. Later we decided we needed market domain knowledge, and that's when we brought on Jim and Beki in the interest of having DOMAIN EXPERTISE IN ROLES (4.2.22). The recruitment strategy was always one of ferreting out matches of interest that would excite the players, amplified by the new nature and somewhat subversive approach of the opportunity. Team pride was an emergent property of this process. We also had our own value system and model of rewards: all team members would share credit for any patents that were issued, and we would seize a leadership role in the organization. We also knew we were catering to the organization's product interests, and that would be rewarded: COMPENSATE SUCCESS (4.2.25).

Beki served as the GATE KEEPER (4.2.10), bringing in ideas from the AOL Instant Messenger world, interviewing (child!) users of the system, and bringing in knowledge of the organization and market opportunities. She and I split duties of PUBLIC CHARACTER (4.2.17) and MATRON ROLE (4.2.18).

We moved forward on design using CRC cards to formulate an architecture, employing SCENARIOS DEFINE PROBLEM (4.2.8) and GROUP VALIDATION (4.2.32). The goal was to get the project "running" on CRC cards and then to implement a first, simple cut in a one- or two-day programming session, all together in one room, doing DEVELOPING IN PAIRS (4.2.28). The CRC cards were given to individuals best suited to those areas, exemplifying both DOMAIN EXPERTISE IN ROLES (4.2.22) and, to the degree one could talk about subsystems at that point, SUBSYSTEM BY SKILL (4.2.23).

At our (frequent) meetings we made sure that work was spread around evenly. We did most things in a group to make sure that the specialization didn't get out of hand. We occasionally traded off CRC cards, all in the interest of having a MODERATE TRUCK NUMBER (4.2.24).

At some point in the process, people felt that the CRC cards weren't enough and that we needed to document the scenarios. We used ping-pong diagrams to do this, first on whiteboards, then using a formal documentation tool (SCENARIOS DEFINE PROBLEM (4.2.8)). But this was done in a SACRIFICE ONE PERSON (4.1.22) mentality, shades of MERCENARY ANALYST (4.1.24) (we were too small to enlist a full fledged MERCENARY ANALYST (4.1.24), but we faked it).

Lalita went away as a SOLO VIRTUOSO (4.2.5) to BUILD PROTOTYPES (4.1.7). The prototype ended not being terribly gee-whiz and it failed to energize the team to take the next steps forward, and things came to an impasse, particularly in light of competing priorities on other development projects.

Dysfunction struck the organization in the untimely departure of Beki and Peter from the project, and afterwards, in Lalita's promotion out of the project. Jim took the ideas forward into another project but took no other people with him. We did not have a FAILED PROJECT WAKE (4.2.26) — perhaps we should have. We didn't get so far as to run the development exercise as a team in a room, at which point INTERRUPTS UNJAM BLOCKING (4.1.25) and DON'T INTERRUPT AN INTERRUPT (4.1.26) would have become important.

4.2.1 Community Of Trust

See Section 4.1.1.

4.2.2 Size The Organization **

...within a larger organization, usually that of a sponsoring enterprise or company, there need to be smaller organizations capable of creating large software systems (greater than twenty-five thousand lines of code) that meet competitive cost and schedule benchmarks. This pattern shows how the proper sizing of an organization is vital to the health of the project and the productivity of its people.

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Large software projects (greater than twenty-five thousand lines of code) are seldom delivered on time and within budget when the development team is too large or too small.

There are two arguments that have led us to this conclusion:

1. There are limits to the size of software development teams that allow them to work effectively. A team can handle a larger problem than an individual can ([BeyerHoltzblatt1998], p. 4).
2. Adding people late to a project rarely helps complete that project on time and within budget.

1. If a software development team is too large, you can reach a point of greatly diminishing returns. We have found empirically that an organization's size affects a deliverable non-linearly. Communication overhead goes up as the square of the size, which means that the organization becomes less cohesive as the square of the size while the "horsepower" of the organization goes up only linearly.

In addition, if the organization is too small, the team won't have critical mass and productivity will suffer. Projects larger than 25KSLOC can rarely be done by a SOLO VIRTUOSO (4.2.5) and overly small organizations have inadequate inertia and can easily become unstable.

However, experience has shown that a suitably selected and nurtured small team of around 10 people can provide a suitable critical mass with a capacity to develop a 1,500 KSLOC project in 31 months, a 200 KSLOC project in 15 months, or a 60KSLOC project in 8 months.

Keeping the organization small makes it possible for everybody to have knowledge of how the project works ("global knowledge"). We have found empirically that most roles in a project can handle interactions with about six or seven other roles; with 10 people, you can almost manage total global communications (and a fully connected network may not be necessary).

Projects that do well have processes that adapt, and processes adapt well only if there is widespread buy-in and benefit. The dialogue necessary to buy-in and benefit can accrue only to small organizations. Tom De Marco has noted that everybody who is to benefit from process should be involved in process work and process decision-making.

Further study might evaluate the relationship between this pattern and Alexander's THE DISTRIBUTION OF TOWNS ([Alexander1977], ff. 16) and related patterns. Here, we stipulate that the social organization must be small; it reflects a SUBCULTURE BOUNDARY ([Alexander1977], ff. 75) and IDENTIFIABLE NEIGHBORHOOD ([Alexander1977], ff. 80). Alexander emphasizes the grander architectural context that balances support for the ecology with the economies of scale that large towns can provide, while supporting the xenophobic tendencies of human nature. Small organizations like that being built here rarely exist in isolation, but in the context of a broader supporting organization. This relationship to the larger organization invokes PATRON ROLE (4.2.15).

2. Adding people late to a project rarely helps complete that project on time and within budget.

One manager writes: “On [one] project, I grew from 10 to 20 people to meet a customer contract....with new people, [I] wound up three months late because of ‘absorption’ of new folks into the organization.”

Many software development cultures support technical manager groups up to around 10 people. Adding more people would force a group split, which can cause a large decrease in productivity, all other things being equal. We have also found that a single team is better than a collection of sub-teams. The faster a team breaks up into sub-teams worrying about their own responsibilities rather than those of the larger team, the less effective the enterprise will be as a whole.

Therefore:

By default, choose about ten people to establish critical mass in the development of large software systems and avoid adding individuals late in the game, or trying to work backwards from a completion date.

Experts vary on the exact number; the number 10 has a bit of tradition associated with it, but numbers like 6 or 7 are also common. Two is too small, and 13 is too big.

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Having 10 people at the start of a large project can be overkill, but it avoids the expense and overhead of adding more people later. However, once a core team establishes an identity, it can grow graciously by PHASING IT IN (4.2.3) or using APPRENTICESHIP (4.2.4). The organization can generate knowledge early on by building and throwing away a prototype (see BUILD PROTOTYPES (4.1.7)). To decide *whom* to hire into the nascent organization, use patterns like DOMAIN EXPERTISE IN ROLES (4.2.22) and ARCHITECTURE TEAM (5.2.4). SMALL WRITING TEAM (10.5.27) [Bramble2002, p. 31] suggests that two or three people be used to write the use cases; others will be in other roles.

Astute readers might consider this pattern and remark, “You have a strange idea of what constitutes a large project! I can see this working for projects that will grow to thirty or forty people and maybe a few tens of thousands of lines of code. But how about for really large projects?”

First, it’s important to understand that there are few real software development teams that are larger than a few dozen people; larger projects almost always self-organize into subcommunities (Divide And Conquer (5.1.6)). But even the largest projects start with an idea, and an idea starts with an individual or a small group of people. This pattern says that a small group should take the project as far as they can before other staff are actively engaged. One of course must anticipate the point of diminishing returns for the seed team and seek people early enough so they will be available and ready when they are needed. And of course people should be brought on gradually (see Phasing It In, Day Care (4.1.23), etc.) But start small, and stay as small as possible as long as possible. Large systems grow from small systems that work.

Second, remember that it is imperative to have Few Roles (5.1.2). With ten people, it is easy to define and fill half a dozen or so roles. But with a large initial team, people will at first be at a loss as to what to do, until they receive assignments (and you can't give everyone an assignment all at once.) So they will find something to do, and will tend to invent roles for themselves. It's a good way to create deadbeat roles.

Joe Walters said that a project shouldn't grow larger than the size of the auditorium of the building where the project is centered.

Staff sizing complete, the project can Size The Schedule (4.1.2).

4.2.3 PHASING IT IN **

... key project players have been hired or otherwise brought into the project and cover the necessary expertise (DOMAIN EXPERTISE IN ROLES (4.2.22)) but the project needs more staff.

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Growing projects must figure out how to grow long-term staff: whom to hire, how many to hire, and when to hire them. Projects must ramp up while minimizing the pains of growth.

You need enough people for critical mass. Yet you cannot just hire anyone off the street; staff are not plug compatible and interchangeable.

The right set of initial people (SIZE THE ORGANIZATION (4.2.2)) sets the tone for the project, and it's important to hire the key people first. You need a critical mass of key people early on. Yet too many people too early create a burden for the core team.

Therefore:

Phase the hiring program. Start by hiring people to meet the basic core competencies of the business and gradually bring on new people as the project needs to grow.

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The organization can staff up to meet development load. This pattern is closely related to APPRENTICESHIP (4.2.4) and to MODERATE TRUCK NUMBER (4.2.24). DAY CARE (4.1.23) can be applied to help with the training and mentoring load that new employees place on the organization.

This is a well-known management technique that allows the project to establish an identity early on, and to grow graciously.

Larry Putnam points out that projects that grow very quickly at the beginning tend to be late. He advocates growing staff gradually. [Putnam1992].

In *The Mythical Man-Month* Brooks states, “V. A. Vyssotsky of Bell Telephone Laboratories estimates that a large project can sustain a manpower buildup of 30 percent per year. More than that strains and even inhibits the evolution of the essential informal structure and its communication pathways.” [Brooks1995], page 293.

What constitutes “core competencies?” Part of this depends on the business you are in. If you are in finance, you want people who can develop financial software. The better people you can get early on, the better off you will be, and it is probably a good return on investment to spare no expense on talent at this early stage. Talent isn’t limited to domain knowledge, though; you also need individuals who can put customers at ease, who can keep a cool head for strategic planning, who can “fill in the cracks” by doing the miscellaneous detailed tasks that others don’t want to do or forget to do, etc. Many individuals have many of these talents; the key is to cover the crucial needs early on with as few people as possible, and to grow the organization once that organization has gelled (see STABLE ROLES (5.1.5)). You can achieve these goals with HOLISTIC DIVERSITY (4.2.19) and DIVERSE GROUPS (4.2.16).

4.2.4 Apprenticeship *

...the project is incrementally staffing up after the first round of experts have been brought on board.

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A project must balance its need for growth with its need to develop and maintain deep domain expertise. You need enough people for critical mass. However, staff are not plug compatible and interchangeable. And academic training and prior experience are rarely, in themselves, adequate preparation for competent work at a new task.

Therefore:

Turn new hires into experts (see Domain Expertise In Roles (4.2.22)) through an apprenticeship program. Every new employee should work as an apprentice (not just a mentee) to an established expert. Most apprenticeship programs will last six months to a year—the amount of time it takes to make a paradigm shift.

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It will be possible to maintain expertise in the organization. This pattern also reduces the organization's "truck number" (the smallest number of people such that, if any one of them were hit by a truck, the organization will have lost a critical resource; see MODERATE TRUCK NUMBER (4.2.24)) by spreading knowledge around. The "masters" feel valued and the apprentices are given a good environment to learn.

Manage drain on expert staff resources with DAY CARE (4.1.23).

DEVELOPING IN PAIRS (4.2.28) is often used as an effective APPRENTICESHIP technique.

It is better to apprentice people than to put people through a "trial by fire" that may damage the project. The apprenticeship approach makes it possible to form domain-specific teams, and it is important to keep the team concept as a central part of organizational values.

4.2.5 Solo Virtuoso *

. . . we have described optimal sizes of organizations needed to create large software systems on time and within budget — Size The Organization (4.2.2). The following pattern explains what to do for smaller systems (less than twenty-five thousand lines of code), when a product must still be created on time and within budget, but when rapid growth is not anticipated after the first release.

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When a smaller software project (less than twenty-five thousand lines of code) is overstaffed, communication overhead increases and talented individuals, who could produce the software entirely on their own, are bridled, their "horsepower" diminished.

We have said that organizational size affects the deliverable in a non-linear manner (Size The Organization (4.2.2)). We have also observed that communication overhead goes up as the square of the size, which means that the organization becomes less cohesive as the square of the size while the "horsepower" of the organization goes up only linearly.

The question then is, what organizational size works best for smaller software projects?

The answer depends on the individual(s) involved in the project. The productivity of a single individual can be higher than that of a collection of productive individuals. We have seen single-person developments generate 25KSLOC of deliverable code in 4 months (a craft interface for a telecommunication system); two-person developments do 135 KSLOC in 30 months. Many of these adhered faithfully to all stipulated reviews and verification steps.

Boehm [Boehm1981] notes a 20-fold spread between the least and most effective developers. A telecommunications developer recently told me that "having the right expertise means the difference between being able to solve a problem in a half hour, and never being able to solve the problem at all."

(Note: Boehm quotes Grant and Stackman [Grant1966] with a 26-fold spread, page 667.)

The result of using a SOLO VIRTUOSO (4.2.5) is an organization limited to small development. Though there is a singleton development role, other roles may be necessary to support marketing, toolsmithing, and other functions. The productivity of a suitably chosen singleton developer is enough to handle sizable projects; here, we establish 25KSLOC as a limit.

Therefore:

Do the entire design and implementation with one or two of your most effective developers.

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This pattern is not a "License to Hack." The work of SOLO VIRTUOSOS (4.2.5) is still subject to technical reviews, validation, and verification at appropriate times in the development cycle — STAND UP MEETING (5.2.7), ENGAGE CUSTOMERS (4.2.6). This combines nicely with DEVELOPING IN PAIRS (4.2.28).

See also MODERATE TRUCK NUMBER (4.2.24), which raises concerns about the use of this pattern in risk-averse business.

4.2.6 Engage Customers **

Clerk measuring customer for a suit of clothes, San Antonio, Texas.

A friend of one of the authors once designed and implemented the user interface for a large system. He got input from customers on how to make it useful for them. Unfortunately, the requirements writers had a different idea, and made him remove the features the customers liked. But then the customers asked for the missing features, and the requirements writers were forced to relent. I guess it didn't help relations between my friend and the requirements writers.

...an organization is in place, and its Quality Assurance function has been generally shaped and chartered. The Quality Assurance (QA) function needs input to drive its work. Many people in the enterprise are concerned about quality.

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It's important that the development organization ensures and maintains customer satisfaction by encouraging communication between customers and key development organization roles. This isn't the responsibility of any single "customer satisfaction" organ, but the need pervades the entire organization structure. Most organizations are averse to direct contact between developers and customers, fearing that the developers are "loose cannons on deck" who will promise to deliver things that go beyond the scope of a job.

Yet you can't know all the requirements up front, so developers need to keep going back to customers for more information—and customers need to keep coming back to developers with their insights, particularly when developers Build Prototypes (4.1.7). Requirements changes occur even after design reviews are complete and coding has started.

Many organizations depend on their marketing organization to provide requirements and needs. But marketing doesn't provide design data (BeyerHoltzblatt1998], p. 30). The best that marketing can do (or *should* do) is to understand what will sell and why people will buy what you want to sell. Designers in turn must understand how people will use the product in a way that creates value for them. Good value sometimes leads to good market potential, but marketing usually looks at other factors (brand name recognition, product name and posturing n the market) about which designers care little.

Missing customer requirements are a serious problem: most problems in software systems can be traced to requirements problems ([Daley1977]; [Boehm1976]). Yet it seems like so much effort to elicit them — which is work that is not directly producing a marketable artifact. It seems like makework and overhead.

Customers are traditionally not part of the mainstream development, which makes it difficult to discover and incorporate their insights. Yet customer contact correlates with project success [KeilCarmel1995].

Trust relationship between managers and coders are often strained, so you don't want them to be the sole intermediary between developers and customers.

Therefore:

Closely couple the Customer role to the Developer and Architect, not just to QA or marketing. In short, developers and architects must talk freely and often with customers. When possible, engage customers in their environment rather than brining them into your environment.

Two things are necessary for this to happen: opportunity and culture. Developers must have the opportunity (and the means) to communicate with customers. They should meet customers personally to establish trust and free flow of communication.

But these visits will be superficial if the organization culture builds walls between customers and developers. In particular, if system requirements must go through a lengthy formal process to be approved, the developer will be hamstrung — unable to respond to customer requests. Therefore, the organization must develop a culture where developers have some latitude to respond to customers. This is not saying, however, that all control of requirements should be relegated to the developer. Order is necessary.

Beyer and Holtzblatt note that "many common ways of working with customers remove them from their work." ([BeyerHoltzblatt1998], pp. 36-7). One way to help this is by "putting designers and engineers directly in the customer's work context" ([BeyerHoltzblatt1998], p. 20). This is particularly important if you are using customer engagement to create wholly new market directions for the enterprise, rather than refining existing work. Putting developers in the customer work environment also trains developers' intuition about good design and good human interfaces, and this intuition can fill in when specific detailed requirements are unavailable [BeyerHoltzblatt1998], p. 35).

Language is a key element of culture that can smooth customer engagement if treated properly, and smother it if treated badly. Don't make your customers learn UML or other technical notations; do your best to learn *their* language and to communicate with them in the terms of *their* culture.

QA can monitor the relationship to keep the direction within contractual business limits, while allowing a free flow of insights back and forth between developers and customers. Such communication can often flow unimpeded; however, see the pattern GATE KEEPER (4.2.10).

Note that this pattern is all about relationships and culture. It is the culture of respect for and communication with customers that makes the communication effective, for example, during the writing of use cases, as described in PARTICIPATING AUDIENCE (10.5.20) ([Bramble2002], p. 35).

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This pattern supports requirements discovery from the customer, as required by SCENARIOS DEFINE PROBLEM (4.2.8) and BUILD PROTOTYPES (4.1.7). Other patterns like FIRE WALLS (4.2.9) also build on this pattern. The pattern RECOMMITMENT MEETING (4.1.12) is a more formal derivative of this pattern in a different context.

A good understanding of customer needs can avoid rework after implementation is done. While it is also important to continuously engage customers through each development episode of iteration, early understanding helps launch the effort in the right direction. A Navision project in Copenhagen felt that improvements in customer engagement helped save time on their development schedule (from a draft pattern "Scandinavian System Development" by Flemming Pedersen, 24 January 2002).

This was a strong pattern in the Borland Quattro Pro for Windows case study. Also, see [Floyd1992] and in particular the works of Reisin and Floyd therein.

Some processes and methods are founded on customer engagement, such as IBM's Joint Application Development. Other methods are conducive to customer engagement, such as Cunningham and Beck's CRC design technique. Other methods, and especially most CASE-based methods, are indifferent or harmful to customer engagement.

Even some of the best customer engagement techniques tend to stop once they achieve some level of contractual agreement about what is to be delivered. Customer engagement in agile processes goes far beyond that. Developers need to assimilate the context in which their product will be used: this is called *contextual design*. Contextual design means gathering data on customers' models of how they do their work rather than creating models of how the program will solve the problem. Use Cases are about the latter; contextual design is about the former. See [BeyerHoltzblatt1998].

The pattern is "ENGAGE CUSTOMERS", in the plural, to support a domain view and to avoid being blind-sided by a single customer.

The project must be careful to temper interactions between Customer and Developer, using FIRE WALLS (4.2.9), GATE KEEPER (4.2.10), and the QA organizational presence as in ENGAGE QUALITY ASSURANCE (4.2.29). A big part of interacting with the customer is to learn how they want to interact with the project as the unfolding software uncovers problems in requirements and systems engineering (see APPLICATION DESIGN IS BOUNDED BY TEST DESIGN (4.2.30)).

Note that "maintaining product quality" is not the problem being solved here. Product quality is only one component of customer satisfaction. Studies have shown that customers leave one company for another when they feel they are being ignored (20% of the time), or because the attention they receive was rude or unhelpful (50% of the time). For customers having problems that cost over $100 to fix, and the company does not fix it, only 9% would buy again. 82% would do business with the company again if the problem was quickly resolved after they complained. (The source for the former pair is The Forum Corporation; for the latter pair, Traveler's Insurance Company [ZuckermanAndHatala1992].)

Joe Maranzano [Maranzano1992] notes that this pattern probably should come earlier in the language. However, it is important that the project roles be defined first—particularly those that interact with the customer, and those that are driven by customer input (such as Quality Assurance). Said in another way, the organization exists to serve the customer, so the organization should be in place before the customer is fully engaged.

This pattern works only if customers are directly accessible to the development team. If that is impossible for business reasons or because of geographic separation, consider SURROGATE CUSTOMER (4.2.7).

4.2.7 Surrogate Customer *

Store dummy displaying Daniel Boone hat, fur trimming detachable, suitable for auto aerial plume (advertisement). Amsterdam, New York.

...the project is beginning to move forward. As architects and developers get deeper into the project, requirements questions begin to surface.

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It is important to exchange ideas and clarify issues with customers. But a customer may not be available.

There are several reasons that a customer may be unavailable. If the project is new, there may be no customers yet. In fact, the product might even create its own customers. Even in existing products, the organization may never have established relationships with customers, and now is not a propitious time to do so.

In some cases, the customer might not have the time right now. They're busy too. But you need answers immediately.

Some corporate cultures are such that the developers are insulated from the customers; they just don't talk. We certainly aren't recommending it, but it does happen.

Whatever the cause, there is a temptation for developers to make their best guess and go on. The problem is that developers are naturally biased by their own designs, and will assume customer behavior that conforms to their design. There are always other ways to think about the application, some of which may not mesh with the developer's view.

Therefore:

Create a SURROGATE CUSTOMER role in the project, and fill it with someone who will try to think like the customer. Use the SURROGATE CUSTOMER like the real customer.

If the organization has human factors people, they are almost natural Surrogate Customers. Their emphasis may be on the human interface, but that is often much of the battle.

System Test organizations are similar to SURROGATE CUSTOMERS, but there are important differences in intent. System testers tend to evaluate a product with respect to a specification, to determine its readiness for market. Customers, real or surrogate, are interested in whether the product meets their need and is easy to use.

Fellow developers tend to make poor SURROGATE CUSTOMERS. Developers think too much alike (but see below).

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Of course, no SURROGATE CUSTOMER will ever replace a real customer. But they allow the project to move ahead in the absence of more concrete information. For more reading on the limitations of the SURROGATE CUSTOMER role, see [ConstantineLockwood1999] and [Bramble2002].

Perhaps a perfect ideal comes where the developers are themselves customers or SURROGATE CUSTOMERS, if one can overcome the nerdish groupthink owing to their identity as developers. See CREATE RATHER THAN CONFORM (8.9) in the Quattro Pro for Windows case study.

Most organizations seat the SURROGATE CUSTOMER with the development team; this role is often a member of the development team. Consider instead seating developers at the customer site to avoid the problem described in the book *Contextual Design* ([BeyerHoltzblatt1998], p. 34):

> Many IT departments avoid these problems by stationing IT developers with the customer organization. This certainly succeeds in making IT more responsive to the customer, but

brings a loss of control.. The developers easily become focused on short-term problems and soltions—they tend to become the local fix-it man. The structure of the customer's work and long-term possibilities for improvement are no more visible to IT developers than to the customer, and without this perspective they, like the customer, focus on the immediate and most visible issues. And they are stationed in a particular department, so cross-departmental issues are as invisible to them as to their customers. They are rewarded for producing quick fixes to pressing problems. The usual result is doezens of small applications, each solving a single problem, that do not work together to support the work coherently.

4.2.8 Scenarios Define Problem *

Discussing a worst-case scenario...

How do you know a programmer is extroverted? He stares at YOUR shoes when he talks to you.

...you want to engage the customer and need a mechanism to support other organizational alliances between customer and developers.

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Design documents are often ineffective as vehicles to communicate the customer vision of how the system should work.

There is a natural business distancing and mistrust between customers and developers. Communication between developers and customers is crucial to the success of a system.

Therefore:

Capture system functional requirements as use cases.

It is obvious that use cases help increase understanding of the requirements, but a less obvious aspect of this is that they help set boundaries of the problem. This became clear as one of the authors

(Neil) consulted with a group who was writing patterns of use cases. When I questioned a member of the group what problem use cases solve, I got an unsatisfying answer. I probed deeper by asking how the situation would look if one didn't apply use cases, and he responded, "You wouldn't know where to start, because the problem would be too broad." Interestingly, he had never thought about use cases as a tool to bound the problem until that point.

Use cases do not capture success scenarios alone, but all the scenarios that the system must deal with. There is no such thing as an exceptional case; make the exception the rule. Interview enough constituencies to get full coverage of the expectations of users and other stakeholders. Use cases also can, should, and almost certainly must be augmented with non-functional requirements.

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It is easy to see that this is a good idea, but what does this have to do with organizations? One of the tensions in many organizations is that the developers are, well, geeks. Many don't have particularly good communication skills, or, more precisely, aren't particularly interested in interpersonal communication. So it is difficult to communicate requirements to developers. Scenarios work. So if you really want to ENGAGE CUSTOMERS (4.2.6), this pattern makes it much easier.

The problem is now defined, and the architecture can proceed in earnest. You can use scenarios as a means of dialogue and requirements clarification with your users, particularly when building and demonstrating a system or subsystem prototype. For more on this, see CATALYTIC SCENARIOS in the DEMO PREP (10.5.9) pattern language from Todd Coram [Coram1996].

Also read about the MERCENARY ANALYST (4.1.24), who captures scenarios and uses them for project documentation (both internal and external).

[Cockburn2000] is one of the most acclaimed references on use cases. Also see CACM Nov. '88 (v. 31, no. 11) pp 1268-1287, according to Ralph Johnson. Also Rubin and Goldberg [GoldbergRubin1995], who take scenarios all the way to the front of the process preceding design. See also [HsiaSamuelGaoKung1994].

4.2.9 Fire Walls **

Nobody gets past this point without my permission!

"A manager should be like the sweeper in curling: The sweeper runs ahead of the stone and sweeps away debris from the path of the stone so that the progress of the stone will be smooth and undisturbed — does this sound like your manager?" [Gabriel1996]

Unfortunately, heavy human use in this same area could lead to bear/ human interactions which could injure humans and cause management actions against the bear. — Sign at an entrance to Boulder Mountain Parks, Boulder, Colorado

...an organization of developers has formed in a corporate or social context where they are scrutinized by peers, funders, customers, and other “outsiders.” Project implementors are often distracted by outsiders who feel a need to offer input and criticism.

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It’s important to placate stakeholders who feel a need to “help” by having access to low levels of the project, without distracting developers and others who are moving towards project completion

Isolationism doesn't work: information flow is important. But communication overhead goes up non-linearly with the number of external collaborators.

Many interruptions are noise.

Maturity and progress are more highly correlated with being in control than being effectively controlled.

Therefore:

Create a MANAGER ROLE, who shields other development personnel from interaction with external roles. The responsibility of this role is "to keep the pests away."

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The new organization isolates developers from extraneous external interrupts. To avoid isolationism, this pattern must be tempered with others, such as ENGAGE CUSTOMERS (4.2.6) and GATE KEEPER (4.2.10).

This pattern was present in both BORLAND QUATTRO PRO FOR WINDOWS (CHAPTER 8) and in A HYPERPRODUCTIVE TELECOMMUNICATIONS DEVELOPMENT TEAM (CHAPTER 9). See also the pattern ENGAGE CUSTOMERS (4.2.6), which complements this pattern.

GATE KEEPER (4.2.10) is a pattern that facilitates effective flow of useful information; FIRE WALLS restricts detracting flow of (even potentially useful) information. You need a balance between them. In the park in Boulder, people (customers) come to see nature, and bears are a part of that nature. But if the customers interact too closely with the core contributors—to the point where it is a distraction—things can get out of control. Developers need information, and they can take advantage of customer contacts and GATE KEEPERS to get the information they need. But they can also use managers as a shield. Furthermore, managers may need to step in to "help" developers who may be afraid to ask not to be bothered by customer contacts, or who are at risk of not fulfilling their own responsibilities if they are embroiled in customer matters.

Be warned that if the organization fills this role with someone motivated largely by personal power, the potential damage to the organization can be large. If other roles like GATE KEEPER maintain good contact with other organizations, communications are more likely to remain open and FIRE WALLS will more likely be called to account for self-serving actions.

Sun Tzu notes: “He will win who has military capacity and is not interfered with by the sovereign.” [SunTzu1989]

4.2.10 Gate Keeper **

... an organization of developers has formed, in a corporate or social context scrutinized by peers, funders, customers, and other “outsiders.”

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A project must develop good interfaces with the many outsiders with whom it interacts, or with whom it should interact.

Most software development professionals — particularly programmers — are more comfortable interacting with their software and working with technology than working with people. Yet isolationism doesn’t work: information flow is important. On the other hand, communication has a cost: communication overhead goes up non-linearly with the number of external collaborators. That wouldn’t be so bad if so many interruptions weren’t noise. And an organization should be in control of its external interactions rather than letting the external interactions control it; that is a hallmark of organizational maturity.

Therefore:

One project member, a Public Character (4.2.17) with an engaging personality, rises to the role of Gate Keeper. This person disseminates leading-edge and fringe information from outside the project to project members, “translating” it into terms relevant to the project. The Gate Keeper may also “leak” project information to relevant outsiders.

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This role can also manage the development interface to marketing and to the corporate control structure.

This pattern provides balance for the pattern FIRE WALLS (4.2.9), and complements the pattern ENGAGE CUSTOMERS (4.2.6) (to the degree Customers are still viewed as outsiders).

GATE KEEPER and FIRE WALLS (4.2.9) alone are insufficient to protect developers in an organization whose culture allows marketing to drive development schedules. This role can be made explicit in large projects whose budget and staffing profiles support funding and support for such a role. But the role can also thrive informally in the margins.

GATE KEEPER is a pattern that *facilitates* effective flow of useful information; on the other hand, the *FIRE WALLS (4.2.9)* role *restricts* flow of detracting information. As described in FIRE WALLS, a self-serving person who works their way into this role can do much damage. It is probably healthier for the organization if this role is filled by someone who is not part of the management establishment, because it is more likely that peer support will sustain that person in the role, and it is more likely that the person will remain responsive to his or her constituencies. But respected managers also make great GATE KEEPERS.

The GATE KEEPER pattern has empirical value. In the discussion of this pattern at PLoP/94, many of the reviewers noted that creating a GATE KEEPER role had served their organizations well.

Engineers are lousy communicators as a lot; it's important to leverage the communication abilities of an effective communicating engineer when one is found.

Alexander notes that while it is important to build subcultures in a society (as we are building a subculture here in the framework of a company, or of the software industry as a whole), such a subculture should not be closed (MOSAIC OF SUBCULTURES, [Alexander1977], ff. 42); also, cp. Alexander's pattern MAIN GATEWAYS ([Alexander1977], ff. 276).

One might muse that the GATE KEEPER takes an outsider through any rites of passage necessary for more intimate access to the development team, by analogy to Alexander's ENTRANCE TRANSITION ([Alexander1977], ff. 548). GATE KEEPER can serve the role of "pedagogue" as in Alexander's pattern NETWORK OF LEARNING ([Alexander1977], ff. 99).

Joe Maranzano (personal interview, 1992) notes that the same person often must fill both the MANAGER ROLE and GATE KEEPER roles, because of the relationships to external people who need the info.

If the GATE KEEPER (4.2.10) function starts taking on an aura of stability and legitimacy in its own right, it might point to the fact that there are key business issues that cut across the existing organizations. Look at FUNCTION OWNER AND COMPONENT OWNER, as well as UPSIDE DOWN MATRIX MANAGEMENT (5.1.19), as solutions that broaden the GATE KEEPER function to organizational scope.

4.2.11 Self Selecting Team **

Japanese-American volunteers taking oath of induction.

I had applied for a job in a different part of the company. It was forward-looking work in a small team. The manager was happy to take me, but it wasn't until the team had interviewed me that I got the job.

... Size The Organization (4.2.2) revealed the need for a small, select team. How do you staff such a team?

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The worst team dynamics can be found in appointed teams.

There are no perfect criteria for screening team members. Yet broad interests (music and poetry for, example) seem to indicate successful team players. Teams staffed with such individuals are often willing to take

extraordinary measures to meet project goals.

However, when such interests are ignored, or when team members are appointed, team dynamics can suffer, greatly diminishing the productivity of a team.

Therefore:

Create enthusiastic teams by letting people select their own teams. Do limited screening on the basis of track record and broader interests.

Such teams often, but not always, come about of their own volition. Sometimes, a Patron Role (4.2.15) or other leader can seed the idea of such a team first as a rallying point for the formation of the team.

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A Solo Virtuoso (4.2.5) or Apprenticeship (4.2.4) role may self-select a team. Form Follows Function (5.1.11) can give such a team its structure. Diverse Groups (4.2.16) can help in the screening process. Temporary Self Selecting Teams can come together to work on Programming Episodes (4.1.19).

A Skunk Works (4.2.14) is a special kind of Self Selecting Team that comes together to share high risk on behalf of the organization.

Self-selection can and should happen at finer granularity than teams, too; see, for example, Deploy Along The Grain (5.2.8).

This is different from "empowered teams." Research has shown that empowerment leads to communication locales that can become blindsided to the broader context of surrounding teams and can unnecessarily narrow the communication channels between teams, though it may increase it within teams [Yates1995].

One danger to be aware of is that an exclusive group of friends may build a team from their own numbers, failing to take advantage of others' skills. The Patron Role (4.2.15) can monitor these dynamics.

4.2.12 Unity Of Purpose **

...the team is beginning to come together. Team members may come from different backgrounds and may bring many different experiences.

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Many projects have rocky beginnings as people struggle to work together.

Often, the people have different ideas about what the final product should be. In fact, the final product may well be a pretty fuzzy concept. Yet the people must have a consistent view of the product if there is any hope of it getting done.

Each person is different and has different views and opinions. They come with different backgrounds and experiences. They must learn to work together.

It is important to get off to a good start — initial impressions, good or bad, tend to be lasting.

Therefore,

The leader of the project must instill a common vision and purpose in all the members of the team. This “leader” can be a manager, or the Patron Role (4.2.15), or a customer advocate, but should be someone who holds the team’s respect and who has influence over the team’s thinking. This is an overt action; you can’t count on it happening automatically. The leader should make sure everyone agrees on the following: What is the product supposed to do? Who are the customers, and how will it help them? What is the schedule, and everyone must feel personally committed to the schedule. Who is the competition?

An important component of this action is to identify strengths of the team, and use them as rallying points as well. This is related to identifying the challenges and competition, and uniting to overcome and surpass them.

As time goes on, the UNITY OF PURPOSE continues to emerge from ongoing dialogue within the team and with customers and other stakeholders. While the team leader primes the pump, team dynamics take over and keep things going.

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The obvious result is that the team is on the same page, and is working together, rather than at cross purposes. But a more subtle, but probably more powerful effect is what it does for the morale of the team. The best teams tend to feel that they are somehow better than others — and they work to prove it!

This pattern relates to some deep-seated principles and values of organizational health. There may be no more important single property of an organization than that its members have a shared vision they are motivated to achieve. Communication—which receives the bulk of the attention in this book—is just a means to achieving that shared vision. UNITY OF PURPOSE is a deeper principle even than effective communication; communications are just a means to UNITY OF PURPOSE.

Related Patterns:

SHARED CLEAR VISION (10.5.25) ([Bramble2002], p. 80) notes the importance of a clear vision in creating unity, from the point of view of writing use cases. SELF SELECTING TEAM (4.2.11) outlines how a team should come together, but that alone is insufficient to achieve UNITY OF PURPOSE. LOCK 'EM UP TOGETHER (5.2.5) helps achieve unity, particularly of architecture. A GATE KEEPER (4.2.10) can help. It can help the team be more unified on what requirements to ENGAGE CUSTOMERS (4.2.6). This pattern sets up COMPENSATE SUCCESS (4.2.25): it's much easier to compensate success when everyone knows what success means. And while UNITY OF PURPOSE is important to galvanize the team, effective team dynamics can come only if every team member is also valued as an individual: HOLISTIC DIVERSITY (4.2.19) comes to play here.

4.2.13 Team Pride **

Problems worthy

of attack

prove their worth

by hitting back.

—Piet Hein (1905-1996)

... you are about to embark on yet another challenging project. The work will be technically difficult, or maybe it's just that you have a very short schedule. But at least you have some idea of what you want to do — the beginning of Unity Of Purpose (4.2.12).

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People are most successful when they feel good about their project, and are confident. But there is a chicken and egg problem here: Confidence breeds success, but success creates confidence.

Pride perhaps goeth before a fall, but so doth apathy.

Most software projects—sometimes even the fun ones—demand a lot of work. And the ones that aren't fun don't have much of a chance of seeing a victorious finish unless something pulls its people together and draws them on towards completion. The hard work feels even harder because of short schedules. Such projects demand the best everyone can give, so motivation is often a key to success.

If people consider the work to be "just a job", the results will reflect it.

Teams tend to become self-fulfilling prophecies: everyone wants to work on a winning team, so teams can pick the best people. On the other hand, teams with low performance tend to be stuck with low morale. People don't join such teams willingly; they come in with a bad attitude.

So how do you bring such a team out of the doldrums? Even better, how do you give a team a winning attitude right from the start?

Therefore,

"We're the best." Instill a sense of elitism into the team. Teams that have a certain arrogance tend to work hard and accomplish what is put before them.

Really, one cannot open a team up and pour in a cup of team pride. Team pride must come from within. But there are many things you can do to help it come to pass:

- Start with a worthwhile problem. Team members are more likely to feel elite if they have a challenging problem to tackle. It is especially good if the problem involves new technology; nothing excites a bunch of geeks more than working with the newest stuff.
- Apply SELF SELECTING TEAM (4.2.11). If the team self-selects, they will go for the best people, in their opinion. So they will believe they are good.
- Find some important strength of the team, and make that a rallying point: teach the team that they are good in a particular area. Be sure to find a *real* strength; people can easily see through a manufactured strength. The strength should be a technical

strength; while a team might rally around "we party better than anyone else", it won't get the software written.

- Provide some explicit separation from other projects. This can be physical location (put people together away from others), organizational, or information (share secrets with the group.) It can also be exemption from some of the rules that everyone else must follow. Just things to make it clear they are set apart from other groups.
- COMPENSATE SUCCESS (4.2.25).
- The parent company must be doing well enough so that it isn't a concern. This author was once on a team that felt it was elite until the company started doing very poorly. The company woes diverted our attention and sapped our morale.
- FIRE WALLS (4.2.9). This generates an attitude of "Top teams shouldn't be bothered by bureaucratic crap."
- As with UNITY OF PURPOSE (4.2.12), it helps to unite against a common enemy.

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By itself, TEAM PRIDE does not guarantee the success of a project. But Boehm and others have pointed out that people are the key success element of any project, and TEAM PRIDE helps nurture and encourage them. It may even be able to overcome poor overall morale in the company.

4.2.14 Skunk Works *

At the end of college, I was interviewed for a job with Lockheed Aircraft Corporation, including their famed "Skunk Works" division. They had a huge skunk painted on the wall at the entrance to their work area. Everyone said the same thing to me: "We can't tell you what we do, but we sure have fun." I ultimately went to work elsewhere, but I occasionally wonder what it would have been like to work there. I don't know what work I would be doing, but I'm sure I would have fun doing it.

...organizations have the freedom to iterate and innovate early in the life cycle of their major products. As a project matures, the context becomes rigid, and innovation becomes "forced" and may appear in the guise of "innovation programs." While these programs are good at the divergent thinking component of innovation, they rarely do a good job of convergent thinking. The result is that novelty, valued for its own sake, finds its way into mainstream development where it incurs costs but leads to results that range from indifferent to disaster; "home runs" are rare. The net result is most often negative.

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A project must accommodate major innovations but must also keep an eye on risk. It is too risky to innovate too much in project development. Some projects have "innovation programs" that value divergent thinking. The fruits of these efforts often make their way into development. It is only rarely that an organization does an honest evaluation of whether such ideas actually added value; the value is often taken on faith. For example, the latest technologies are always held to have value in their own right; conversion to OO, or to components, or to patterns, is considered “good” without a second thought. Too often, these new ideas have either indifferent results or in fact increase cost. They may decrease time to market or decrease cost, but if they decrease cost at the expense of time to market, then the overall effect is disastrous if time to market is the highest business priority. And, in fact, any new idea can both increase time to market and cost in ways that may never be noticed, in part because of the stock taken in the buzzword value of the idea.

Yet projects become dead if there is no way to get paradigm shifts into the project now and then.

Therefore:

Allow a limited-cost SKUNK WORKS to form (as a SELF SELECTING TEAM (4.2.11)) to develop an idea outside the constraints of project development, to build confidence in the idea. Give the SKUNK WORKS organization ownership and credit for the idea.

The organization is sustained by strong FIRE WALLS (4.2.9) that insulate it from the scrutiny of upper management and funders; in fact, the very existence of the SKUNK WORKS should be a secret. The idea is to keep the project off of management radar screens to foster the kind of innovation that leads to success before tradition and its constraints, as embodied in managers, can dampen innovation.

The success of the idea is assessed according to the fruits of the SKUNK WORKS effort: the ability of the resulting product to attract customers willing to invest time, money or people in building the product or in otherwise furthering the idea. The product must *tangibly* show positive results that differentiate it from the mainstream product line; if it is to thrive over existing external *and* internal competitors, it must demonstrate distinguishing market superiority. Directly moving new ideas into the business units rarely works. As a practical matter, this evaluation of success and the ensuing steps to act on it happen at unusual places in the management structure: at a higher level of management, in an organization that has venture funding, or by using the leverage that marketing can bring from customer needs statements and customer commitments. However, the technology’s chance of long-term success is much higher if the skunkworks team includes developers who also have product responsibilities in existing products. They can become seeds for new development teams for the new products or, if they are very lucky, they can be conduits for introduction of the new technology into development organizations. Therefore, this pattern also depends on giving some small set of interested developers some limited amount of time to work with the Skunk Works team in a Gate Keeper (4.2.10) capacity.

The Skunk Works organization itself rarely can take a product all the way into production. It usually lacks the infrastructure, and sometimes the skill set, to build a solid product. This phenomenon is at the root of many well-known stories about large companies not being able to capitalize on their greatest inventions.

If the idea succeeds, the team should reap the benefits of the idea. The organization subsidizes some of the risk of the team under the sponsorship of a Patron Role (4.2.15), so that the risk-takers are guaranteed some minimum level of security even if they fail. However, they are not *guaranteed* the same level of rewards as people who succeed in lower-risk ventures; see Compensate Success (4.2.25).

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This pattern is a bit different from Build Prototypes (4.1.7). Prototyping is one strategy towards running a Skunk Works; however, a Skunk Works project may just buy an existing product and integrate it with existing products or market it differently without doing any prototyping.

This pattern does not integrate with the other scheduling and organizational structures in the pattern language because it's a decoupled effort. The effort should evolve into a product over time and eventually incorporate patterns like Size The Schedule (4.1.2) and Size The Organization (4.2.2), but only after it's on its feet and has proven itself.

It is important that the Skunk Works be organizationally separate from the mainline organization. This allows so-called disruptive technologies to flourish within the company. (For further information on disruptive technologies, see works by Clayton Christiansen, professor at Harvard [Christianson1997].)

Though it's clear how Skunk Works fit into a large organization, it can work on a smaller scale in small organizations as well. A couple of team members can develop innovative ideas "in the margins" as a side activity. This may be a particularly good outlet for employees whose skills are high enough that they seek challenges beyond those offered by day-to-day business.

4.2.15 PATRON ROLE **

...the development organization has come to the point where DEVELOPER CONTROLS PROCESS (4.1.17), and now additional roles are being defined.

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It is important to give a project continuity. But centralized control can be a drag. And anarchy can be a worse drag. However, most societies need a king / parent figure and an organization needs a single, ultimate decision-maker. The time to make a decision should be less than the time it takes to implement it.

Therefore:

Give the project access to a visible, high-level manager, who champions the cause of the project. The patron can be the final arbiter for project decisions, which provides a driving force for the organization to make decisions quickly. The patron is accountable to remove project-level barriers that hinder progress, and is responsible for the organization's "morale" (sense of well-being).

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Having a patron gives the organization a sense of being, and a focus for later process and organizational changes. Other roles can be defined in terms of the patron's role. The manager role is not to be a totally centralized control, but rather a champion. That is, the scope of the manager's influence is largely outside those developing the product itself, but includes those whose cooperation is necessary for the success of the product (support organizations, funders, test organizations, etc.). This role also serves as a patron or sponsor; the person is often a corporate visionary.

We have observed this in Philippe Kahn in QPW; in Ravi Sethi and others in early C++ efforts in AT&T; for a manager in a high-productivity Network Systems project at AT&T; and in another multi-location AT&T project.

This relates to the pattern FIRE WALLS (4.2.9) which in turn relates to the pattern GATE KEEPER (4.2.10). Patrons are central to the success of SKUNK WORKS (4.2.14). They can help arbitrate the membership of SELF SELECTING TEAMS (4.2.11) to guard against exclusivity.

Block talks about the importance of influencing forces over which the project has no direct control [Block1983].

In a Joint Application Development (JAD [Kendall2002], pp. 132-135) session, one of the key roles is a "tie breaker" who is usually a manager who appears only occasionally at the meetings.

The etymology of Patron is instructive:

> The term pattern comes from Middle English patron (and the more ancient French patron) which still means both 'patron' and 'pattern.' In the 16th century, patron, with a shifted accent, evidently began to be pronounced patrn, and spelt patarne, paterne, pattern. By 1700 the original form ceased to be used of things, and patron and pattern became differentiated in form and sense.
>
> 1 a 'The original proposed to imitation; the archetype; that which is to be copied; an exemplar' (J.); an example or model deserving imitation; an example or model of a particular excellence. aC. 1369 CHAUCER Dethe Blaunche 910 Truely she Was her chefe patron of beaute, And chefe ensample of al her werke.

From a dictionary of medieval terms, related by Aamod Sane at University of Illinois.

4.2.16 Diverse Groups *

... a development team is coming together, and Birds of a Feather tend to Flock Together.

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Homogeneous teams that comprise too many of the same kind of people easily fall into groupthink-like dysfunction.

Design is the act of making change to the world. In software, it usually means changing the literature of an author who came before and encoded a solution in a programming language. That author usually remains as part of the community that retains an interest in the code (see Code Ownership (5.2.13), and the combination of Conway's Law (5.1.7) and Organization Follows Market (5.1.9) (which implies that architecture follows market).

Change is a process that has several phases, starting with complacency, which is upset by an opportunity or realization of an oversight. There is a struggle to identify solutions, the process of realizing the solution, culminating in deployment.

Different people are more comfortable with some parts of this process than with others. Some people are good at identifying problems, others with the innovative processes of identifying solutions. Yet others are good at focusing on implementation. The variance in comfort comes from variance in experience and individual background and temperament. This is true even when programmers in their role as designers, making a change, are the same programmers who were the original authors of the code.

Therefore:

Consider temperaments and diverse experience backgrounds when assembling a team. This diversity sometimes lines up with social classifications like age and gender, but more generally can be assessed on a personal level.

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One source of variation is the variety of domains in the application itself; see Domain Expertise In Roles (4.2.22). There is an open question whether a Self Selecting Team (4.2.11) prejudices a homogeneous group outcome; in any case, Diverse Groups (4.2.16) can be a good audit of a Self Selecting Team (4.2.11).

Another source of variation is the variation in roles. In a vestigial pattern Diversity Of Membership, the pattern recommends building a requirements teams from diverse roles:

> The team should include a developer, a user or user's representative, and a system tester (at least one of each). These individuals will work through the issues surrounding product requirements, often using small prototypes to identify the requirements and determine testing criteria. The user of prototypes can be closely tied to using use cases or similar usage scenarios as analysis and validation tools.
>
> One area in which this approach is especially useful is in the specification and design of the user interface. The developer creates mock-ups of the user interface, and the user and system tester examine them. In this way, this small subteam can go through many different designs of the user interface and select the best one.

See more about this kind of diversity in Holistic Diversity (4.2.19).

Sometimes teams form around mutual interest and talent in a domain, as in Subsystem By Skill (4.2.23), and diversity falls along other dimensions of interest.

Yet another kind of diversity is ethnic diversity. The oft-touted value of ethnic diversity is that it brings together people who can think about problems differently, from much different perspectives, which improves the chance of finding a good solution. But there are other subtle advantages. In a large multinational corporation, we found that each department had a few members of French national origin. The French all ate lunch together, which provided a natural path of communication flow between departments.

One kind of person you want in the mix is a PUBLIC CHARACTER (4.2.17).

However, one must guard against stereotyping people; e.g., using personality instruments or other information to *limit* the roles of people in organizations. See [KerthCoplienWeinberg1998].

See the related pattern BALANCED TEAM (10.5.5) in [Bramble2002].

4.2.17 Public Character *

...an organization structure is emerging, both formally and informally, and frequent contact at the workplace cultivates friendships as well as a social context that begs for support of common social graces and functioning.

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An organization is a social entity whose smooth functioning depends on more than professional relationships.

Much of what defines "culture" is the widely known but rarely spoken myths, tidbits, history, and interpretations of these stories. However, most professional organizations are built around the exchange of more structured information in blatantly public forums: memoranda, meetings, explicit policies, and executive pronouncements.

Yet the daily small pieces of information, details, and deep insights are the glue that hold the organization and its systems together. Furthermore, this information might include insights on shortcuts and other expediencies that serve the culture and its value system while falling short of the "letter of the law." The formal organization rarely has any organ that legitimizes the exchange of such information, yet such information is crucial not only to the smooth operation of the enterprise, but to its very survival.

Such information includes information outside of the primary business goals, but which is nonetheless important to the support of the work environment: where to find a good place for lunch, how to find the boss when she's not in the office, who knows how to fix the jam in the copy machine. It also includes meta-knowledge, how to find out where to find out certain kinds of information: who would know how to find answers to questions about the web server machine? who would know where to direct questions about personnel issues.

Therefore:

One or more people serve in the role as Public Character to help social processes both behind the scenes and through social events.

There may be socio-technological role combinations. For example, an Architect role might spend time passing information between development coordinators who otherwise wouldn't take the initiative to talk with each other [CoplienDevos2000]. We wrote up this pattern as "Shmoozing Architect" at OT '99.

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Matron Role (4.2.18) and Gate Keeper (4.2.10) are examples of Public Characters.

From Jane Jacobs's *The Death and Life of Great American Cities*, [Jacobs1961]:

> The social structure of sidewalk life hangs partly on what can be called self-appointed public characters. A Public Character is anyone who is in frequent contact with a wide circle of people and who is sufficiently interested to make himself a Public Character. ... His main qualification is that he *is* public, that he talks to lots of different people. In this way, news travels that is of sidewalk interest.

Jacobs goes on to say that, once the neighborhood recognizes a Public Character, people consciously tell him gossip (meeting dates, lost items) that they want propagated. A Public Character is a sort of living bulletin-board, with highly advanced search capabilities.

One finds a similar function in the *Maven* role in *The Tipping Point* [Gladwell2000].

In our experience, large software projects usually have at least one Public Character, and s/he is critical to project success. When you want to know who understands the persistence layer, you don't ask the architect; he's too busy. You ask the Public Character, who won't know beans about persistence, but will know that Mary knows a lot about databases, and that she will either understand the persistence layer or know who does.

One interesting form of Public Character is the Jester or Wise Fool (4.2.21). In medieval courts, the Jester was a person who could make fun of the king with impunity. The king was not obliged to follow the jester's insights; rather, these insights provided stimulus for thought. A jester Public Character can incite the organization to introspection and care; again, part of their qualification is that they are public. Such a person might be instrumental in facilitating workshops using creative techniques, visual meeting, system envisioning, and games—as well as reporting on user fears and expectations and being a change agent. This is also reminiscent of the "laughing uncle" configuration Bateson talks about in his writings of Pacific cultures [Bateson1958]. This uncle advised a child's father of feelings that the child might not convey to the father directly.

Project members are often penalized for being Public Characters — "Oh, Mary never gets anything done, she's always gossiping." Public Characters are a vital part of keeping large projects connected and successful. In a number of cases, we have seen that the disappearance of a single public character caused a major turn in morale and culture in the organization, *to a much greater degree than the loss of a key technical person might do.* The role is essentially informal; a project manager can't successfully assign somebody to this role. Rather, the role is something that is recognized and taken advantage of when already present. The recognition can help sustain the role.

If you see a team member "always gossiping", consider whether the team member has become a Public Character. Ask him or her a couple of team-related questions ("Where can I find out more about the garbage collection? Who understands the compiler tools"?) If he or she can handle these, as well as other questions ("Where's the best place to have lunch?" "How can I find Phil if he isn't at his desk?" "And what about... Naomi?"), you've found your Public Character.

It is instructive to compare the Public Character, Matron Role (4.2.18), and Gate Keeper (4.2.10); the Public Character is related to, but different from, both. The Matron Role is concerned with the nurturing of the organization, and is inward-focused. On the other hand, the Gate Keeper is outward focused; always looking forward for the next great direction. The Public Character is somewhat in the middle of these two, but separate from each. An ideal project has each of these roles, filled by different people.

A good place for the PUBLIC CHARACTER to hang out is at THE WATER COOLER (5.1.20).

4.2.18 Matron Role *

One of the members of my group was a woman named Anita. She was certainly technically competent, but I remember her more for the non-technical things she did for the group. For birthdays, Anita was almost always the one who brought cakes, pies, or other treats to celebrate. Because she liked to cook, many treats were homemade; in fact, she occasionally brought something just because she had tried out a new recipe. She did other things for the group too. She was often on picnic committees, and helped arrange "take our daughter to work" days.

Anita eventually moved on to another group, and our group has since been fragmented into other groups. But we still remember ourselves as a cohesive team, and Anita is a major part of the team.

...once a team is established, it needs regular care and feeding to maintain the unity of the team.

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Teams do not survive simply on the work they do. Some social activities are necessary to keep the team going on the technical work.

"All work and no play makes Jack a dull boy." This is also true of teams; unless teams play together some, they have trouble maintaining healthy interpersonal relationships, even in work situations.

But many people are not particularly adept at arranging social functions for their teams. This is particularly true among software organizations, which are dominated by introverts. In fact, some people are not even sufficiently aware of such things to be of any use in planning them.

Therefore:

Make sure that the team contains a Matron who will do the social and interpersonal things necessary to keep the team unified.

The Matron keeps track of birthdays and other occasions for celebration. The Matron is often willing to plan activities, and usually finds himself/herself on party committees.

Note that you can't force this role on someone; a person is either naturally a Matron or not. Therefore, you need to find one rather than manufacture one.

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With a MATRON ROLE, the team is much more likely to be cohesive through thick and thin.

Don Olson's PEACE MAKER (10.5.21) pattern ([Olson1998a], p. 168) is similar ([Rising2000], p. 131):

> A peacemaker is a placeholder in an organization who tries to calm and hold things together until a leader can be found or a reorganization is complete. The peacemaker should be someone who is well liked but who is not necessarily technically proficient. Usually this individual has many years with the company, knows the political ropes, and can buy time for a team as well as the team's management.

MATRON ROLE is a broadening of PEACE MAKER.

The MATRON ROLE is usually a PUBLIC CHARACTER (4.2.17).

4.2.19 Holistic Diversity *

Even the manager pulls his weight in this small team cooking up some new concoction.

...during the course of a project, groups of people begin to specialize. Teams are structured by specialty or by phase deliverables. This leads to bureaucratic processes, lack of inter-team communication, and a “throw it over the wall” style of development. As a result, teams don’t trust each other, and product quality and efficiency suffer.

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Development of a subsystem needs many skills, but people specialize.

Project development demands fast feedback, with fast, rich communications, on decisions. Feedback is fastest and within one person’s head, then slows with distance (room / floor / building / city) and medium of expression (interactive spoken face-to-face / video / written).

Multiple skills are needed to develop a piece of the system, particularly the user functions; it is hard to find people with those multiple specialties. In addition, people tend to specialize, and even protect their own unique skills against others; it’s a natural self-preservation mechanism. This leads to teams that tend to specialize.

So a project requires multiple skills, that tend to reside in separate teams. But this is not optimal. People within a team are more likely to help each other. People in different teams blame each other. Communication across teams tends to be inefficient and incomplete.

The obvious approach is to create one giant team for the project; this should solve the problem, right? But if the team is too large to put in one room, it tends to fragment naturally — along lines of specialization.

Therefore:

For each function or set of functions to be delivered, create a small team (2-5 people) which is responsible for delivering that function. That team can be given or can evolve specialists in requirements gathering, user interface design, technical design and programming, databases and testing. Evaluate the team as a single unit, so there is no benefit to hiding within a specialty. Arrange the team size and location so they can communicate directly with each other, instead of by writing. The team has no internal documentation requirements, although they do have documentation requirements responsibility to the rest of the project. However they choose to split up their work is their choice.

Note that this leads to organizing teams along architectural lines, namely CONWAY'S LAW (5.1.7). This means that it is necessary to coordinate the teams to get consistency of deliverables (requirements document, user interface design, software architecture, etc.) across teams.

Beware of making teams too small. If the team size is one person, that person will have difficulty mastering all the specialties, and changing mental context to perform well in the different specialties (meetings take quite a different temperament and more concentration than designing OO frameworks). (See SOLO VIRTUOSO (4.2.5)) On the other hand, if the team size is large, the communications will lag.

See also OWNER PER DELIVERABLE (10.5.19), that ensures that somebody owns each function, class, and required deliverable.

This is similar to DIVERSITY OF MEMBERSHIP [Harrison1996], to ensure that requirements gathering teams include users.

Jim McCarthy [McCarthy1995] wrote Feature Teams as a best practice, with much the same intent.

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Try to create one person with several bodies. It is hard to find single individuals who can master the needed specialties and change work contexts as needed. Creating a small, co-located, mixed-specialty team with no written deliverables between them increases the communication bandwidth between people, while letting the individuals develop their strengths. Rewarding them as a team keeps them motivated to help each other deliver, rather than hide behind their specialty.

There is a tight connection between the specialties. A designer or programmer may discover something that reveals that the requirements are more difficult that thought. The analyst may have a flawed view of the business. The final code must be a valid business model. The suggested user interface may be impractical to implement, or perhaps the user interface designer knows best how to implement it. Putting the people on the same team speeds the feedback from programming back up the chain to requirements. Separating those same people and putting written deliverables between them slows that feedback.

Alistair Cockburn tells of experiences with a project:

> Project Winifred was initially structured by function, which produced the trouble that many people were altering one class at any moment in time (see Function / Component Owners).
>
> It was next structured by phase deliverables, requirements / analysts separated from designers and programmers. The analysts produced ineffective models, communications between the people became sluggish, the analysts and programmers looked down on each other, and the analysts' designs did not match the final system design (the programmers ended up designing it as they needed to make it work).
>
> There was a very brief period of "everyone does everything". It did not last long because the mental load was too great on each person trying to do everything, and people rapidly fell into the specialties they could handle.
>
> The fourth, and successful arrangement, was HOLISTIC DIVERSITY (4.2.19). Those who could do the requirements gathering and analysis went to meetings, interviewed people, and investigated interfaces and options. They communicated the results rapidly, face-to-face, with the people who navigated the class library and designed classes and frameworks. A

> function team consisted of a combined requirements gatherer / analyst with two to four programmer designers.
>
> The team used JUST DO IT to move rapidly through the design. They had no internal deliverables, but created the deliverables as required by the project for interteam communication and maintenance. Most of the communication within the team was verbal. They talked several times a day, either in one-hour mutual-education sessions, or in small, several minute interchanges to mention a recent discovery. This amount of communication could not have been handled through formal deliverables.

See also DIVERSE GROUPS (4.2.16).

This pattern was originally written by Alistair Cockburn [Cockburn1996].

4.2.20 Legend Role *

Baseball legends George Sisler, Babe Ruth, and Ty Cobb

The hero Westley had returned in the guise of the Dread Pirate Roberts. He explained to Princess Buttercup that he had been trained by the previous Dread Pirate Roberts: "One day Roberts pulled me aside. I'm not the Dread Pirate Roberts, said he. And the man before me wasn't either. Then he explained that the name was important. You see, no one would surrender to the Dread Pirate Westley." (From *The Princess Bride*, [MGM1987])

...over time in a project, certain people really excel in their jobs. They become real masters, and take on many important jobs in the project.

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Certain individuals take on so many jobs, and become so important to the project that when they leave, the project is in more than just serious trouble.

These individuals are generally the elder statesmen and women in the project. They have been around longer than most anybody else, and their depth of experience is invaluable. But because of their age, they are the ones most likely to retire.

Not all people are like this. These are the ones who tend to pick up extra work and the associated expertise. So their absence is felt all the more. In fact, it seems like it would take two or more people to fill their shoes.

Therefore:

Name a role after the person, and make it an honor to fill that role. People will want to emulate the legendary person, and do just as good a job.

In many cases, the role named after the person will naturally emerge. Then it is a matter of formalizing it a bit, and filling it as the legend retires.

There *must* be training provided for the person filling the role. Ideally, it is offered by the original legend, as part of turning over the role to the new person. This is as important as naming the role itself.

A software company we analyzed had a role named “Simon”. They told us that Simon had been a key player in the project, and had done seemingly everything. They kept the name, and the jobs he had done.

Some corporate cultures are built around archetypes, like electric power companies built around the heroic acts of linemen working during threatening weather.

Emulation can be encouraged with an award. This author wrote some patterns of shepherding. Later, the Neil Harrison Shepherding Award was established, which encourages people to be better shepherds.

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This helps maintain project knowledge and expertise over time, helping to keep a MODERATE TRUCK NUMBER (4.2.24). Note that there is a useful lifetime of legend roles; they will fade over time, which is generally all right.

There is a subtle but important difference between having a legend *role* and having the actual legendary *person* on staff. CULT OF PERSONALITY from Don Olson ([Olson1998a], 154-155) offers this advice:

> A tight schedule, poorly defined requirements, uneven distribution of skills among the development team, and new technologies has put a project in jeopardy. To save the day, bring in a legendary figure among the developers to take over the

> lead. Team members who are not impressed may need removal or reeducation.

LEGEND ROLE looks longer term and intends to be an inspirational rather than remedial pattern. CULT OF PERSONALITY can work if the legendary figure offers true leadership and develops growth in the team; but then, it is no longer a “personality cult” in the vernacular sense. It is dangerous for a team to develop too much dependency on a single power figure, because the team has difficulty adjusting to a new communication structure, authority and control structure, and culture, when the legendary figure is gone. Also, the LEGEND ROLE could become a bottleneck under these situations; see DISTRIBUTE WORK EVENLY (5.1.13).

This in fact was noted by Alistair Cockburn as being a problem in the XP-based [Beck1999] C3 project, where he characterizes XP as a high-discipline methodology and likens it to Humphrey’s Personal Software Process. [Humphrey1995] This commentary comes from the WIKI WIKI Web (http://c2.com/cgi/wiki?HighDisciplineMethodology , 27 May 2001):

> I consider XP a HIGH DISCIPLINE METHODOLOGY, one in which the people will actually fall away from the practices if they don’t have some particular mechanism in place to keep them practicing. Ron [Jeffries] is that mechanism at the moment. Should (when) Ron leave, then unless he is replaced in his role, I quite expect to see the team not following the practices properly in less than 6 months.

Ron did leave the project and we find on the CTHREE PROJECT TERMINATED page:

> *... It wasn’t “to live” it was to stop following all of the practices.*
>
> - “unless [the coach] is replaced in his role, I quite expect to see the team not following the practices properly in less than 6 months. I think that is a fair test of a HIGH DISCIPLINE METHODOLOGY. — ALISTAIR COCKBURN”
> - “I’m no longer on C3 full time. Alistair’s six-month clock has started. — RON JEFFRIES 6/25/99”

- "As of the first of February, 2000, the C3 project has been terminated without a successful launch of the next phase."

The coach in fact does figure strongly in the XP organization ([Beck1999], 145-146). The coach is "responsible for the process as a whole" and sometimes must intervene to the point of "rudeness." However, XP as published recognizes both the danger and difficulty of interventions that are overly direct and immediate. But our study of several projects claiming to be using XP practices found strong elements of a personality cult. In one case, in an XP project in an insurance company, the team leader became more assertively involved when the project got behind schedule (the project dutifully and effectively uses the XP planning game).

If instead the legendary figure consults with the team, with the aim of helping the team members to grow, this can be an effective approach. See [Weinberg1986] for ideas.

4.2.21 Wise Fool *

I marvel what kin thou and thy daughters are: they'll have me whipped for speaking true, thou'lt have me whipped for lying; and sometimes I am whipped for holding my peace.

— The fool, *King Lear*, act 1, scene 3.

...a team has been established and is functioning. It is faced with a continual barrage of technical and non-technical challenges, about which it must make decisions.

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Interpersonal dynamics often discourage good ideas from being aired, and bad ideas from being weeded out.

There are two dynamics at work here, depending on the persons involved. Authority figures are often unchallenged: you might be reluctant to challenge your boss because of the perceived danger to your employment. People are also loathe to challenge the word of a respected elder in the organization for slightly different reasons. But this tends to keep allow bad ideas promoted by authority figures to promulgate without sufficient challenge and discussion.

The other dynamic is the group itself. It is difficult to stand up in the face of the entire group to challenge an idea. These days, such trouble-makers are rarely tarred and feathered, but they might be ostracized, or labeled “not a team player.”

Yet somebody needs to be the catalyst to cause occasional group introspection. Someone needs to shout the warning when the group heads in the wrong direction.

Therefore:

Nurture the role of the wise fool, who can raise uncomfortable truths with impunity.

The Wise Fool asks the questions that may be unpopular or seem politically risky, but they make the project pause and reexamine decisions. Often, many people want to ask the same question, but do not dare. Wise fools have a mix of insight, candor, and foolhardiness.

The Wise Fool is legendary. The most famous Wise Fool may well be found in the story of the Emperor’s New Clothes. It was a small boy who had the courage to point out the obvious.

The Wise Fool is much like a Public Character (4.2.17). But it differs in that the Public Character makes the group function smoothly, while the Wise Fool focuses mainly on the outputs of the group—mainly technical. But like the Public Character, the Wise Fool is not designated, but emerges. A Wise Fool is usually highly respected technically, and may been be (or become) a Legend Role (4.2.20), but is known for lack of tact. They usually eschew managerial opportunities, and may even show disdain for management. An acquaintance of the author was once honored with the words, “In the face of management opposition, he charged ahead and did what was right.”

Some organizations recognize Wise Fools. One organization we studied included a role called “Agitator”.

A Wise Fool needs to recognize the difference between asking legitimate questions and whining. Questioning things that one has no control over is often construed as whining. With too many such questions, the court of public opinion can demote a Wise Fool to a Whiner rather quickly.

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Organizations who have the good fortune to have a Wise Fool in their midst are likely to make fewer wrong decisions than other organizations. However, the Wise Fool may not receive the recognition they deserve; they may be perceived as troublemakers. This is slightly reminiscent of Sacrifice One Person (4.1.22), in a strange sort of way. Managers should be sensitive to this, and make sure that Wise Fools are supported.

Note that the key here is that the organization itself must be willing to accept criticism from within. There will always be people around willing to fill this role, but only the healthy organizations benefit from their insights. In fact, it often doesn't come naturally even to healthy organizations. Some organizations within Siemens hold workshops to help create a culture where people can speak out [Ackermann2002]. Unhealthy organizations may ignore, or even worse, actively suppress criticism. This creates a climate of fear of speaking out, which leads to widespread cynicism. In such cases, a few Wise Fools will refuse to be silenced, and become whistleblowers. When they report illegal conduct to authorities, they may even need laws to protect their actions.

4.2.22 Domain Expertise In Roles **

Naval air base, Corpus Christi, Texas. A top notch mechanic, Mary Josephine Farley expertly rebuilds airplane engines. Although she's only twenty years old she has a private pilot's license and has made several cross country flights.

...you know the key atomic process roles (Form Follows Function (5.1.11)) including a characterization of the Developer role.

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Matching staff with roles is one of the hardest challenges of a growing and dynamic organization. All roles must be staffed, and, all roles must be staffed with qualified individuals. Just as in a play, several *actors* may be assigned to a single role, and any given actor may play several roles.

You'd like to use domain-inspecific qualification criteria like college grades or years of experience to qualify people for jobs. Such an approach gives the project flexibility in staff allocation; it helps it avoid being overly dependent on individual skill sets and experience. In short, the hope that such criteria might work provides project managers a basis for keeping the project from becoming overly dependent on certain individuals; such individuals may leave or may hold the organization hostage for higher salaries or to see their own policies implemented unilaterally. Yet successful projects tend to be staffed with people who have already worked on successful projects.

Spreading expertise across roles complicates communication patterns. It makes it difficult for a developer or other project member to know who to turn to for answers to domain-specific requirements and design questions.

Therefore:

Hire domain experts with proven track records, and staff the project around the expertise emodied in the roles. Teams and groups will tend to form around areas of common domain interest and focus. Any given actor may fill several roles. In many cases, multiple actors can fill a given role.

Domain training is more important than process training.

Local gurus are good, in all areas from application expertise to expertise in methods and language.

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This is a tool that helps assure that roles can be successfully carried out. It also helps make roles autonomous. Empirically, highly productive projects (e.g., QPW) hire deeply specialized experts. OLD PEOPLE EVERYWHERE ([Alexander1977], ff. 215), talks about the need of the young to interact with the old. The same deep rationale and many of the same forces of Alexander's pattern also apply here.

This is also a systems principle that one finds in software development; see http://gee.cs.oswego.edu/dl/rp/roles.html .

A seasoned manager writes, "The most poorly staffed roles are System Engineering and System Test. We hire rookies and make them System Engineers. (In Japan, only the most experienced person interacts with customers.) We staff System Test with 'leftovers'; after we have staffed the important jobs of architecture, design, and developer."

Other roles (ARCHITECT CONTROLS PRODUCT (5.2.3), DEVELOPER CONTROLS PROCESS (4.1.17), MERCENARY ANALYST (4.1.24), and others) are prescribed by subsequent patterns.

If expertise becomes too narrow, the organization is at risk of losing key expertise if a single person leaves, is promoted, etc. Temper this pattern with MODERATE TRUCK NUMBER (4.2.24).

Domain experts can naturally come together in PROGRAMMING EPISODES (4.1.19). The pattern APPRENTICESHIP (4.2.4) helps maintain this pattern in the long term. Diverse Groups (4.2.16) is, in some sense, a more general version of this pattern.

See also Subsystem By Skill (4.2.23) and Upside Down Matrix Management (5.1.19).

4.2.23 Subsystem By Skill *

...an organization of developers exists. They have different skills and specialties, but there is not yet any structure in the organization, nor in the system architecture, that reflects such specialization or interest.

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Birds of a feather flock together. By Conway's Law (5.1.7), you want the architecture and organization to match each other. Yet there are many possible principles of organizing both the software and the organization that builds it. There is one structure that relates to domain knowledge and the system architecture; there is also a business structure, and a geographic structure as found in Organization Follows Location (5.1.8). But in Organization Follows Location, each location is largely autonomous and has its own organizational decisions to make, so the issue remains of how to modularize the organizational structure locally. Organization Follows Location conveys global constraints that relate to business priorities and concerns; Conway's Law offers guidance in the large, but doesn't extend as well to the fine structure at the group level. And that structure—the primary low-level structure of the organization—relates to the subsystem structure. So: how do we help Conway's Law with a set of partitioning criteria?

Therefore:

Separate subsystems by staff skills and skill requirements.

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This is a refinement of the pattern CONWAY'S LAW; it tells what criterion by which the structures of the organization should be aligned with those of the product.

People skills tend to be relatively stable over time, so this organization protects against shifts in staff.

The variation protected against here is the variation in staff skills over time. On a small enough project, the few people may have multiple skills that enable them to mix UI design with infrastructure design with domain design. Unhappily, their successors may not, which makes system evolution more difficult and costly.

On larger projects, the many people are more likely to have single skills and specialties. If their code is intermingled, two expensive difficulties accrue: getting the different people to learn to understand each other and come to common decisions, and the same system evolution difficulty as with the smaller system.

Separating their specialties into different subsystems lets them work with their special issues in their special vocabulary, lets their successors see those issues in isolation, and makes the project easier to staff, since the staff need not be so multidisciplinary. Once the subsystems are identified, various forms of teaming may be used to develop them.

The pattern of course should be applied in moderation; too many subsystems means complex, slow software. And too fine of an organization structure is unwieldy and cumbersome.

Note the relationship to DOMAIN EXPERTISE IN ROLES (4.2.22). This pattern removes one degree of freedom in DIVERSE GROUPS (4.2.16).

Related subsystems may be connected, while still providing a degree of independence between teams by using STANDARDS LINKING LOCATIONS (5.2.12) from ORGANIZATIONAL MULTIPLEXING PATTERN LANGUAGE.

UPSIDE DOWN MATRIX MANAGEMENT (5.1.19) is a way of handling SUBSYSTEM BY SKILL.

Discussion

Alistair Cockburn offers the following analysis of the relationship between HOLISTIC DIVERSITY (4.2.19) and SUBSYSTEM BY SKILL (4.2.23):

HOLISTIC DIVERSITY is aimed at streamlining communication: "For each function or set of functions to be delivered, create a small team... evolve specialists in requirements gathering, UI design, technical design, ..." "Evaluate the team as a single unit. Arrange the team size and location so they can communicate directly." "You will have to coordinate the teams to get the ... UI design, software architecture and so on consistent across teams."

SUBSYSTEM BY SKILL is aimed at protecting the system against "variation in staff skills over time" — I thought of it primarily as a software design pattern, rather than a project management pattern, which is why I hadn't thought of them together. "Many people are more likely to have single skills and specialties... Separate their specialties into different subsystems"

What happens if you put the two together? You get the team structuring I described in my book ([Cockburn1998], p. 88) for a 40-person project: function teams (using HOLISTIC DIVERSITY), infrastructure teams, ARCHITECTURE TEAM, and technology teams. The UI gets its own subsystem, the domain model gets it own subsystem, the database gets its own subsystem... and now you have to use HOLISTIC DIVERSITY to get all the parts put back together to make a working system. Expertise from each specialty on each team (some team members bring more than one specialty with them). And you also have to run a UI group across function teams to get consistent UIs; a persistence and a domain group similarly to get consistency there, too. The software ends up partitioned by skill. So you work extra hard to see that the teams don't get similarly segregated. This is the stuff that my book covers, in its tiny way.

What happens if you don't put the two together? If you don't do SUBSYSTEM BY SKILL, then you get UI, domain, persistence, networking code all mixed together. Yuck, but that's well known. Why have we long separated these things? Because they change independently or because they capitalize on different specialties?, or we have those specialties because they change independently or they change independently because we have those specialties?

I don't know and won't guess.

What if you don't do HOLISTIC DIVERSITY? Then you get a room full of UI designers, another room full of domain modelers, another room full of persistence designers / db designers, etc. I think we have all seen enough of this and its negative consequences. I am, by the way, currently in an organization separated this way, and trying to get the people, who sit only steps apart, to talk to each other on microteams.

So I think we need both: a project management pattern and a software architecture pattern, that work together.

4.2.24 Moderate Truck Number

In an insurance company we studied, the project scheduled some of their release dates around the vacation times of a small number of key staff. While this is much better than constraining vacation times to the release schedules, it would have been better if the project had been less dependent on those employees. As should have been predicted, the release date slipped and interfered with the vacation dates, anyhow.

... you have built an organization around specialists whose background and training match the expertise required by the application and market, Domain Expertise In Roles (4.2.22).

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A project cannot become overly dependent on any small number of individuals. It's important to have specialization. No amount of general accomplishment can compensate for experience. And this experience is embodied not in any abstract concept of roles, nor is it often found in any supporting document or knowledge base that a plug-compatible-interchangeable-developer could leverage. The expertise is most often embodied in a living human being who can make choices.

Such human beings may make unpleasant choices, such as leaving the organization for another company. Or they may make silly choices, like walking out in front of a truck at a busy intersection, never to return to the project again.

And life may make choices for such individuals, such as giving them prospects for promotion. Sadly enough, there is a high correlation between an individual's perceived expertise and the chances that a company will offer them promotion to optimize the chances for the PETER PRINCIPLE to have its way. Or another project within the organization may take them away.

It is a risk if there are too many cases where your project depends on such individuals for singular knowledge. You know you're in trouble if your project keeps a list of people and schedules release dates around their vacation times.

Yet it's still important to embody expertise in individuals, since it reduces communication between individuals regarding decisions within a certain business area and ensures that the right experience is brought to bear in such decisions.

And it's important to recognize that *everyone* brings some expertise to the table; if everyone were the same, there would be useless redundancy in the organization (see DIVERSE GROUPS (4.2.16), HOLISTIC DIVERSITY (4.2.19)).

Yet not everyone can know everything. Being a true expert in a topic requires all of one's attention, and it is difficult to sustain multiple areas of expertise.

Define the *truck number* as being the number of people in the organization who have unique *critical* domain expertise. You don't want the truck number to be large, because that means that the probability is large that the loss of any given team member would mean the loss of critical expertise. The risk would be too high. Yet it's impossible to make the truck number very small (it's almost impossible to make it zero). Even if you could make it small, you probably wouldn't—because if it were one, then everyone but the critical resource is intellectually redundant, and by some rationale, all the other members of the organization could turn into just overpaid worker bees or software assembly line workers.

Therefore:

Keep the truck number low; retain a small number of key experts with unique knowledge. Build a culture of shared knowledge that increases the breadth of knowledge over time, particularly for

knowledge that easily can be codified, taught, or otherwise conveyed.

How do you do this? One way is to use DEVELOPING IN PAIRS (4.2.28). Another is to make sure the experts rub shoulders with the mere mortals. Use ARCHITECT ALSO IMPLEMENTS (5.2.10). Of course, you retain a non-zero truck number by keeping the architects from becoming mere mortals themselves; see ARCHITECT CONTROLS PRODUCT (5.2.3).

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Cross-training can be an effective technique for sharing knowledge. In particular, APPRENTICESHIP (4.2.4) is an effective form of cross-training. However, some of the deepest knowledge and "good guts"—gut feeling—cannot be conveyed from an expert to an apprentice.

A pattern language of the organization's key competencies can provide some relief for experts and can reduce the risk for the organization. Collect patterns from domain experts.

It is *not* the goal to level the playing field. You still need DOMAIN EXPERTISE IN ROLES (4.2.22). It is too expensive (in time and talent) to guard against any possible staff loss by completely replicating talent. You want enough cross-training to control the costs of recovery from losing a person. Trying to spread expertise too broadly will in fact just dilute the overall expertise by detracting from each expert's focus.

Truck Number is a measure of vulnerability of an organization. It's usually pretty easy to calculate it: just ask yourself, "Which people in my project can we absolutely not do without?" It's likely that several names immediately come to mind. These people are the key architects, programmers, or perhaps even testers. And they are critical in part because they know things that others don't. So we try to get them to share that knowledge with the rest of the team.

Note that although we speak of the Truck Number as a number, it has a subjective qualitative aspect to it as well. In other words, not all critical experts are created equal. The loss of some experts may cause serious problems, but the loss of others may be absolutely devastating!

One of the authors once studied a small software company. While the company and its (single) product looked good, one particular employee seemed to be unusually dominant. If he were to leave, the company would be in serious jeopardy. Unfortunately, he did leave, and the company suffered greatly. The moral is to watch closely for such individuals, and make sure they continually share their expertise.

Why doesn't DEVELOPING IN PAIRS (4.2.28) solve the problem completely? It certainly helps, but people are still individuals, and have different skills. You can have a pair in which each member is good at something different; the pair is greater than the sum of the individuals.

As with any risk reduction activity, reducing the Truck Number is an exercise in trade-offs. You may find that duplicating the expertise of certain people just isn't cost — or time — effective. So you live with the risk. Maybe you try to reduce it in other ways, such as creating incentives for those people to stay on the team (see, for example, COMPENSATE SUCCESS (4.2.25).)

4.2.25 Compensate Success **

When I was in fourth grade (about 9 years old), we had a spelling test every Friday. Our teacher told us that if everyone got a perfect score on a spelling test, she would bring each of us a candy bar the following Monday. We were excited about the prospect, but as time went on, it seemed that it might never happen. There were always some who just couldn't seem to spell. Jimmy was probably the worst speller of all. He typically missed about half the words. There was no hope with him in the class.

But one week the words were particularly easy. In the practice test on Wednesday, everyone except Jimmy got all the words right. And Jimmy missed only four words. The anticipation in the class was electric, as we all gave special help and encouragement to Jimmy. On Friday, when everyone got a perfect score, it was hard to tell whether we were more excited about the upcoming candy bar or for Jimmy's success.

...a group of developers is striving to meet tight schedules in a high-payoff market. It is important to reward individuals in a way that motivates them to do things that achieve business objectives in line with the value system of the enterprise.

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Successful projects remain successful by rewarding behaviors that lead to success.

Schedule motivations tend to be self-fulfilling: a wide range of schedules may be perceived as equally applicable for a given task. And schedules are poor motivators.

Some organizations count on altruism, but altruism and egoless teams are quaint, Victorian notions.

Companies often embark on make-or-break projects, and such projects should be managed differently from others.

You need both to reward teams and outstanding individuals. Yet disparate rewards motivate those who receive them, but may frustrate their peers.

You need both to reward solid workers and risk-takers; yet from an economic perspective, you need to manage the risk of any investment into speculative work. And if speculative work fails, and the contributors are rewarded according to performance, it will disincent the organization from embarking on future risk-taking projects.

Some contributions are difficult to quantify, such as those of THE CATALYST (see Peopleware by De Marco and Lister) who facilitates communication between team members and perhaps helps morale.

Therefore:

Establish lavish rewards for individuals contributing to successful make-or-break projects. The entire team (social unit) should receive comparable rewards, to avoid de-motivating individuals who might assess their value by their salary relative to their peers. “Very special” individuals might receive exceptional awards that are tied les strongly to team performance.

A celebration is a particularly effective reward [ZuckermanAndHatala1992].

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As a result, you get an organization that focuses less on schedule (but see SIZE THE SCHEDULE (4.1.2)) and more on customer satisfaction and systemic success.

In most enterprises you do not want to reward risk-taking in a way that encourages people to take risks that don’t serve the long-term viability of the enterprise. The reward should always be more focused on meeting the organization’s goals than on *how* the goals are met. If the organization’s job is to produce a product, then reward people for what they do in support of delivering the product. Sometimes this includes an element of risk-taking, and to that degree risk-taking should be rewarded. However, you want to remove *obstacles* to risk-taking. That will allow people to take appropriate risks motivated by meeting organizational objectives, rather than for the sake of having taken a risk. See more about this in the pattern SKUNK WORKS (4.2.14).

Similarly, most software development organizations shouldn't encourage people to seek crisis situations as opportunities for the contributions that will receive the highest reward. That almost guarantees that the project will become crisis driven. There are some jobs that are legitimately built around a hero culture, such as (real-world) fire fighters and their figurative namesakes inside software projects, but these are the exception rather than the rule. Be sure to reward what the organization values, knowing that people will tend to do what they are rewarded to do.

Similarly, it can be problematic to reward those who work for the sake of the work ethic alone. Reward working smart more than working hard; there should be no prize for the most hours worked. Paul Bramble relates:

> Working for stock options that could be expected to turn into $12 million was a horrible experience. And having peers with similar expectations only made it worse. It clouded their judgment and they stopped using DOMAIN EXPERTISE IN ROLES (4.2.22). Instead, they started giving the more difficult assignments to the perceived "gung-ho" crowd rather than to the people most likely to be able to do them. ... Some of the fanatics were regularly working 80-hour weeks and used the reward system as leverage to exact punishment against those who tried to work reasonable hours and balance work and family life.

The liability of high rewards for meeting key corporate objectives is that people who take on those responsibilities can over-extend themselves, leading to personal stress with potential risk to the project. This is particularly problematic for rewards to management staff who run the risk of developing a burnout culture in their subordinates to meet the objectives (see "The Psychology of Burnout" in THE OPEN CLOSED PRINCIPLE OF TEAMS (6.1.4)).

There are factors that lead to success that are difficult to measure or even identify, so it's best to orient the rewards around the organization's shared value system of what is important to achieve. Scoping the concern of "organization" in this context is key to the long-term success of the enterprise; a closed group can't sustain values that are inconsistent with those of the enclosing organization or the next higher level of management.

Success makes it possible to build up the work environment infrastructure, making it a more attractive place to work. This is a form of long-term compensation or of recognition of success and is particularly important in team settings. In one organization we used windfall funds to buy an interactive terminal which, in that era (about 1974) was a treat for the staff. On a broader scale you can buy an espresso machine (for which Bell Labs computer science research was famous), just a coffee machine, or a water cooler—or build an entire culture of food. See the pattern THE WATER COOLER (5.1.20).

High rewards to some individuals may still de-motivate their peers, but rewarding on a team basis helps remove the "personal" aspect of this problem, and helps establish the mechanism as a motivator, in addition to being just a postmortem soother. On the other hand, see the discussion in THE ROLE OF MANAGEMENT (6.3.7) that puts individual contributions in a broader perspective: are individual successes really just team success in misleading packaging?

The grounding for this pattern is empirical. There is a strong correlation between wildly successful software projects, and a lucrative reward structure. Cases include QPW, cases cited at the Risk Derivatives Conference in New York on 6 May 1994; see *Pay and Organization Development*, by Edward E. Lawler, Addison-Wesley, 1981. The place of reward mechanisms is well-established in the literature [Kilmann1984].

Dennis DeBruler noted at the PLoP review of this pattern, that most contemporary organization culture derives from the industrial complex of the 1800s, which was patterned after the only working model available at the time: military management. (One common model of military management is: REWARD INDIVIDUALLY PUNISH CORPORATELY, which leads to fear of failing and resentment towards those who fail.) He notes that most American reward mechanisms are geared more toward weeding out problems than toward encouraging solutions. A good working model is that of groups of doctors and lawyers, where managers are paid less than the employees.

Paul Bramble adds, “The trick is to be discerning—sometimes it’s the quiet plodders who generate the success, and you have to be able to see past the self-promoting employees to see who really gets the work done.”

See also COMPENSATE RESULTS [Beedle1997].

4.2.26 Failed Project Wake *

The Trident project was the most exciting project I had ever worked on. We were a small team with an aggressive schedule, but we made good progress and were actually ahead of schedule. Then one day the the company made a major business decision that meant that the Trident project was probably unnecessary. Sure enough, the project was canceled a few days later. We all agreed that it was probably the right decision, and we appreciated the speed with which it was made, but it still hurt.

For a week we walked around in a fog. We did nothing. Finally, we took the afternoon off, and had a party at someone's home. We brought our families and played croquet in the back yard. After that it was much easier to move on to the next project.

...projects fail for a variety of reasons. Many of these are attributable to the team involved in the project; in fact, this pattern language is designed to help with many such problems. But software developers don't work in a vacuum. There are many external factors that contribute to the success or failure of any project. Changes in the market, for example, can doom a product before it ever gets out the door. You can have the greatest, hardest working team in the world, and their project still might get canceled, in spite of their best efforts.

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Canceling a project, even for the best external reasons, is particularly demoralizing to a team that has put its heart and soul into it.

It doesn't matter much that the team members fully understand the reasons behind the cancellation, they still feel bad. They feel powerless, somewhat apathetic, and sometimes betrayed. At best, they will have some "down" time, even if they have another project to jump into immediately. At worst, they may quit.

They may note that successful projects are rewarded, but it wasn't their fault that their project was canned. This feeling of inequity can be strong.

Therefore:

Hold a wake for the failed project. This should be much the flavor of an Irish wake; a party for the dead.

Don't try to placate them with false statements of "success." They all know the project bombed, so just hold a party over that.

Go ahead and make it a big party; make it more than just cake and punch in the cafeteria. And make it a real party; it shouldn't be a project retrospective. There is a time and a place for retrospectives, and this isn't it. (Gerhard Ackermann [Ackermann2002] points out that it is possible to combine the two, if you have a strong facilitator, and the main purpose continues to be the wake.)

It's best to hold the wake off-site. That helps people break from the old project, and avoids even the appearance of a retrospective.

It's even more helpful to hold the wake during working hours; an afternoon works well. Holding the wake during work hours sends a subtle "thank-you" message: everyone knows they don't get a bonus (see COMPENSATE SUCCESS (4.2.25)), but they appreciate some acknowledgment of their efforts.

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Just like the death of a loved one, the death of a project causes a period of mourning. A wake helps people get through the stages of mourning.

It also serves as a bit of a catharsis. People will come out of it much more ready to attack the next project, "and this time we'll succeed!" It is particularly important for upper management explicitly to express appreciation for the effort, especially when the failure owes to business decisions rather than to decisions owned by the development team. Paul Bramble notes that this helps “calm people down and to be less worried about their future at the company.”

4.2.27 Dont Interrupt An Interrupt

See Section 4.1.26.

4.2.28 DEVELOPING IN PAIRS **

Randy and I work on a software tool together. Over the years that we have developed it, we have found that we spend a lot of time at each other's desks. We often write code, debug, and test together. It is not uncommon for one of us to be typing, while the other one tells what to type. And often, the one not typing will point out typos or logic errors. That can be annoying, but it certainly reduces the cycles of compiling and debugging.

Nobody told us to work this way. We just found that it works well.

...a development organization is in place, and people have started to commit to work and are about to start building the work artifacts. Some of the work may be allocated on the basis of CODE OWNERSHIP (5.2.13). There is enough understanding about overall requirements to start work, though many requirements may have loose ends.

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Some people don't want to work alone, and working alone has great risks of blindsiding and misfits. And you need to provide for people who don't want to work alone, and in general engage people who are working alone but probably shouldn't be.

People sometime feel they can solve a problem only if they have help. Some problems are bigger than an individual, so even people who are comfortable working alone should work closely with someone else who at least provides another set of eyes to look over the work.

It takes extra resources to do this in real time; one might argue that code walkthroughs and inspections and reviews are enough to compensate for these problems. But these reviews are usually analytical rather than opportunistic. And reviews set up an adversarial context where the critics don't have the same stake as the programmers. And reviews catch problems after the programmer has committed to the corresponding structures and algorithms and expended a lot of effort in elaborating them, rather than stopping them at the conceptual stage. And many of these decisions are too detailed to arise in design reviews or simply can't be foreseen until the programmer grapples with implementation, yet are weighty enough that they might threaten the viability and long-term health of the code.

Only a limited number of people can sit in front of a keyboard and screen. Communication and coordination effort increase nonlinearly with number of people. So you can't always create a team that works together as a unit to contribute to an artifact in front of a single screen.

Therefore:

Pair compatible designers to work together; together, they can produce more than the sum of the two individually.

There are two keys to making this successful. First, the individuals must be able to work well together. This means that pair assignments must not be made arbitrarily. In fact, because a pair is in reality a small team, SELF SELECTING TEAM (4.2.11) must be applied. The chief consideration for creating a pair is that the two *want* to work together.

Second, the style of pair development must not be dictated; it should be left up to the individuals. Simply put, there should not be a rule that no line of code is written unless both people are at the keyboard. Instead, give the pair the assignment, and let them figure out how to do the development. Note that this practice supports FEATURE ASSIGNMENT (5.2.14).

The pair needn't always comprise developers only. In BUILD PROTOTYPES (4.1.7), and in many other activities, one of the pair can be a customer, systems engineer, or technologist representing an area of risk being explored by the prototype. At Mediagenix, a tester sometimes pairs with a developer as the tester drives with tests, and the developer fixes bugs. This makes it possible to circumvent the project's formal bug reporting bureaucracy, reducing the time to a stable load (see also COUPLING DECREASES LATENCY (5.1.22)).

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Overall, this leads to a more effective implementation process. Experience has shown that, contrary to simplistic reasoning, it may cost less overall to program in pairs than to have one coder work on code at a time. In an analogous study, it was just found that it actually saves money in a hospital to have a pharmacist follow doctors on their rounds as they make prescriptions. The pharmacist's insights in correcting the doctor's errors (e.g., prescribing drugs that are incompatible with each other) saved more money (in additional health costs) than the pharmacist cost; plus, it capitalized on the pharmacist's dead time between activities.

A pair of people is less likely to be blindsided than an individual developer.

You help ensure that SOMEONE ALWAYS MAKES PROGRESS (4.1.20).

If enough people use DEVELOPING IN PAIRS, and if the pairs rotate occasionally, you get an emergent structure and emergent organizational behavior that contributes to cross-training, information sharing, and trust.

Compare this pattern with GROUP VALIDATION (4.2.32) and RESPONSIBILITIES ENGAGE (5.1.14). One special case of DEVELOPING IN PAIRS occurs when one developer asks another developer (or other suitable expert) do a desk check of recently written code. This is much less costly and not less effective than the traditional code inspections, code walkthroughs, and code reviews. Though probably less effective than the "canonical" form of DEVELOPING IN PAIRS, its worth has empirically been validated [Votta1993].

There are other configurations which have much of the dynamics of DEVELOPING IN PAIRS but which are not strictly just a dynamic duo. At Mediagenix we found teams that "programmed with the projector" where the computer screen was projected onto a wall, and a team jointly commented and guided the work as one person sat at the keyboard. In Bell Laboratories, Joe Davison, Ricky Spiece and Martin Biernat worked on a team with one at the white board, one at the terminal "thinking out loud" and representing the customer. In this case, the code was written on the board, transcribed into the computer (in Smalltalk) and the third person did a real-time code review.

And in what might be viewed as another slant on pair programming, Doug Lea used a variant of the clean room methodology that employed a single programmer: once in a role as programmer, and once in a role as tester. Clean room techniques separate these two roles to make sure one's knowledge doesn't unduly influence the assumptions of the other. In the extreme application of clean room, developers are not allowed to use the compiler to check their own code, but await such feedback from the tester. Doug mimicked this behavior by wearing two hats. In one sense, this is as unlike popular pair programming as one can get: each "side" of Doug worked in isolation. But the interplay between the two perspectives was where the power lies: bringing multiple perspectives to bear on the same artifact with tight coupling of minds. Doug's mind provided the tight coupling.

4.2.29 Engage Quality Assurance **

FSA (Farm Security Administration) supervisor and farmer-client examining quality of silage from trench silo. Sheridan County, Kansas

...you have a development organization mature enough that roles have been congealed and a customer has been engaged (Engage Customers (4.2.6)). You need some filter between the two to both facilitate and regulate interactions between them.

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Customer engagement is a key element of quality assurance. Though developers feel they get everything right, a good dose of customer reality helps bring the perspective that perfect software is hard.

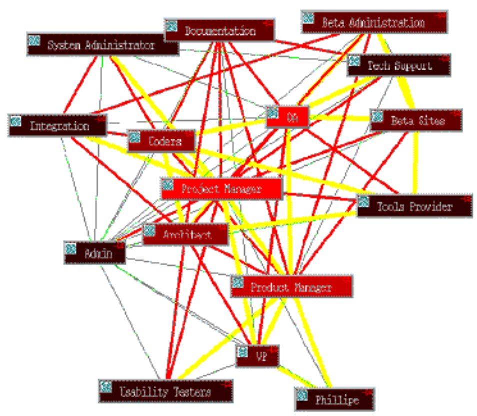
Too many organizations defer quality until "later" or equate quality assurance with the late activity of testing. Yet success depends on high quality, and early feedback is important to address fundamental quality problems.

It's important to do testing, and most developers do their own testing. But individuals easily get blindsided by their own design thinking in terms of what needs to be tested. And they may use testing as their quality criterion; yet, you can't test quality into a product: you can only build a product and test its quality.

Therefore:

Make QA a central role. Couple it tightly to development as soon as development has something to test. Test plan development can proceed in parallel with coding, but Developers declare the system ready for test.

Quality Assurance (QA) was central to the development of Borland's Quattro Pro for Windows:



The QA organization should be outside the context of the project: the planning and reporting of tests should not be accountable to the development organization. The development organization develops a sense of accountability for delivering quality product, since their own view of their reputation is linked to minimizing the bugs that "those people in QA" find.

QA should be engaged with marketing to understand the needs and challenges a system will face.

QA people have skills and perspectives that allow them to view customer needs from a perspective that may not be reflected in requirements or other articulations of needs. A good example is security companies that develop security software utilities for commercial operating; their own probing of the operating system often uncovers security holes, and then they work with the vendor to fix the problems.

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Having engaged QA, the project will be ready to approach the Customer. With QA and the Customer engaged, the quality assurance process can be put in place (use cases gathered, etc.).

There are at least two reasons for making QA a separate organization from that holding Developers' allegiance. First, test development shouldn't be blind-sided by the Developer perspective. If both the Developer and QA perform their own tests, testing becomes a double-blind experiment with the software as a subject. Second, QA should be put outside the domain of influence by the development organization in the interest of objectivity. This is an obvious pattern in QPW.

Indeed, ENGAGE QUALITY ASSURANCE requires a separate QA organization. This is in contrast to the ideals espoused in Extreme Programming. XP advocates extensive unit testing, but in the words of Kent Beck, "documentation, design, formal review, separate QA; it's all a waste of our time." [Waters2000] This may be a reaction to organizations that have a separate QA organization, but do not engage it. That's a recipe for disaster: you have the overhead of a separate organization, but not the benefits. In order for a separate QA organization to be effective, it must have frequent and positive interaction with development.

Note that quality assurance should be engaged early in the project; by the time testing starts it is too late to build the trust needed for quality assurance to happen smoothly. This is spelled out in GET INVOLVED EARLY (10.5.13) [Delano1998]. It is not just the developers' responsibility to engage the testers; the testers must reach out to the developers as well (see DESIGNERS ARE OUR FRIENDS (10.5.10) [Delano1998].)

See also APPLICATION DESIGN IS BOUNDED BY TEST DESIGN (4.2.30).

4.2.30 Application Design Is Bounded By Test Design *

An M4 tank tops the ridge on a test course. The tank was designed to meet all the challenges of the test course — the test course should simulate all the extremes of the field.

...a development organization has mechanisms to document and enforce the software architecture, and developers to write the code. You are planning how to engage your customer. A Testing role is being defined.

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When do you design and implement test plans and scripts?

Test development takes time, and cannot be started just when the coding is done (“when we know what we have to test”).

Scenarios are known when requirements are known, and many of these are known early (see Scenarios Define Problem (4.2.8)).

Test implementation needs to know the details of message formats, interfaces, and other architectural properties in great details (to support test scripts and test jigs). Both software developers and testers need to work closely together from the same “script”—the Use Cases that define customer needs.

Yet external tests are largely ignorant of the internal software structure, so much test development can take place in parallel with design and implementation of the deliverable software. Implementation changes daily; there should be no need for test designs to track ephemeral changes in software implementation.

Therefore:

Use case-driven test design starts when the customer first agrees to use case requirements. Test design evolves along with software design, but only in response to customer use case changes: the source software is inaccessible to the tester. When development decides that architectural interfaces have stabilized, low-level test design and implementation can proceed.

Software designers can and should use test specifications as a major touchstone for requirements.

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This provides a context for SCENARIOS DEFINE PROBLEM and complements ENGAGE QUALITY ASSURANCE (4.2.29). Once the expectations are established between the testers and developers in the context of customer expectations (perhaps through FIRE WALLS (4.2.9) and GATE KEEPER (4.2.10)) you can approach the customer to capture Use Cases.

Making the software accessible to testers causes them to see the developer view rather than the customer view, and leads to the chance they may test the wrong things, or at the wrong level of detail. Furthermore, the software will continue to evolve from requirements until the architecture gels, and there is no sense in causing test design to fishtail until interfaces settle down.

In short, test design kicks off at the end of the first major influx of requirements, and touches base with design again when the architecture is stable.

4.2.31 Mercenary Analyst

See Section 4.1.24.

4.2.32 Group Validation *

Testing homemade screen door for strength.

...an activity such as analysis, design, or implementation has been completed and is to be assessed.

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Product quality is crucial to the success of the enterprise. The job of QA is to assess quality. QA usually assesses the quality of the end product, doing only black-box validation and verification. A group setting brings many insights on product problems and opportunities. Individuals may not have the insight necessary to discover the bug plaguing the system (this may be an issue of objectivity).

Therefore:

Even before engaging QA, the development team—including the Customer—can validate the design. Techniques such as CRC cards and group debugging help socialize and solve problems. Members of a validation team can also work with QA to fix root causes attributable to common classes of software faults.

The software shouldn't be the only focus of debugging and review. Recurring types of software bugs may point to systemic problems in the structure of the organization itself. For example, if the project is seeing a high rate of mismatches in interfaces between components, it might be that integration is taking place too quickly for all the team members to keep in step with the current state of the architecture. The organization can write new patterns to solve these systemic problems (UPDATING THE PATTERNS (3.3)). See [Fagan1976].

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One can create a culture where the quality of the system is constantly brought into focus before the whole team. Problems will be resolved sooner than if they are deferred to the "official" Quality Assurance function, which typically interacts with the project at the boundaries of design and coding. The cost of this pattern is the time expended in group design / code debugging sessions.

The CRC design technique has been found to be a great team-building tool and an ideal way to socialize designs. Studies of projects inside AT&T have found group debugging sessions to be unusually productive. Bringing the customer into these sessions can be particularly helpful. The project must be careful to temper interactions between Customer and Developer, using the patterns mentioned in the Resulting Context.

There is an empirical research foundation for this pattern. See "An implementation of structured walk-throughs in teaching COBOL programming," CACM, Vol. 22, No. 6, June, 1979, which found that team debugging contributes to team learning and effectiveness. A contrary position can be found in [Meyers1978], though this study was limited to fault detection rates and did not evaluate the advantages of team learning.

There are times when reviewing need not be a group effort; sometimes, all it takes is a little help from a friend. DEVELOPING IN PAIRS (4.2.28) is one example; the kind of desk checks mentioned in [Votta1993], where one person liberally marks up the work of another, also can be effective (Votta shows that this mode of review is almost as effective and much less costly than a meeting). The CREATOR- REVIEWER (10.5.8) pattern [Weir1998] calls this a "distribution review" as opposed to a "meeting review". Doug Lea once took this approach to an extreme, working on a one-person Clean Room programming team where he played the roles both of programmer *and* of reviewer, with no use of a compiler to validate the code between the steps (see DEVELOPING IN PAIRS). We imagine the psychological forces must have been both interesting and compelling.

STAND UP MEETING (5.2.7) is an informal form of this pattern.

CHAPTER 5 *Organization Construction Patterns*

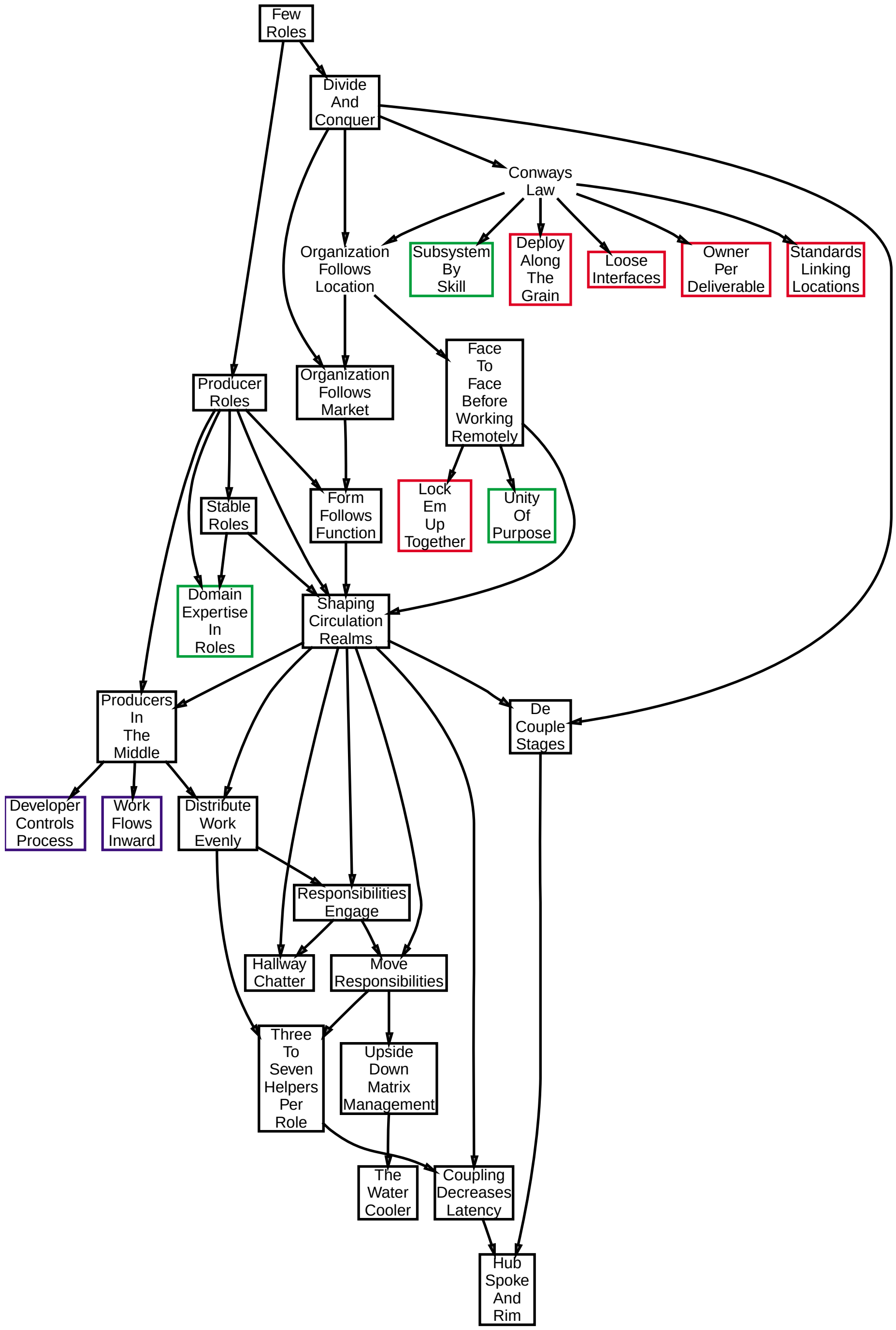
Once design is done—the organization is conceptualized and has been framed out—it's time to start putting it together. We hire people, fine-tune teams, and put processes in place. The patterns in this chapter are construction patterns: patterns for dealing with day-to-day realities and the real stuff of building an organization.

There are two pattern languages here: one is about Organizational Style, and the other is about PEOPLE AND CODE. Organizational Style is akin to management style. Each manager will use different techniques to help an organization unfold.

The PEOPLE AND CODE pattern language talks about the day-to-day impact of CONWAY'S LAW (5.1.7). As the code takes shape the organization should track it. There are architectural artifacts which themselves have achieved the stature of patterns and, by CONWAY'S LAW (5.1.7), we might expect to find analogous structures in the organization. And we do. These are those organizational patterns, patterns that one allows to take shape piecemeal in the organization as the code itself changes. Of course, it can work the other way, too: coding structures and interfaces can reflect business structures that are reflected in the organization or in the geographical distribution of the development groups.

5.1 *Organizational Style Pattern Language*

The Pattern Language



Few Roles
Divide And Conquer
Conways Law
Organization Follows Location
Subsystem By Skill
Deploy Along The Grain
Loose Interfaces
Owner Per Deliverable
Standards Linking Locations
Producer Roles
Organization Follows Market
Face To Face Before Working Remotely
Stable Roles
Form Follows Function
Lock Em Up Together
Unity Of Purpose
Domain Expertise In Roles
Shaping Circulation Realms
Producers In The Middle
De Couple Stages
Developer Controls Process
Work Flows Inward
Distribute Work Evenly
Responsibilities Engage
Hallway Chatter
Move Responsibilities
Three To Seven Helpers Per Role
Upside Down Matrix Management
The Water Cooler
Coupling Decreases Latency
Hub Spoke And Rim

Our organizational analyses have uncovered various styles of organization. Our studies of these organizations captured these patterns of roles and communication links between them. Some style work better than others in their respective contexts. There is no single right style, but different kinds of organizations suggest elements of style suitable to their success.

A Story About Organizational Style

One of the most fun projects I ever worked on was code-named Trident. We started out with about ten people (see SIZE THE ORGANIZATION (4.2.2)), but we had FEW ROLES (5.1.2). Nearly all the roles were PRODUCER ROLES (5.1.3). As a result, the producer roles were at the center of communication — they got the information they needed (PRODUCERS IN THE MIDDLE (5.1.4)). The roles remained stable throughout the life of the project (STABLE ROLES (5.1.5)).

We were making significant modifications to an existing product, so naturally our organization mirrored the architecture of the product (CONWAY'S LAW (5.1.7)). We had a single market, but it was different from the market for the existing product, which was why we were formed as a separate organization in the first place. (ORGANIZATION FOLLOWS MARKET (5.1.9)).

The organization, small as it was, was split across two locations. We began with FACE TO FACE BEFORE WORKING REMOTELY (5.1.10), and then split the work along geographical lines (ORGANIZATION FOLLOWS LOCATION (5.1.8).) One person agreed to a temporary move to the other location, which was a form of SHAPING CIRCULATION REALMS (5.1.12), and helped HALLWAY CHATTER (5.1.15).

There was no overloaded central role (DISTRIBUTE WORK EVENLY (5.1.13)); this was helped by keeping THREE TO SEVEN HELPERS PER ROLE (5.1.21). The smallness of the team allowed high coupling, which contributed to efficiency (COUPLING DECREASES LATENCY (5.1.22)).

Ultimately, shifts in the marketplace caused the project's demise. Fortunately, the decision was made quickly, and until that point, the project was on or ahead of schedule.

5.1.1 Community Of Trust

See Section 4.1.1.

5.1.2 FEW ROLES **

Actors rehearsing a new play by Langston Hughes, Chicago, Illinois, 1942.

...as an organization establishes its identity, the roles that the members of the project assume begin to take shape. The roles emerge from project needs as well as from individual preferences. Project members, playing these roles, pass information among themselves..

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People in a project must communicate with each other for the project to make progress. Yet the overhead of this communication can hinder the very progress it should facilitate.

The number of possible communication paths among roles increases quadratically with respect to the number of roles. Five roles have ten communication paths, but ten roles have 45 paths. And twenty roles have 190 possible communication paths. It is clearly not possible to have every role communicate with every other. Therefore, information often reaches roles indirectly; through other roles. But this increases both latency (delay) and overhead.

It is true that individuals may play several roles and receive information destined for one role that is useful for other roles. Our experience, however, is that in such cases, there are enough different communication needs in the different roles that it does not appreciably decrease the number of communication paths required. The source of information is sometimes as important as the information content itself.

Therefore:

Identify the roles in the organization. Try to keep the number of roles to about sixteen or less. If you have more, try to reduce the number of roles by identifying the value of various roles, and consolidating or eliminating roles that add less value.

We have found that the healthiest and most productive organizations tend to have around sixteen to twenty roles. Aiming for the lower bound gives one space to allow additional roles to emerge as needed.

The combinatorics of communication encourages few roles. Fewer roles means that communication becomes more efficient, both in resources consumed and in speed.

Roles tend to be stable in an organization over time, more so than processes, and even personnel. Roles are a reflection of the culture and the values of the organization. Keeping the number of roles low makes it easier for new people to assimilate the organizational culture, and become part of it.

Roles are not the same as people. Several people may play the same role; most organizations have several people in the Developer role, for example. Conversely, one person may fill more than one role. For example, a person may be mainly a developer, but may function part time as the project manager. Multiple roles per person is common in small teams, but is often seen in large organizations as well.

How do you determine what the roles of an organization are? In particular, how do you know whether certain tasks are responsibilities of a role, or whether those tasks form a new role? One can examine the collaborations that emanate from those tasks, and see whether they correspond to the role in question, or have a different pattern of communication. In practice, though, it is simpler than that. Just ask the organization to identify their own roles. Every organization we have ever studied knew what their roles were. Organizational health seems to closely track the crispness with which project members can delineate roles.

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Large organizations may find themselves with large numbers of roles. One can then approximate Few Roles (5.1.2) by applying Divide And Conquer (5.1.6).

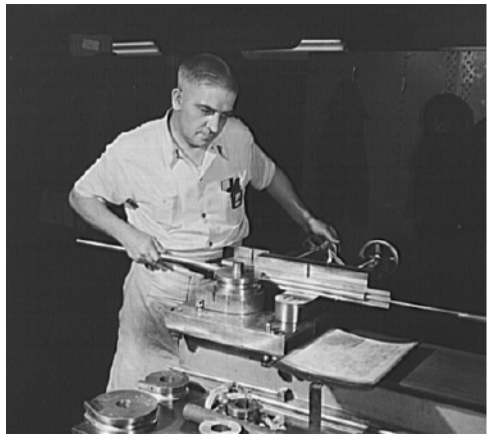
After you have identified the roles, it may not be obvious which roles can be combined or eliminated. Use Producer Roles (5.1.3) to characterize the roles.

As you keep the roles down, communication saturation will stay high, and communication patterns will resemble Responsibilities Engage (5.1.14).

Note that this is different from Size The Organization (4.2.2). It deals with the number of people on the project; Few Roles (5.1.2) is about the number of roles, regardless of the number of people.

This is closely tied to Producer Roles (5.1.3). It also makes Distribute Work Evenly (5.1.13) possible.

5.1.3 Producer Roles *



...once you have identified the roles in the organization, you are in a position to optimize the role structure. This usually involves reducing the number of roles, particularly for mature organizations.

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The overhead and bureaucracy in the organization is excessive, as manifest by the presence of too many roles. Yet all the roles seem important. It looks like there is no way to reduce the bureaucracy.

An organization needs some bureaucracy to keep projects running smoothly; there is much administrative work to be done. Programmers don't want to bother with it. But left unchecked, bureaucracy tends to grow: new roles get created and the communication overhead increases.

People tend to gravitate to those roles they are most comfortable with. This is healthy. However, some people need the recognition associated with titles (German: Titelsucht), and roles are obligingly created to fill that need. Such roles have no intrinsic value to the project.

Over time, the responsibilities of roles evolve. In some cases, the real benefit of a role drains off to other roles, leaving little more than a shell behind. In one organization, the chief responsibility of a particular role was "worry." It added no value to the project. But because of the history of the role, it is easy to simply assume that the role is important.

Therefore:

Identify each role as a producer, supporter, or roles that add no value to the project (deadbeats). Eliminate the deadbeats, and in some cases, eliminate or consolidate some supporters. Nurture the producer roles; they are the ones that pay the bills.

Producer roles are those roles that contribute directly to the end product; there is an obvious connection between their work and the revenue of the company. The canonical producer role in software organizations is "developer".

An organization has numerous support roles. These roles contribute to the effectiveness of the producer roles, but don't directly develop the products. Many support roles are vitally important, such as FIRE WALLS (4.2.9), GATE KEEPER (4.2.10), and PATRON ROLE (4.2.15). Roles that provide computing support, for example, are also essential. But support roles are inherently higher in overhead than producer roles. There may be opportunities to gain efficiency by combining support roles.

Deadbeat roles, as other types of roles, can be identified by their responsibilities. They may do nothing more than receive information and pass it on without adding any value to it. Watch for other responsibilities that add no value to the project, such as the aforementioned "worry." If a role truly adds no value to the project, it should be eliminated.

Note that in some cases, a role that passes information adds value by doing so. For example, a person who passes information by "pushing" it to those who would normally not get the information may prevent project inconsistencies, or might even detect such inconsistencies before they get out of hand (see WISE FOOL (4.2.21)). Such a role is an important support role.

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Although eliminating roles fosters greater organizational efficiency, it may lead to bruised egos, or even feelings of insecurity. In some cases, roles might be preserved, but reshaped to contribute more directly to the project. Refer to FORM FOLLOWS FUNCTION (5.1.11) and SHAPING CIRCULATION REALMS (5.1.12) for further help.

It sets up Producers In The Middle (5.1.4). There is a link to Domain Expertise In Roles (4.2.22). See also Fire Walls (4.2.9), Gate Keeper (4.2.10), and Patron Role (4.2.15).

5.1.4 Producers In The Middle **

The chef, the producer of food, is often the center of attention.

...one of the first steps a project takes in self-understanding is the identification of roles, and in particular, which roles are the Producer Roles (5.1.3). But it is the information flow among the roles that helps get the work done.

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In a project, not all roles hear everything. But much of the information communicated has important implications for the product.

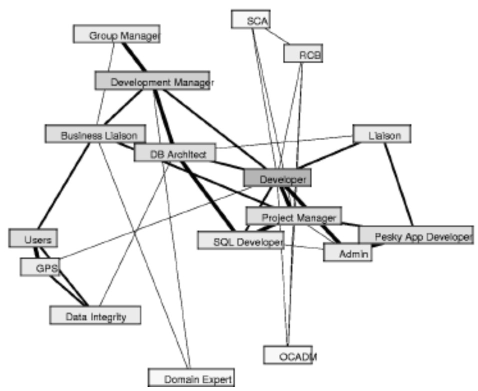
Within any software project, there are many activities, roles, and individuals competing for attention. Of course, there are the developers. But project managers have a need to be at the center of everything. They need to have their finger on the pulse of the project; to know everything that is going on. That's their job. In a similar manner, perhaps to a lesser degree, other roles also need to be involved in the project.

But all roles are not equal. Certain roles (developer and a few others) contribute directly to the product; they create it. Most other roles contribute indirectly to the product; they (should) exist only to help the producers do their job. The producer roles need information in order to do their job.

Therefore,

The producer role(s) must be at the center or very near the center of the hive of communication. Make sure the producers are party to all, or nearly all communication about the project.

The role at the center of the project must be a producer role (in fact, it should be the producer role that gets the most done — like developer.) Consider the developer roles at the center of this healthy organization, an organization that develops financial trading software on tight schedules:



The role at the center shows the focus of the project. In most cases, it is a role like Developer or Coder. In a few cases, the most central role is a management role (we have seen this, but rarely.) In this case, the focus of the project is not on developing the product, but rather it is on managing the development of the product.

If you find that your most central role is not a producer, you need to, as a project, sit down and do some soul searching. Why isn't your focus on the product, like it should be? What is getting in the way? For example, are you so preoccupied with something like ISO 9001 certification that you have lost your focus?

Note that this can be taken to an extreme. If you have too many roles, and they all focus on the Coder, for example, (see picture), the coder will have so much communication that they can't get anything done. So this must be applied together with Few Roles (5.1.2). See also Distribute Work Evenly (5.1.13).

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The natural tendency when this pattern is applied is toward WORK FLOWS INWARD (4.1.18) — the developers will tend to get the information they need. This is not always true, as it can get sidetracked by managers who are overly meddlesome. However, left alone, developers will evolve naturally to this pattern, and then to WORK FLOWS INWARD.

This pattern is closely related to DEVELOPER CONTROLS PROCESS (4.1.17). If the developer — a producer role — controls the process, he or she is likely to be a hub of communication. In fact, allowing the developer to control the process is one way to help make this pattern happen.

5.1.5 Stable Roles *

No, not THAT kind of stable!

In our organization studies, we ask teams to simulate their typical development experience. During one such exercise, the team described a quality crisis, and how they formed a task force to handle the problem. I was struck that the team seemed to thrive on crisis; crisis management was valued and rewarded. When I mentioned this during the debriefing, the architect said, "Yes, we run on crises like a car runs on gasoline."

... a team has been formed, and the Producer Roles (5.1.3) are in place. During the course of development, disruptions and distractions are common. The team's response to them can have long-term impact on the health of the organization.

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If a team overreacts to disruptions, the team can become perpetually dysfunctional.

A well-functioning team is like a spring, stretched over some distance. A disruption is like a wave induced in the spring; it travels along the spring for a while, keeping things from working as they did before. The right response damps the wave and life returns to normal. But the wrong response tends to amplify the wave and keep it going. In organizations, the danger is twofold: first, that the disruption interrupts the team more than it should, and second that the team members begin to see the disruption response as the normal way of life.

Disruptions to teams come in many flavors. The most obvious ones are crises such as emergency bug fixes. But team growth, changes in requirements, reorganizations are also disruptions.

Each disruption requires action which takes attention away from the task at hand. So the challenge is to take the appropriate action while minimizing the attention it draws away from the main job. An important aspect of this challenge is rewards: dealing with disruptions, particularly crises, deserves rewards, but one must be careful not to value fire fighting over fire prevention. People have been known to commit software development arson in order to become software fire fighting heroes.

Therefore,

Whenever possible, keep people in roles for at least the duration of the project release. Avoid elevating transient tasks dealing with disruptions to the status of roles.

Obviously, in order for this to work, the roles themselves must be around for the duration of the project.

The key is that as a disruption comes up, don't create a new role to handle it. Handling disruptions, particularly crises, has a certain status to it. If you allow a role to emerge, then the role institutionalizes the behavior, which tends to encourage the disruptions to happen. So instead, focus on nurturing the PRODUCER ROLES (5.1.3). This can be done carefully in the rewards (see COMPENSATE SUCCESS (4.2.25).)

Beyond typical crises, this pattern can be used as the team composition changes. Such disruptions may be less dramatic, but often are more devastating. Even team growth can cause serious disruption. So as the team changes, keep the remaining people in the same roles as much as possible. Instead, try to keep the role changes to the natural breaks in the project, such as just after the project ships.

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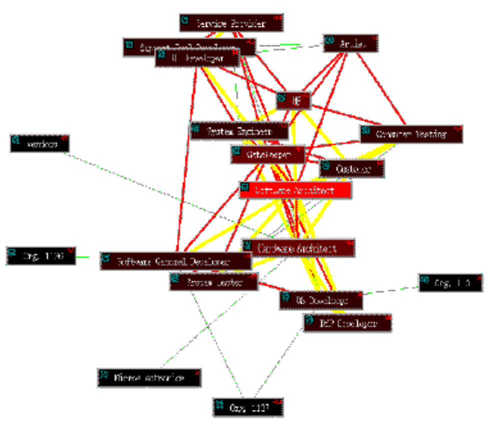
The impact of this action is manyfold. If you keep people in the same roles, the learning curve is obviously flattened. It helps maintain DOMAIN EXPERTISE IN ROLES (4.2.22). If people's roles don't change when they must deal with a crisis, they still retain their primary focus. Furthermore, the organization keeps its values focused on the long-term solutions, and not on the short-term disruptions.

This may seem like simple common sense, and it is. But the trouble with common sense is that it is, well, so uncommon.

5.1.6 Divide And Conquer **

...the roles have been defined for a process and organization, and the interactions between them are understood. The organization has grown to a point where it cannot easily manage itself. Perhaps there are too many people or, more seriously, too many roles, for the organization to hang together. The organization's decision process breaks down and progress bogs down for more and more decisions. Or the organization can foresee growth to a point where these problems arise.

For example, this organization has no apparent regular structure, and though it is productive, it is not likely to evolve well.



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Successful projects must learn to accommodate the growth that accompanies success in projects and that outstrip team dynamics. If an organization is too large, it can't be managed. Incohesive organizations are confusing and engender dilution of focus.

Separation of concerns is good. Even distribution of responsibility is good because it distributes the work load. Regular structures, such as hierarchies, can easily be grown by adding more people, without destroying the spirit of the original structure. But a regular hierarchical structure does not distribute responsibility evenly.

It is useful to have organization boundaries that are somehow lightweight.

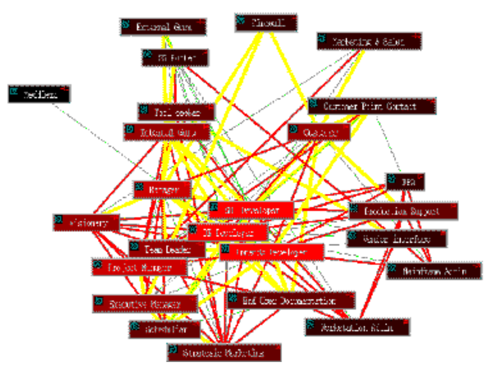
Therefore:

Find clusters of roles that have strong mutual coupling, but that are loosely coupled to the rest of the organization. Form a separate organization and process around those roles. Make sure the organization has identifiable sub-domains that can grow into departments in their own right as the project thrives and expands to serve a maintained market.

It is sometimes easiest to do this by identifying core roles that can form the root of sub-organizations that precipitate from a larger organization. Let the sub-organizations cluster around these roles.

You should apply this pattern between releases so as to minimize turmoil that might confuse work in progress.

This organization has no well-partitioned structures, but one can identify logical partitions within it (*Customer, Developer, Management*, etc.)



This establishes an overall organizational framework as a basis for organizational growth. Each new sub-organization is a largely independent entity to which the remaining patterns in this language can be independently applied. It makes it possible to have FEW ROLES (5.1.2) in any given closure of interaction.

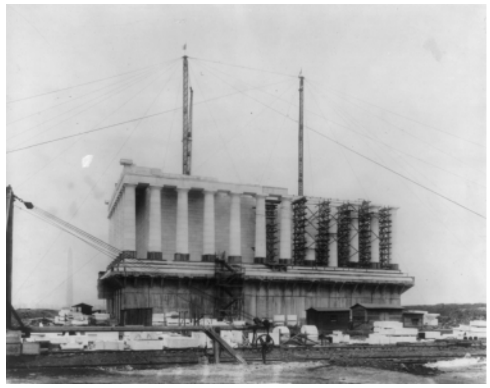
Implement this pattern using ORGANIZATION FOLLOWS MARKET (5.1.9), ORGANIZATION FOLLOWS LOCATION (5.1.8), and SACRIFICE ONE PERSON (4.1.22).

In the forces, note that each sub-organization that arises from this pattern is fodder for most other patterns, since each subsystem is a system in itself. Also, to see an organization that has been reverse engineered and redivided into new processes, see the picture for the pattern MOVE RESPONSIBILITIES (5.1.18).

The business structure is a key consideration in building an organizational structure. Much of the business structure becomes articulated in the architecture, so CONWAY'S LAW (5.1.7) is an important pattern supporting this one. If you can find no core roles around which sub-organizations might form, then the organization may not be partitionable. For example, it is difficult to grow a Chief Programmer Team organization.

If you need to divide things up in *time*, rather than across team structure, see GET ON WITH IT (4.1.3).

5.1.7 Conway's Law **



Construction of the Lincoln Memorial, 1916.

...an Architect and development team are in place. The architecture is fairly well-established.

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If the parts of an organization—such as teams, departments, or subdivisions—do not closely reflect the essential parts of the product, or if the relationships between organizations do not reflect the relationships between product parts, then the project will be in trouble.

The system architecture shapes the communication paths in an organization. De facto organization structure shapes formal organization structure. Formal organization structure shapes architecture. Early architectural formulations are only approximations and are unstable. However, there are major rhythms in the architecture that reflect areas of core business competency, and that level of concern is more closely tied to organizational structure than the broader concerns of the whole architectural structure.

Therefore:

Make sure the organization is compatible with the product architecture. At this point in the language, it is more likely that the architecture should drive the organization than vice versa.

An organization will have periodic reviews of the architecture, and potentially of project management strategies (see Stand Up Meeting (5.2.7)). At each of these meetings (if indeed they are separate) care should be taken to align the structure of the architecture with the structure of the organization, by making piecemeal changes to one or the other.

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The organization and product architecture will be aligned. It becomes easier for the pattern Developer Controls Process (4.1.17) to succeed.

One reason to let the architecture dominate more than organizational concerns is that the architecture is more often constrained by the problem, and that ties into the core reasons for the existence of the enterprise; see Organization Follows Market (5.1.9), for example. However, political forces are also powerful and may dominate even over core business needs; however, that usually bodes for serious organizational struggles.

The best structure in the long term is one that comes from a three-way alignment between the main structures of the business (domain), the structure of the organization, and the structure of the software. One approach is to design the major software artifacts around domain analysis considerations and to align the organization with the architecture accordingly; this works best for greenfield projects and where the original design team is small. Another approach is to design the organization around the business needs and let the architecture follow the organization; this is more important in legacy organizations where "expertise tradition" may suggest both organizations and architectures that don't follow more standard domain analyses.

Of course, all three of these structures must change over time to deal with evolution in the market, technology, and staff, though the fundamental assumptions about relationships between parts are unlikely to change frequently in a successful business. But even less momentous changes must be dealt with and, more importantly, the project must take opportunities to leverage its growing understanding of the business, of the suitability of specific technologies to support the business, and the organizational and system structures that can support the business. Much of this pattern language aims at maintaining the project communication essential to the long-term alignment of these structures. Specific patterns like STAND UP MEETING (5.2.7) should be viewed as opportunities not only to review the architecture, but to review the organizational structure and business strategies as well.

Gerard Meszaros (formerly of Nortel) notes that you want to bind the organization to the architecture only after the architecture has stabilized. If you bind the organization to the architecture too early, architectural drift will lead to interference between individuals' domains of control. On the other hand, Alistair Cockburn points out in SKILL MIX (10.5.28) [Cockburn1996] that it is sometimes necessary to separate subsystems according to the staff skills you have, since it takes advantage of the skills the team already has.

SUBSYSTEM BY SKILL (4.2.23) addresses finer team structure with regard to architectural considerations. DEPLOY ALONG THE GRAIN (5.2.8) or, more specifically, OWNER PER DELIVERABLE (10.5.19) and CODE OWNERSHIP (5.2.13), are CONWAY'S LAW in the small. Use STANDARDS LINKING LOCATIONS (5.2.12) to overcome the isolationism of CONWAY'S LAW.

The rationale is historical, from Conway's timeless paper "How do committees invent?" [Conway1968].

5.1.8 Organization Follows Location **

Different parts of the country may have different cultures and architectural styles.

I was once involved in planning a large project that was to be split between two locations. My organization was located in a new building in Colorado with blue carpet. The other half of the project was in New Jersey; their building had green carpet. When I presented our plan to my organization, I showed slides with different parts of the architecture colored blue or green, depending on where the development was to take place. The organization got the message immediately.

...a product must be developed in several different hallways, on different floors of a building, in different buildings or at different locations. This may owe to political reasons or to the need to have some development teams colocated with remote markets, or for reasons of standards or the distribution of physical facilities (e.g., the separation between different trading centers, or between a radio telescope site and a research university that uses its data), or even economic or trade issues that drive development to a different country.

There needs to be a degree of trust and camaraderie within an organization, since an organization is a decision-making body that must converge on and buy into joint decisions. Allegiance to an organization falls strongly along the lines of geographic distribution.

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It is important to assign tasks and roles insightfully across a geographically distributed work force.

Communication patterns between project members follows geographic distribution. Coupling between pieces of software must be sustained by analogous coupling between the people maintaining that software. People avoid communicating with people who work in other buildings, other towns, or overseas (see below). People in an organization usually work on related tasks, which suggests that they communicate frequently with each other.

Therefore:

The architectural partitioning should reflect the geographic partitioning, and vice versa. Architectural responsibilities should be assigned so decisions can be made (geographically) locally.

This is a variant of CONWAY'S LAW (5.1.7). Since the organization *will* follow the architecture, you want the organization, architecture, and geography to line up. Geographical considerations are often the most severe, and since architecture can be a strong lever for organization, it is a good tool to bring these three aspects into alignment.

One of the most significant characteristics of geographic differences is allegiance: people are naturally more loyal to local managers than to remote managers. This is even more extreme if a remote location is part of a company as a result of a merger or acquisition. If work is split between two locations where the work itself does not split cleanly, one or the other location must be in charge. And that naturally causes resentment on the part of the other location. Instead, try to make the work assignments as autonomous as practical; this instills trust.

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Sub-organizations that can be further split or organized by market or other criteria (see ORGANIZATION FOLLOWS MARKET (5.1.9), WORK FLOWS INWARD (4.1.18), and others). You still need someone to break logjams when consensus can't be reached, perhaps using ARCHITECT CONTROLS PRODUCT (5.2.3) or PATRON ROLE (4.2.15). If the organization is modularized along geographic boundaries, and the architecture is not then it will be impossible to apply ARCHITECT ALSO IMPLEMENTS (5.2.10): it's difficult for the architect at one location to oversee and contribute to the code at another.

Thomas Allen [Allen1977] has found that social distance goes up rapidly with physical separation (see also “House Cluster” ([Alexander1977], ff. 197) of Alexander). We have noted frequent cases of international collaboration (usually overseas) that strongly exhibit symptoms of this problem and which have had low prospects for success owing to just such separation. This is a crucial pattern that is often overlooked or dismissed out of consideration for political alliances or fashion (for example, outsourcing software development is very fashionable in management circles at this writing). Peter B¸rgi’s studies of geographically distributed organizations in AT&T bore out the importance of this pattern.

We have seen few geographically distributed organizations that exhibit positive team dynamics. There are exceptions, and there are rare occasions when this pattern does not apply. Steve Berczuk (then at MIT) notes: "... communications need not be poor between remote sites if the following items are true:

1. The number of developers on a project, including all sites is small;
2. Most of the communication is done via something like email (wide distribution and asynchronous communication—in [one case of his experience] ... more people were in the loop than if the primary means of communication had been hallway chats);
3. The people involved have been together for *some* time so that they feel like they know each other (this can be as short as a kickoff meeting; see FACE TO FACE BEFORE WORKING REMOTELY (5.1.10));
4. Folks aren’t so burned out by “unnecessary” travel that they are willing and happy to travel when it is needed. In some situations [complete work split by location] is not possible because of the nature of the project, so we need a way to address the issue of remoteness." (Personal communication with Steve Berczuk, August, 1994.)

There are times when the market demands geographic distribution; see ORGANIZATION FOLLOWS MARKET (5.1.9) and [Berczuk1996]. In these cases you need FACE TO FACE BEFORE WORKING REMOTELY (5.1.10).

As an organization grows, it may want to split geographically for a number of marketing and political reasons (DIVIDE AND CONQUER

(5.1.6)). The OTI corporation relates how it splits organizations geographically to keep reusable assets uncontaminated by each other.

That people be colocated within a building is probably more important to organizational effectiveness than to allocate offices as perks of seniority. Senior staff may have a need for larger or more secure offices than junior staff, but not for an office near the rest room or an office with a window.

See STANDARDS LINKING LOCATIONS (5.2.12) as a technique supporting this organizational structure in the PEOPLE AND CODE PATTERN LANGUAGE (5.2).

5.1.9 Organization Follows Market *

Vegetable market, San Diego, California.

....the market comprises several customers with similar but conflicting needs. The project has adopted sound architectural principles, and can organize its software according to market needs.

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There needs to be an identified role or organization with accountability to each market segment.

For example, AT&T used to market both private branch exchanges (PBXs), which customers owned and administered on site, and a feature called CENTREX that ran on telephone company switches to offer PBX-like features to its customers. Different organizations marketed CENTREX and PBXs, which caused confusion about how best to serve the company's markets.

The development organization should track and meet the needs of each customer. Customer needs are similar, and much of what they all need can be done in common. Different customers expect results on different schedules.

Therefore:

In an organization designed to serve several distinct markets, it is important to reflect the market structure in the development organization. One frequently overlooked opportunity for a powerful pattern is the conscious design of a "core" organization, that supports only what is common across all market segments. Ralph Johnson calls this a *framework team*. It is important to put this organization in place up front.

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Note that since CONWAY'S LAW (5.1.7) states that organization and architecture are isomorphic, that the architecture must follow the market. In reality, if the organization is set up to follow the market, it makes it easier to have a clean architecture that follows the market lines. The success of this pattern is necessary to the success of ARCHITECT ALSO IMPLEMENTS (5.2.10), since the architect's focus and intent are driven much by the market. ARCHITECT ALSO IMPLEMENTS (5.2.10) should be seen as an audit, refinement, or fine-tuning of this pattern.

Once taken care of, this pattern allows the organization to start forming around patterns like FORM FOLLOWS FUNCTION (5.1.11) to flesh out the structure at a finer level.

AT&T actually solved this problem in an extreme way—by spinning off its PBX organization as a separate company.

Most of the rationale is in the forces. Two of the major forces relate to individual customer schedules, and to posture the organization to respond quickly to customer requests. Two important aspects of domain analysis are broadening the architecture (e.g., by working at the base class level), and ensuring that architectural evolution tracks the vendor understanding of customer needs. A single organization can't faithfully track multiple customer needs, and this organization allows different arms of the organization to track different markets independently.

5.1.10 FACE TO FACE BEFORE WORKING REMOTELY **

Camp Carson, Colorado. Colonel Wilfrid M. Nlunt, the commanding officer shakes hands with Colonel Denetrius Xenos, military attache of the Greek ambassador to the United States — a face-to-face meeting before working remotely.

Designing a new aircraft is a big deal. A very big deal. It's very involved, very expensive, and pretty risky. It takes the coordinated efforts of many different teams. When the Boeing Corporation began work on the new 777 airplane, it brought everyone on the project together for a kickoff meeting. There were thousands of people, all together, to get the project off on the right foot. Fortunately, Boeing owns many large aircraft hangers, so it could accommodate a meeting of that size.

...market or personnel conditions sometimes require that a project be geographically distributed. In such cases, ORGANIZATION FOLLOWS LOCATION (5.1.8) is used to partition the work. But even when the work is partitioned in this manner, it is a challenge to actually implement the partitioning effectively. It may look good on paper, but the real people will run into a host of difficulties as they work it out.

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The pull of local organizations is so strong that it can overwhelm common architecture, market, and social aspects of a project.

Geographic distance makes communication harder. Different time zones create logistical difficulties for conversations. The cultural differences that often go hand-in-hand with long-distance cooperative work are sometimes staggering. The obvious problem is finding common times, but there are more subtle forces at work. One project was split between the United States and England. Conference calls took place in the morning in the U.S., which was late afternoon in England. Consequently, the U.S. people were fresh, but their colleagues in England were winding down, ready to hit the local pub.

Difficulties in communication often weaken direct, effective communication paths, shunting communications to more indirect paths through the organization. Local leaders receive marching orders and pass them to their colleagues, but unintentionally add their own interpretation. Some may remember the children's game, "gossip" where a message is whispered from one player to another until it bears no resemblance to the original message.

Although partitioning the project along geographic lines is necessary it has the side effect of isolating one location from another. They must communicate at defined interfaces (see STANDARDS LINKING LOCATIONS (5.2.12)), and this results in people working on these interfaces without being able to get to know the person at the other end. People naturally tend not to work as well with those they don't know. It's hard to work with someone who is no more than a remote keyboard or a faceless voice on the phone.

Therefore:

Begin a distributed project with a fact-to-face meeting for everyone. This meeting should establish project unity, as well as give people a chance to get to know those they work with.

The meeting establishes unity by talking about project goals, intended markets, competitors, and the project architecture (important). (It isn't necessary that the architecture be nailed down yet; in fact, this can be a springboard for LOCK 'EM UP TOGETHER (5.2.5).)

The social aspects of a meeting are vitally important. Betsy Hanes Perry notes, "It is vital to leave at least half of the on-site time as UNSCHEDULED TIME. This allows group members to have impromptu conversations with the people they're closely coupled to. If you don't provide time for these conversations, you will find that bathroom breaks stretch on forever, and that the visitors leave frustrated.” Steve Berczuk adds: “At Kodak we once had a group meeting of everyone in the division, from every location. The agenda was packed so tightly that we never really got a chance to meet each other.” These social interactions are one of the reasons that videoconferences are no substitute for the face-to-face meeting.

Every organization needs a place to call “home”. Hold the meeting in a place that is memorable because of its uniqueness, beauty, great food, or other memorable quality, so that the group can identify with that place and its good memories. Hold group activities at that place, beyond the drone of everyday business activities, that will make the place memorable.

In a large project, the prospect of an initial face-to-face meeting may be daunting. But the Boeing company brought thousands of people together at the inception of the 777 project. Of course, they *do* own a few planes...

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The importance of this initial meeting should not be underestimated. For a distributed project, it may be the very best way to establish Unity Of Purpose (4.2.12). Furthermore, the social aspects of people getting to know each other go a long way toward resolving the tension between Organization Follows Location (5.1.8) and Standards Linking Locations (5.2.12). It sets up an environment where you can do Shaping Circulation Realms (5.1.12) successfully.

An initial meeting of everyone can easily be followed (often immediately) by a Lock ’em Up Together (5.2.5) architectural session.

It may not stop with a single meeting. You may find that regular “all hands” meetings are worth the transportation expenses.

5.1.11 Form Follows Function

Visitors' overlook building at Kentucky Dam. This structure is in the form of an open shed because the other functions of TVA (Tennessee Valley Authority) visitors' buildings being accommodated in the nearby construction village, there was need for shelter only at this point. Since the project is in a hot climate, ample ventilation is promoted by the open front, a balustrade height opening toward the back underneath the display and grilles to ventilate the roof space. Most of the displays are arranged as transparencies, with natural illumination during the day, and with floodlights used as substitutes during the night.

...you know the key atomic process activities, but there is little specialization and few well-defined roles. People don't know where to turn for answers to questions.

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A project must delineate well-defined roles to help identify and leverage expertise relevant to emerging problems.

Individual activities are too small, and their sequencing relationships too dynamic, to be useful process building blocks.

You could build talent lists of the individuals in an organization and partition the work among them, but that makes the organization sensitive to personnel changes. And it would be nice to sometimes be able to talk about the organization structure at a higher level of abstraction than individuals.

You could organize around classical roles such as “developer” and “designer” and “manager,” but that’s only a partial solution. These roles don’t apply to all organizations, and stereotypical roles can’t generalize to a wide range of domains.

Activities often cluster together by related artifacts or other domain relationships.

You want to match up specialization, expertise and experience when staffing an organization.

Therefore:

Group closely related activities (that is, those mutually coupled in their implementation, or which manipulate the same artifacts, or that are semantically related to the same domain). Name the abstractions resulting from the grouped activities, making them into roles. The associated activities become the responsibilities (job description) of the roles. Roles, rather than activities, become the basic project building blocks.

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For example, if a project depends heavily on a software library, there should be some ownership (see CODE OWNERSHIP (5.2.13)) embodied in a role such as *Librarian*. The *Librarian* has responsibilities and social communication patterns distinct from those of a developer, which makes it a separate role. Other roles such as *Vendor Coordinator*, *Rules Developer*, or *Computer Graphics Artist* speak to the function of the organization and its product.

Other roles convey more subtle aspects of organizational function and structure. One organization featured the roles *Code Police* and *Agitator*, reflecting a lighthearted attitude towards what might otherwise be considered onerous functions.

This approach yields a partial definition of project roles. Some roles (MERCENARY ANALYST (4.1.24), developer, architect, GATE KEEPERETC.) are canonical, rather than deriving from this pattern. Those roles, too, are in concert with this pattern, though at a more generic level.

The idea was used in a large project re-engineering effort that Jim Coplien worked with in March of 1994.

Louis Sullivan is the architect credited with the primordial architectural pattern of this name ([Rybczynski1989], p. 162).

This pattern interacts with other structural patterns such as ORGANIZATION FOLLOWS LOCATION (5.1.8), ORGANIZATION FOLLOWS MARKET (5.1.9), and ARCHITECT ALSO IMPLEMENTS (5.2.10). Also see ENGAGE CUSTOMERS (4.2.6).

One manager notes: "In my experience from Project Management Audits ... projects both leave out roles (e.g., no named architect) and define several people with the same role. The second is most problematic, since it causes staff confusion. But the missing role also occurs because projects have inexperienced managers. This is a big problem...around System Engineering roles, or lack thereof."

5.1.12 Shaping Circulation Realms *

Square dancing — overt shaping of circulation realms.

...in the application of communication patterns, you need to reshape the social network of the organization to move roles closer or further to the center, or closer or further from the customer, or to balance load, or to otherwise support some pattern of communication structure in the organization.

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One cannot just expect communications to happen spontaneously; more so, one cannot expect any particular configuration of communication to arise in an arbitrary social environment.

Proper communication structures between roles are key to organizational success. Communication can't be controlled from a single role; at least two roles must be involved. Communication patterns can't be dictated; some second-order force must be present to encourage them. Communication follows semantic coupling between responsibilities.

Therefore:

Create structures in the organization or in the work space that encourage the communication connections that support other patterns.

Give people titles that creates a hierarchy or pecking order whose structure reflects the desired taxonomy. Give people job responsibilities that suggest the appropriate interactions between roles (see also MOVE RESPONSIBILITIES (5.1.18)).

Physically collocate people whom you wish to have close communication coupling (this is the dual of the pattern ORGANIZATION FOLLOWS LOCATION (5.1.8)).

Tell people what to do and with whom they should interact; people will usually try to respect your wishes if you ask them to do something reasonable that is within their purview and power.

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This pattern is a building block for other patterns in the language, including ORGANIZATION FOLLOWS MARKET (5.1.9), DEVELOPER CONTROLS PROCESS (4.1.17), DECOUPLE STAGES (5.1.16), ARCHITECT ALSO IMPLEMENTS (5.2.10), ENGAGE QUALITY ASSURANCE (4.2.29), ENGAGE CUSTOMERS (4.2.6), RESPONSIBILITIES ENGAGE (5.1.14), THE WATER COOLER (5.1.20), HALLWAY CHATTER (5.1.15), SUBSYSTEM BY SKILL (4.2.23), and others. This pattern may also apply to circulation realms outside the project through patterns like FIRE WALLS (4.2.9), and many others. The goal is to produce an organization with higher overall cohesion, with sub-parts that are as internally cohesive and externally de-coupled as possible.

This follows an Alexandrian pattern ([Alexander1977], ff. 480) of the same name, and has strong analogies to the rationales of "House Cluster" ([Alexander1977], ff. 197). An analogous rationale for organizational structures can be found in [Allen1977]. In fact, the organizational structure may be homomorphic with the structure of the buildings and rooms in which the organization lives and works, so Alexander's pattern of the same name may be a crucial driving force behind this ostensibly organizational concern.

Note that MOVE RESPONSIBILITIES (5.1.18) is a closely related pattern.

See related notes in the Rationale for GATE KEEPER (4.2.10).

5.1.13 Distribute Work Evenly *

A twenty-mule team distributes work and communication evenly.

...an organization is working to organize in a way that makes the environment as enjoyable as possible and which makes the most effective use of human resources.

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It is easy to depend on just a few people to carry most of the organization's burdens. Managers like this because it minimizes the number of interfaces they need to manage. And some employees strive to do all they can out of a misplaced feeling of monumental responsibility. In fact, we find that Producer Roles (5.1.3) tend to have stronger communication networks than other support roles.

But if this unevenness continues, it is difficult for a heavily loaded role to sustain the communication networks necessary to healthy functioning of the enterprise as a whole. Resentment might build between employees who don't feel like they are central to the action. And the central people may easily burn out.

Define the *communication intensity ratio* as the ratio of the number of communication paths of the busiest role to the average number of communication paths per role. Empirically, one finds that the organization has a problem—some unhealthiness—if this ratio becomes too large.

Therefore:

Try to keep the communication intensity ratio to two or less. (We have found that it isn't easy to get much below two.) The easiest way to do it is to have Few Roles (5.1.2). It also helps to identify the Producer Roles (5.1.3) and eliminate any deadbeat roles. You can also identify all the communication to the most central role and see which are really necessary.

Some of this communication overhead isn't very subtle, and these cases are easy to identify. You can eliminate redundant or misdirected communication using simple and direct methods, without going to the level of deep structure or principles of the organization, in these cases.

Other situations take more finesse and generativity, building on other patterns in this pattern language.

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If an organization becomes so out of balance that the work is concentrated in a few people, the organization is more likely to have spots of burnout. Such unevenness might also point to deeper problems in the organization. For example, the more lightly loaded people may not have the technical skills or the human interaction skills to be able to integrate into the larger team or organization. Personality differences can be compensated for with human effectiveness training programs that help communication from the level of appreciating differences to the level of effective presentation. Skill mismatches can be dealt with by re-assigning people or by training.

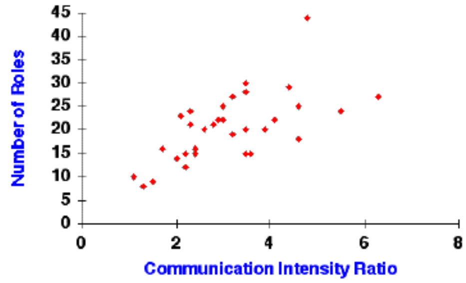
Unbalance may also point to insecurity in the person or clique that tries to take on all the work. Such insecurity may manifest itself as lack of trust of others. Encounters between the insecure parties and the rest of the project polarizes the positions of each, and a form of schismogenesis may set in—the rise of factions in the organization (see THE OPEN CLOSED PRINCIPLE OF TEAMS (6.1.4)). It may show up either as the insecure subgroup withdrawing, or as in the insecure subgroup trying to hijack the project by strong-arming people into doing their bidding. This may be accompanied by some of the dynamics of burnout; e.g., shutting down communication with "outsiders." Patterns like GATE KEEPER (4.2.10), JESTER ROLE, and Patron can help avoid this.

In any of these dysfunctions, it is the job of the MANAGER ROLE to counsel the insecure or dysfunctional parties and to take strong intervention. The fix is often intricate and time-consuming.

This pattern follows PRODUCER ROLES (5.1.3) and PRODUCERS IN THE MIDDLE (5.1.4), which are prerequisite to SHAPING CIRCULATION REALMS (5.1.12). This pattern itself is a refinement of SHAPING CIRCULATION REALMS (5.1.12). FEW ROLES (5.1.2) makes this pattern happen.

This pattern can be implemented and elaborated by using THREE TO SEVEN HELPERS PER ROLE (5.1.21) and RESPONSIBILITIES ENGAGE (5.1.14).

Here are data on communication intensity ratio for some of our early research subjects. We find that the successful organizations tend to be near the origin of the graph.



5.1.14 Responsibilities Engage

The responsibilities of raising children encourage parents to be actively engaged in their children's lives.

...the organization has been established, and people have settled into their roles. Communication tends to be centralized.

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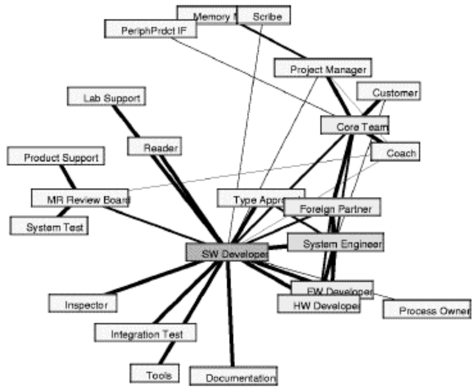
If communication predominately flows through the center of the organization, two things happen: communication takes too long, and the most central roles become overburdened with communication

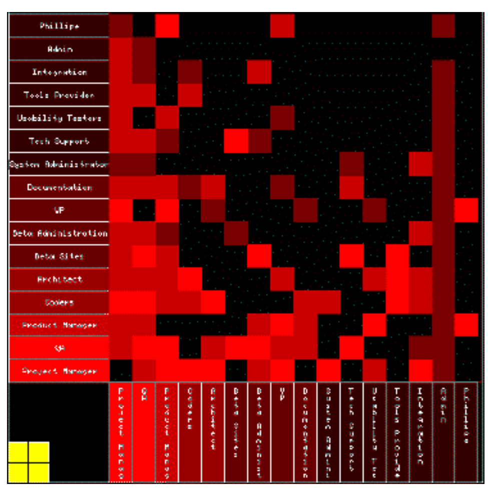
The most central roles in an organization have the most information about the project, thus they are the most logical ones to transmit and receive information. However, they are also the key producer roles in the organization as well. So time they spend in communication directly impacts their development productivity.



But there must be central coordination (which is a weak form of control) or some other acceptable point of control. Fully distributed control tends to lead to control breakdown. Coordination helps accountability, efficiency, camaraderie, can reduce decision time for changes in the business environment (such as requirements changes), and so forth.

Therefore:

Shuffle responsibilities among roles in a way such that outer roles collaborate with roles other than the most central roles.



For example, a tester role may be isolated from the project. It would be well for the tester to learn which areas of the project are especially troublesome, so they can be tested especially rigorously. But this information is often not forthcoming. The tester could ask the key developers what the project "hot spots" are, but this would be inefficient and cause bottlenecks. Therefore, give the tester some project management responsibilities, where they actively participate in status meetings. They will pick up information relevant to testing through the project management responsibilities.

Note that in some cases, moving responsibilities will actually cause roles themselves to migrate, and even merge. In most cases, that is actually a good thing.

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This infuses a level of "distributed control with central tendency" that lends overall direction and cohesion to an organization. It complements DIVIDE AND CONQUER (5.1.6), both by providing for bonds within organization clusters and by providing linkages between sub-clusters, linkages less formal than a GATE KEEPER (4.2.10) role. It adds symmetry to DIVIDE AND CONQUER.

This pattern can stand on its own, but it is nicely completed by the application of HALLWAY CHATTER (5.1.15).

Laurie Williams notes that DEVELOPING IN PAIRS (4.2.28) achieves some of the same effect. When she uses this in a pedagogical setting, students learn to rely more on each other and less on the teacher for answers to common questions.

5.1.15 Hallway Chatter *

One day a friend came into my office, depressed about her project. She was in a test group, and their group was essentially shut off from the rest of the project. They didn't get timely information about what was happening; they didn't hear the latest project gossip. The only people they could talk to were each other. Following the anthropologist Bateson, we call this condition "schismogenesis"—the creation of schisms. Her situation was the most striking example I had ever seen. She went on to other projects, so I didn't find out what ever happened with the organization. I suspect the problem wasn't fixed until the project was reorganized, or until a quality crisis forced them to involve the testers better.

...the organization has been established, and people have settled into their roles. This has led to uneven communication among the team members, and some members do not feel a part of the team.

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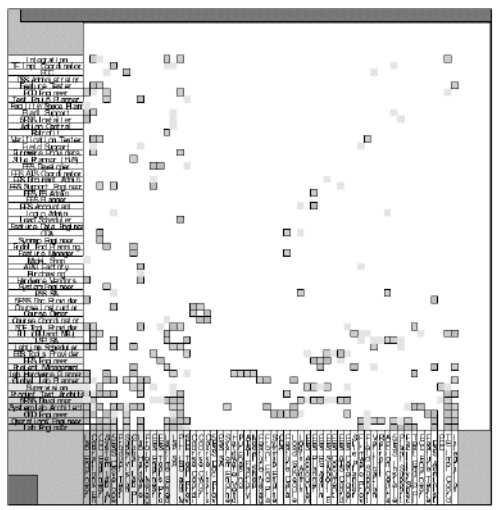
If people are left out of the main communication flow, they become dissatisfied, gripe among themselves, and may even leave the project. And by the way, they can't do their jobs as well.

When people become disengaged from communication networks, they can feel alienated from the community. They sometimes commiserate with others in the same situation, forming alliances with others who are equally distant from the center of the community. This phenomenon was first observed by Bateson in the Sepik tribes in New Guinea, and was named "schmismogenesis." [Bateson1958]

The following interaction grid (see SOCIAL NETWORK THEORY FOUNDATIONS (7.5.2)) shows an organization exhibiting schismogenesis. One can see interactions along, but not on, the diagonal. These are best explained as "comfort groups" that differentiate themselves according to their shared centrality (or relative lack thereof) with respect to the organizational structure. See THE OPEN CLOSED PRINCIPLE OF TEAMS (6.1.4) for more on schismogenesis.

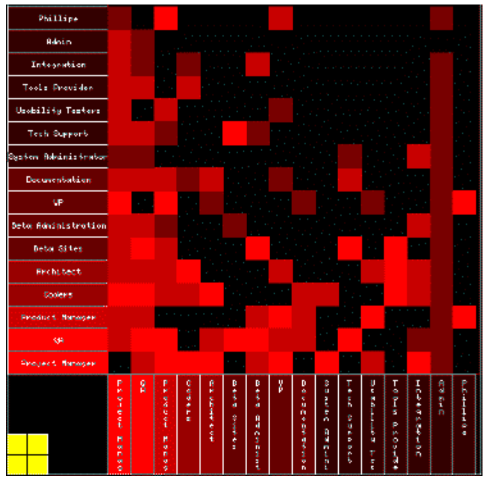


For any given role, there is a certain amount of information which is formally required for that role to be fulfilled. But this is usually insufficient for optimal efficiency; we tend to do better when we have contextual information as well as essential information.

But the hard thing is knowing what that additional information is. It's elusive: for example, a project might be officially on schedule, but the developers are murmuring among themselves that development isn't going so well. There is nothing concrete to put one's finger on, but something isn't quite right. This is important information if you are the tester waiting for delivery.

Therefore:

Move team members physically as close to each other as possible. Be sure that people with outer roles are located close to the central roles.



Thomas Allen [Allen1977] gives guidelines for physical distance.

Of course, some projects, for various reasons, are split geographically. This can lead to exactly this problem unless Organization Follows Location (5.1.8) and Conway's Law (5.1.7) are followed.

Note that it is a misapplication of this pattern to apply it to only a subset of an organization responsible for a project. If for example, one clusters all the developers together in a "developer's ghetto", and forgets System Test or Marketing, you violate Engage Quality Assurance (4.2.29) and Engage Customers (4.2.6). And you actually create, rather than alleviate schismogenesis. In addition, communication with individuals outside the project is also important. Allen [Allen1977] points out that the high performers had significantly more communication outside the project than low performers. See The Water Cooler (5.1.20) for additional ways to encourage communication, particularly outside the project.

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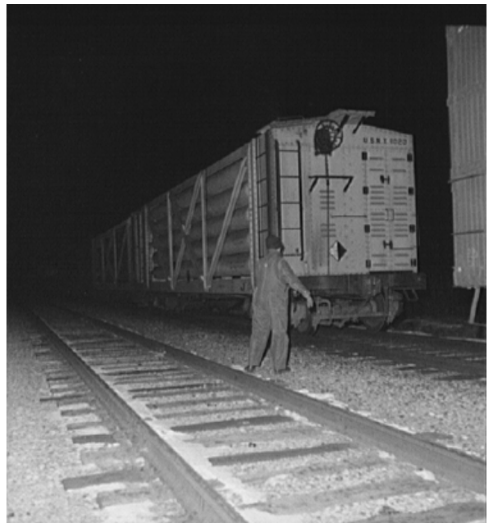
The pattern complements DIVIDE AND CONQUER (5.1.6) both by encouraging symmetries within local groups, and establishing pathways between groups.

There are two complementary effects of this action. First, the people in the outer roles feel like they are a part of the project, and their morale improves. They are less likely to gripe about the project with other outsiders because they are no longer outsiders. The second thing that happens is that they pick up more technical information through informal means, such as the chatter in the hallways, and they can do their jobs better. This secondary effect is the generative nature of this pattern: As communication improves quality and time-to-market are improved, which tends to reduce the number of people needed for the project, which reduces communication overhead, which helps improve communication, and so on.

An organization consists of both roles and the people who fill those roles. Both must be considered. While most of the patterns in this language address one or the other, this pattern is unusual in that it bridges the two.

A PUBLIC CHARACTER (4.2.17) such as a MATRON ROLE (4.2.18) or GATE KEEPER (4.2.10) can be a catalyst for HALLWAY CHATTER.

5.1.16 Decouple Stages



...a design and implementation process have been established for a well-understood domain. Well-understood, high-context domains have less need for patterns like Build Prototypes (4.1.7) and can actually proceed well according to a standard waterfall model.

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Development stages should be independent to reduce coupling and promote autonomy of teams and developers. There is a tradition of decoupling architecture, design, and coding in a development process. While this doesn't make sense for most software development — and is especially suspect for greenfield development — it sometimes makes sense in mature, high-context development projects. But there is still a trade-off: while independence creates opportunities for parallelism, it also hampers information flow.

Therefore:

For known and mature domains, serialize the steps. Hand offs between steps should take place via well-defined interfaces. This makes it possible to automate one or more of the steps, or to create a pattern that lets inexpert staff carry out the step.

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The new organization allows for specialization in carrying out parts of the process, rather than emphasizing specialization in solving the customer problem.

This approach is "safe" only for well-understood domains, where the mapping from needs to implementation is straightforward. Domains that are well-understood are also good candidates for mechanization. For less mature domains, the process should build on the creativity of those involved at each stage of the process, and there should be more parallelism and interworking.

You can afford to do this in high-context, mature areas because the patterns of work are repeatable and rarely bring surprises. That means that each stage can be carried out independently. That means less communication between stages, which means better efficiency. One can further raise the efficiency by building on specializations and domain knowledge pertinent to individual stages. Example domains include database administration (with steps such as database modeling, normalization, and query optimization), packaging, delivery and installation, and many administrative functions like bug tracking or the high-level business processes supporting field error report resolution.

Though interfaces between process steps help insulate the steps from each other, these interfaces should also be effective and useful. These interfaces shouldn't exist for their own sake or empire-building, or even to establish formal organization boundaries. They should encapsulate well-understood domains of control that ease hand offs between stages. If the interfaces increase cost and latency, they are wrong: either they have been implemented improperly or they shouldn't be there at all.

This pattern prepares for HUB SPOKE AND RIM (5.1.17).

5.1.17 Hub Spoke And Rim

...you have a design and implementation process in a well-understood domain, and want to implement the principles of Decouple Stages (5.1.16). The organization is mature and the process well-understood; it is fairly well optimized and has good partitioning in the spirit of Divide And Conquer (5.1.6). Mature development organizations have well-defined development stages—such as requirements acquisition, design, and coding.

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Some processes can almost be automated, but still require a degree of human intervention and coordination. This is particularly true for highly detailed processes.

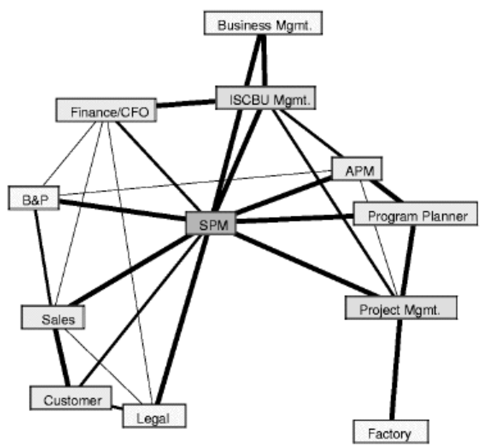
For example, even if a process is mature enough to have well-delineated development phases, it may need additional mechanisms to integrate these stages and coordinate the interactions between them.

Process stages should be decoupled to reduce the communication associated with hand offs and promote independence between stages. Such independence creates opportunities for parallelism and increased throughput. Yet independence generally hampers information flow.

Therefore:

Link each role to a central role that orchestrates process activities, with the activities taking place serially. The hub plays a simple coordination and management function to ensure all steps are completed successfully, while the work is done in the rim. The "rim" carries the hand off and its associated information between roles. The "spokes" provide the link to the central coordinating agent, and are lighter links of communication than between the "rim" roles.

This organization, a front-end process for a large development project, exhibits HUB SPOKE AND RIM:



The process supports sales and marketing activities and is highly responsive.

The hub role should be encouraged to avoid micro-managing, particularly with respect to the mechanisms individual rim roles use in achieving their tasks. The hub role *should* scrutinize deadlines and schedules and should be in close enough contact with the rim roles to facilitate hand offs from role to role if necessary, and to communicate the state changes to other parts of the project as necessary. In this sense, the hub role can also act as a natural FIRE WALL for the rim roles.

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The rim roles still maintain a good modicum of autonomy; each can focus on its own domain-specific task. There need not be any essential *domain* coupling between the roles on the rim; the only coupling is with respect to sequencing. The hub can coordinate that coupling and can optimize it (juggle priorities, give different projects or customers different priority) to meet project priorities. The hub is a management role rather than a development role—a controller or sequencer. The hub role holds things together and ensures that progress ensues from state to state. Here, we want to ensure progress in the *process*; compare with the design pattern SOMEONE ALWAYS MAKES PROGRESS (4.1.20). HUB SPOKE AND RIM is an implementation pattern that achieves the intent of SOMEONE ALWAYS MAKES PROGRESS (4.1.20) in a limited context.

Prof. Aaron Gelman (Northwestern University) notes that in the contemporary airline market, the hub pattern contributes to congestion. Many airlines are acquiring small planes that can take small numbers of passengers directly between end destinations, acting as “hub busters” and relieving such congestion. The analog is a concern for over-application of this pattern. (WBBM Radio News, Chicago, IL, Sep. 30, 2000)

The organization must be wary of the central role becoming a bottleneck, and address such bottlenecks with other patterns (e.g., MOVE RESPONSIBILITIES (5.1.18)).

This configuration has higher latency than a highly coupled process, but it is likely to be able to support higher throughput (see COUPLING DECREASES LATENCY (5.1.22)). However, it cannot easily support essentially creative processes that are common to design, coding, and testing. In the creative process of design, communication is more important than sequencing, since a repeatable sequence is unlikely to be found in such a creative process.

In a less mature domain, it is more appropriate to apply DEVELOPER CONTROLS PROCESS (4.1.17) as the alternative. *Most* domains in fact lack the maturity for HUB SPOKE AND RIM to be appropriate.

Parallelism can be re-introduced if the central role pipelines activities become a bottleneck.

5.1.18 Move Responsibilities *

Moving responsibilities among roles is a delicate balancing act.

...you want to change the communication patterns of the organization as a whole, not in a way that depends on a specific role, but in a way that optimizes the effectiveness of communication of an entire organization.

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Unscrutinized relationships between roles can lead to poor overall patterns of coupling in the greater organization.

In the spirit of Conway's Law (5.1.7), organizations tend to form around loci of communication; that is, the roles tend to communicate chiefly with each other, rather than to other (small) organizations in the larger enterprise. But some roles find themselves pulled in two different directions: they have substantial communication needs outside the organization.

You want cohesive roles. And you want cohesive organizations. Decoupled organizations are more important than cohesive roles. And there may be fundamental trade-offs between coupling and cohesion.

Moving an entire role from one process or organization to another doesn't reduce the overall coupling, but only moves the source. You could move a person from one organization to another organization to make things more balanced, but responsibilities don't always align with individuals. You could replicate responsibilities across multiple roles or organizations to increase locality; however, that tends to confuse ownership and coordination, and is not guaranteed to decrease the coupling, anyway.

Therefore:

Move responsibilities from the role that creates the most undesirable coupling, to the roles coupled to it from other processes. Simply said, this is load balancing. The responsibilities should not be shifted arbitrarily; a chief programmer team organization is one good way to implement this pattern (in the context for Developer role responsibilities).

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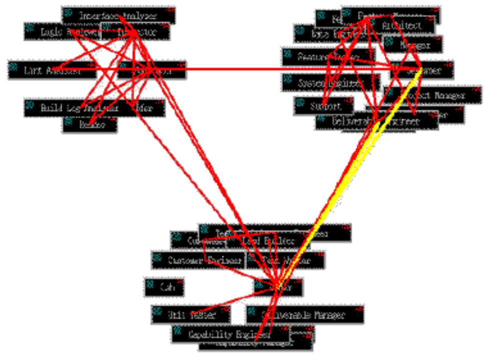
The new process may exhibit more highly de-coupled groups. It is important to balance group cohesion with the de-coupling, so this pattern must be applied with care. For example, the Developer role is often the locus of a large fraction of project responsibilities, so the role appears overloaded. Arbitrarily shifting Developer responsibilities to other roles can introduce communication overhead. A chief programmer team approach to the solution helps balance these forces.

Hallway Chatter (5.1.15) is an alternative load-balancing pattern; Responsibilities Engage (5.1.14) can be seen as a refinement of this pattern that evens load. Upside Down Matrix Management (5.1.19) is a refinement of this pattern that's particularly applicable across enterprise boundaries.

Most of the design rationale follows from the forces themselves.

This is isomorphic to Mackenzie's model that task interdependencies, together with the interdependencies of task resources and their characteristics, define project roles [Mackenzie1986].



This organization can be improved by redistributing some of the responsibilities of **Tester** at the bottom center.

5.1.19 Upside Down Matrix Management *

A rowing team has a single point of reporting and allegiance, embodied by the coxswain.

...you are assembling teams, and tend to build teams and organizations within the framework of the indigenous corporate structure.

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Sometimes it is difficult to reconcile a task or work function with the existing organization of the enterprise.

Assigning work to groups within your own organization may starve them from resources or expertise that they need. While Gate Keeper (4.2.10) and other roles can deal with this problem in degree, sometimes the need is so great that no existing organizational structure seems to fit the need.

For example, you may not have staffing resources that fit a given profile of domain expertise, which makes it difficult to achieve Domain Expertise In Roles (4.2.22). Or you may not be able to achieve scheduling goals with the staffing constraints of your organization. Or the problem may beg interdisciplinary solutions that don't fit your current structure: the logical and physical business architectures may not be aligned.

You could reorganize into a new set of disjoint groups that are a better fit for the problem, but there are always concerns that cut across others, so there is no guarantee that a useful disjoint partitioning even exists.

Any team assignments you make may have long-term repercussions for the organization and architecture (per CONWAY'S LAW (5.1.7)). While some teams can be created to address intermittent problems, some of these "misfit" needs reflect bona fide long-term core competencies or business concerns. That begs an organization to nurture such work.

Therefore:

Form new groups from the right roles and people in a way that may cut across the current organizational structure. Temper legacy structures that owe to casuistic barriers (historical, political, or organizational boundaries). Challenge financial barriers that keep the dysfunctional partitionings in place by adjusting funding models.

Often these new structures can be found in organizations other than your own. Consider creating these structures in the customer space, or partner with other internal organizations, external contractors, and suppliers to fill these organizational needs. However, beware of jumping to the outsourcing solution. Carefully create groups and teams around key areas of competency and concern, letting the partitioning fall across enterprise boundaries where it may. Temper with the pattern ORGANIZATION FOLLOWS LOCATION (5.1.8); its forces are probably more powerful than those at work here.

Note the name of this pattern. In a matrix-management paradigm, individuals or groups are asked to report to two (or more) managers in an attempt to solve this problem. This turns that notion on its head: instead of multiple reporting roles, a separate team is formed, so that the team members have a single point of reporting and allegiance.

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In his pattern WORK ALLOCATION (10.5.29), which is related to this one, Beedle reports use of this pattern between Navistar and Good Year. Navistar has shifted some of its work back to its suppliers. Instead of managing its own warehouse inventory of tires to be installed on the trucks it manufactures, it delegates Good Year, its supplier to do that, because they have better inventory management methods. He also reports similar arrangements between Wal Mart and its suppliers, and between Ford and its suppliers.

THE WATER COOLER (5.1.20) is similar to this pattern, but works in the space of everyday social life rather than in institutional structures.

5.1.20 The Water Cooler *

Boys cooling off around a fire hydrant, Chicago, Illinois, 1941. The cool water of the fire hydrant created a setting for social interaction among the boys.

When I transferred to the Forward Looking Work department at Bell Laboratories, I eventually found myself working for a manager who was a fanatic hobby runner. Each day, instead of taking lunch he would take a five-mile run outside, even in inclement weather. Several of his group members, not to mention several of his peer managers, were also runners. There was a culture of cross-organizational communication both in the locker room (a makeshift converted service corridor) and on the running trails that surrounded the site. I quickly learned that becoming a runner was a good way to have communications with the boss that could venture into topics that would be difficult in the office.

...your teams are starting to build identities. Team locality and identity lead to isolation and insularity in team dynamics.

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Organizations need cross-team structures that guard against isolation.

In a large organization, individual teams build their identity around their team or geographic location. In a large building it is difficult to support frequent interaction across teams; most “excuses” to visit another team arise in the forms of meetings and other formalisms that don't support spontaneous communication. Distance, inconvenience, or xenophobia (a "belonging at home" feeling) discourage such informal interactions.

Yet people need to have social contact with each other. And in fact people want to "get out" now and again to see what life is like on the other side of the fence, in other organizations.

Therefore:

Encourage social structures that are unrelated to workplace structures and which will likely cut across the formal partitioning of the organization.

The Water Cooler is the time-honored example of this pattern. One Alliance site in Vienna has a strong coffee culture that revolves around coffee machines on each floor of each wing of the building and one can find small groups congregating there all day, especially mid-morning and mid-afternoon. Another common (but dieing) practice is the smoker's area; in Schlumberger in Houston, members of this group would gather at an outside terrace; in another company, they met secretly in the stairwell.

At the Navision company in Copenhagen, there was a strong food culture: the company served breakfast and lunch. Breakfast in particular was a time of social connection, a relaxed beginning to the day. The company also had well-stocked refrigerators and pantries for snacks during the day, and many of these were enjoyed in a group setting. Food is fun, and is a key element of any culture, but the main contribution to the communication network comes from the social structures built around food.

Corporate clubs, singing groups, running clubs, chess clubs, and a million other social structures can also help serve this purpose. What can you do to encourage such structures? Give them a place to be. Buying a coffee machine or water cooler provides a place for the social dynamics to unfold. Make it special. People won't come by for coffee that is worse than instant coffee they can make in their office. Investing in quality also has the benefit of demonstrating a sense of caring within the organization.

Remember: location, location, location! You can't just plop a water cooler down in a hallway and expect people to congregate around it; you must put it in a place where people can sit or stand comfortably for a time. You may wish to incorporate several of Alexander's patterns [Alexander1977] as you lay it out. The research department in

AT&T where both authors worked for a time had a room with comfortable furniture and a pleasant ambiance. As an added draw, it had a small library. On the other hand, one facility had a water cooler stuffed in a back storeroom of a lab with restricted access—it was no more than a place to get (or perhaps just store) cold water.

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This pattern not only gives people a break during the day, but it contributes to fundamental human needs and desires that lie in the deep foundations of any human culture. And it will contribute strongly to inter-team communication: most professional communication takes place outside formal channels [GrinterHerbsleb2000].

One potential danger in this pattern is "cliquishness,'' a form of schismogenesis (see THE OPEN CLOSED PRINCIPLE OF TEAMS (6.1.4)). If the group is in any way exclusive, some people will feel left out; the locker room example is one such example. A runners' club may literally leave non-members (and even novice members) behind. Coffee clubs might be uncomfortable for those who do not drink coffee. Problems of complementary schismogenesis can be solved by having a bounty of such cross-cutting organizations, but that can also lead to symmetrical schismogenesis. A better solution, where feasible, is to broaden the base of the organization (e.g. the coffee corner can also offer tea and juice). But a healthy environment should be able to sustain even highly specialized groups. In all cases: build on the local culture and its mores.

This pattern rounds out UPSIDE DOWN MATRIX MANAGEMENT (5.1.19) by going outside the context of the business interests of the enterprise, building on potentially deeper social relationships and normative practices of the culture of the area, town, or other constituency. It complements and rounds out RESPONSIBILITIES ENGAGE (5.1.14) as an independent pattern.

This pattern is similar to HALLWAY CHATTER (5.1.15); in fact, both work to improve informal communication. But notice the difference: HALLWAY CHATTER moves people close so that they will go to each others' offices or cubicles. That communication, while informal, is planned, and tend to be more of a technical nature. On the other hand, THE WATER COOLER enables chance meetings and non-technical conversations. Both are necessary and these patterns are complementary.

Combined with an application of ENGAGE CUSTOMERS (4.2.6) where you seat your developers in the customer work space, THE WATER COOLER can be a powerful way to uncover important requirements details. Beyer and Holtzblatt ([BeyerHoltzblatt1998], p. 37) relate:

> Many of the important aspects of work are invisible, not because they are hidden, but just because it doesn't occur to anyone to pay attention to them. Intuition doesn't help make these aspects explicit:
>
> An entire project team hangs out in the hallway outside their offices every morning and chats over coffee and donuts. Does anyone on the team know this is a critical project coordination session?
>
> A worker in accounting calls a friend in order processing to gossip and mentions that a rush order is on its way. Does his manager know this informal communication is the only thing keeping the company's rush orders on time?

5.1.21 Three To Seven Helpers Per Role

Chef and helpers in the camp kitchen. Allegan project, Michigan, 1937.

...the organization has a basically functional social network. The organization shows overly strong centrality; individual roles are overloaded while others are starved for communication.

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An effective organization has a well-balanced distribution of communication.

You don't want to overload specific roles with interrupts, chatting with people, and meeting, which is a waste of resources. That causes the organization to be limited by overutilized resources. Manager roles often suffer from this problem, but so do roles staffed by domain experts. On the other hand, you must not starve other roles of human interaction, which drives them to work ineffectively and which results in a lowered process efficiency. Underutilization relates to information starvation and poor coupling to other roles. Overutilization can be caused by having too many suitors, particularly in the case where productivity falls because of thrashing, context switching, or indecision.

Therefore:

Organize the enterprise so each role has three to seven long-term stable relationships.

You can do this using MOVE RESPONSIBILITIES (5.1.18) and other ORGANIZATION CONSTRUCTION PATTERNS (CHAPTER 5). Most of this load balancing can build on intuitive and innovative shifting of work.

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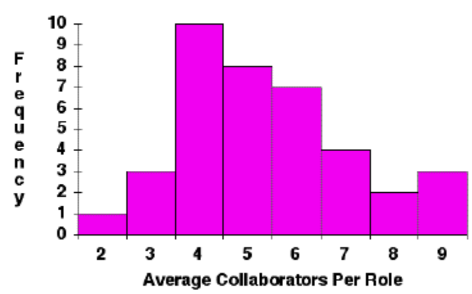
This leads to a more balanced organization, with better load-sharing and fewer isolated roles. It helps DISTRIBUTE WORK EVENLY (5.1.13).

It is possible, with a lot of focus and energy, to increase coupling and decrease latency, particularly for short periods of time; see COUPLING DECREASES LATENCY (5.1.22).

For roles such as domain experts that become magnets for people, use a pattern like SACRIFICE ONE PERSON (4.1.22) or DAY CARE (4.1.23) to balance load.

Our empirical results from the organizations studied in the Pasteur project show that, in most projects, any given role can sustain at most 7 long-term relationships. In particularly productive organizations, the number can be as high as 9. Particular needs might suggest that the process designer go outside these bounds, if doing so is supported with a suitable rationale.

The following histogram presents a distribution of collaborations per role for the roles in our early organizational analyses:



The highest number of organizations (ten of them) is able to support four collaborators per role. As the number of collators per role increases we find fewer and fewer organizations are able to sustain those levels. But about 75% of the organizations can sustain three to seven helpers per role.

Communication between roles is complete in an organization if every role communicates with every other role. As stated in DISTRIBUTE WORK EVENLY (5.1.13), the *communication intensity ratio* of an organization is the ratio of the number of communication paths of the busiest role to the average number of communication paths per role. For a given project size, Harrison has found this ratio to be lower in highly productive organizations than in average organizations [HarrisonCoplien1996].

5.1.22 COUPLING DECREASES LATENCY *

Northern Pacific freight train going over Bozeman Pass. Gallitan County, Montana.

...the organization supports a service process or, in some special cases, a small design / implementation process using an iterative or incremental approach. Responsiveness is important, but you note that development intervals are too long and market windows are not met.

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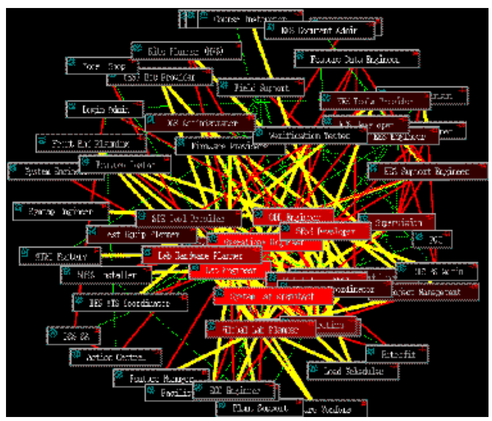
The structure of an organization can artificially reduce the throughput and increase the latency of business processes. And in some business processes, speed (time-to-market, service responsiveness) are of the essence. An organizational structure that causes information to flow through many roles not only increases latency (delay), but can cause loss of information fidelity. Like light, as information passes through many filters, it loses definition and accuracy.

Process stages should be independent to reduce coupling and thereby promote developer independence; developers can be more effective the less that their work is encumbered by communication. Furthermore, independence improves opportunities for parallelism. But independence hampers information flow.

Therefore:

Open communication paths between roles to increase the overall coupling/role ratio, particularly between central process roles. Communication between roles can be shaped using patterns such as Work Flows Inward (4.1.18), which helps concentrate more communication on the core of the organization, and Responsibilities Engage (5.1.14), which deals with the issue more broadly. Both of these can be helped more generally with Move Responsibilities (5.1.18).

This pattern suggests either increasing the density of the communication network, *or* finding the key communication paths that are important to market success and focusing on making them more effective (e.g., communications between marketing and engineering). This organization, a support organization, has a highly responsive process, which owes in part to its high degree of internal coupling:



The second approach is more difficult because it's difficult in general to know which communication links are more important than others. Organizational introspection can help identify such links, however.

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Coupling of course increases dependence between roles, which may not always be a good thing.

This pattern is somewhat related to Interrupts Unjam Blocking (4.1.25). Information flow in an organization can be compared to a batch processing system or a timesharing system. In the batch mode of communication, information comes through certain central roles in the organization (generally manager-type roles), and then is disseminated to the producer roles. In a timesharing mode of communication, interrupts drive the communication, thus decreasing communication latency, as information flows to the producer roles directly and in a timely manner.

Hand offs can increase latency. The number of "hops" between roles should be kept small for any given problem. Eliminating "pipeline" and "deadbeat" roles helps eliminate hops. One way to do so is to use Hub Spoke And Rim (5.1.17), where appropriate. In fact, that pattern is a logical step from this one. Occasional close coupling between developers and testers reduces administrative overhead, which reduces latency.

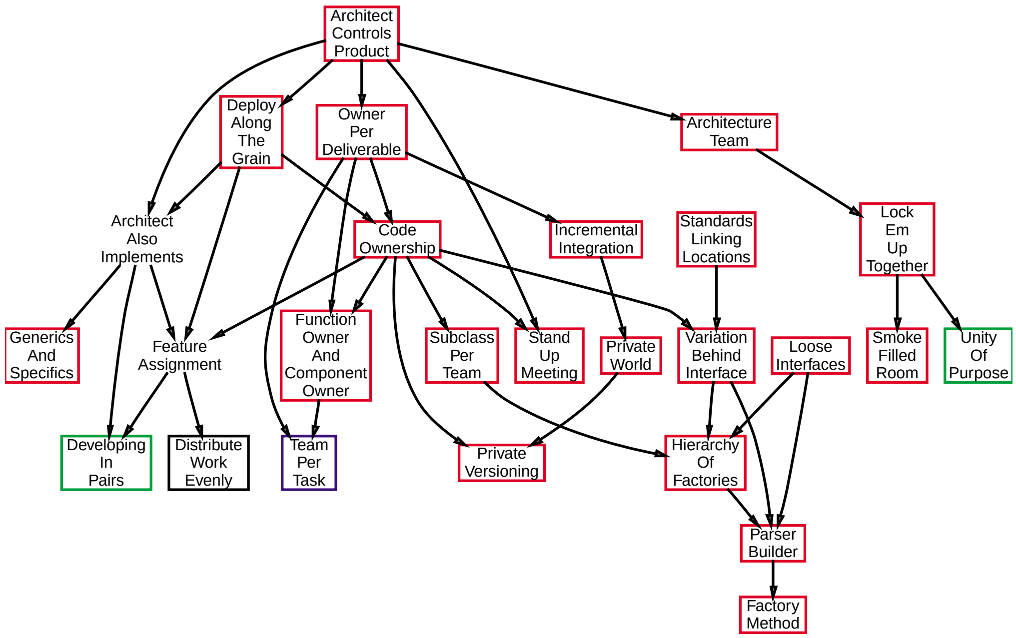
The pattern is based on a basic software engineering principle that reflects itself in the organization.

5.1.23 Standards Linking Locations

See Section XXX.

5.2 *People And Code Pattern Language*

The Pattern Language



A Story About People and Code

"The system engineer wrote a set of requirements, then left the project." That was hardly an auspicious beginning to a project. Yet in spite of this initial setback, or perhaps in part *because* of it, the team came together in a remarkable way to complete the project on time. We learned much from analyzing this team.

Project development began with designing an architecture, but there was no single architect; instead there was an ARCHITECTURE TEAM (5.2.4). (A manager later commented that he could not identify a single architect, because the team knew the architecture so well. See MODERATE TRUCK NUMBER (4.2.24).) The team met numerous times to create the architecture, but made little progress until they isolated themselves (LOCK 'EM UP TOGETHER (5.2.5)). When they came out, they had an architecture that guided them through the project (ARCHITECT CONTROLS PRODUCT (5.2.3)). As importantly, they had a very high degree of UNITY

Of Purpose (4.2.12). All the architects practiced Architect Also Implements (5.2.10).

The project was geographically split, which created a natural organization break. They recognized the need for Conway's Law (5.1.7) and Organization Follows Location (5.1.8). In practice, this led to Code Ownership (5.2.13) and Feature Assignment (5.2.14). They defined interfaces over time (Loose Interfaces (5.2.17)), and while they hardened the interfaces, they allowed Variation Behind Interface (5.2.15).

The project had a unique twist to Developing In Pairs (4.2.28). They had group debugging! In fact, the entire team at one of the locations would all gather around one person's computer to debug problems. It didn't turn out to be any less efficient than single-person debugging, but it had the benefits of maintaining a Moderate Truck Number and preserving the architectural integrity of the system. Interestingly, since the entire team was present, the group debugging sessions also served many of the purposes of the Stand Up Meeting (5.2.7).

The team had some novices, and used Generics And Specifics (5.2.11) to help make the novices productive.

At the end of the project, personnel from a partner company paid them a very high compliment: "We don't believe any other company could have pulled it off."

5.2.1 Community Of Trust

See Section 4.1.1.

5.2.2 Conways Law

See Section 5.1.7.

5.2.3 Architect Controls Product **

...an organization of developers exists and needs strategic technical direction.

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Even though a product is designed by many individuals, a project must strive to give the product elegance and cohesiveness. One might achieve this by centralizing control, but totalitarian control is viewed by most development teams as a draconian measure. One person can't do everything, and no single person has perfect foresight. However, the right information must flow through the right roles; individual areas of competency and expertise must still be engaged.

Furthermore, there needs to be some level of architectural vision. While some domain expertise is distributed through the ranks of the development team (Domain Expertise In Roles (4.2.22)), the system view — and in particular, the design principles that create a common culture for dialogue and construction — usually benefit from the conceptual integrity we associate with a single mind or small group.

Therefore:

Create an Architect role as an embodiment of the architectural principles that define an architectural style for the project, and of the broad domain expertise that legitimizes such a style. The Architect role should advise and influence Developer roles, and should communicate closely with them. The Architect doesn't dictate interfaces (except in cases where arbitration is necessary). Instead, the Architect builds consensus with individual developers, developer sub-teams, and if necessary with the entire development staff, commensurate with the architectural style. The Architect is the principal bridge-builder between development team members.

The Architect should also be in close touch with Customers so the domain expertise is current, detailed, and relevant.

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This does for the architecture what the PATRON ROLE (4.2.15) pattern does for the organization: it provides technical focus, and a rallying point for technical work as well as market-related work.

The architect doesn't *control* the product in any dictatorial sense; it is more inspirational guiding and leadership. We could have called this "ARCHITECT LEADS PRODUCT" or "ARCHITECT GUIDES PRODUCT" but all these words have their own problems.

Resentment can build against a totalitarian Architect; use patterns like STAND UP MEETING (5.2.7) to temper this one.

Intellectually large projects can build an ARCHITECTURE TEAM (5.2.4).

We have no role called Designer because design is really the whole task. Managers fill a supporting role; empirically, they are rarely seen to control a process except during crises.

While the Architect controls the architectural direction, the DEVELOPER CONTROLS PROCESS (4.1.17), and there is still an OWNER PER DELIVERABLE (10.5.19). The Architect is a "chief Developer" (see pattern ARCHITECT ALSO IMPLEMENTS (5.2.10)), or as Alexander thinks of himself, a "master builder." Their responsibilities include understanding requirements, framing the major system structure, and guiding the long-term evolution of that structure. The Architect controls the product in the visualization accompanying the pattern ENGAGE QUALITY ASSURANCE (4.2.29).

Because ORGANIZATION FOLLOWS LOCATION (5.1.8) and CONWAY'S LAW (5.1.7), there should probably be an architect at each location. Architects can be the focus of local allegiance, which is one of the most powerful of cultural forces in geographically distributed development.

A more passive way of implementing this is to have the architect review everything. We have seen this work in several projects. However, in most of these projects, we fear that it put the "truck number" in danger (see Moderate Truck Number (4.2.24)). Also, if there is a conscious plan for the architect to review everything, the architect — in capacity as a developer (see Architect Also Implements (5.2.10)) may "swoop" and fix things that are the responsibility of others (see Code Ownership (5.2.13)). Such "swooping" can be demoralizing to the original code author. The architect can review everything if that role still defers to the implementor for execution and even for the decision about making the change. See, of course, Stand Up Meeting (5.2.7).

Architectural control must balance developer authority, and this role of being "keeper of the flame" and of the principles should tread neither on developers' feelings of ownership of their code, nor on their ownership of the code development processes. Architects intervene in processes largely at the business level, and should meddle in implementation processes only in exceptional circumstances.

"Les oeuvres d'un seul architect sont plus belles...que ceux d'ont plusiers ont taché de faire." ("The works of a single architect are more beautiful than those that several have tried to achieve") — Pascal, *Pensées*.

5.2.4 Architecture Team *

Architects and engineers studying plans for Greenhills project, Ohio. 1936

...you have a project direction defined, and now you need to come up with a structure for the system.

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You need to create an architecture that is simple and cohesive, but which accommodates a variety of constituencies.

Most systems are too large for a single mind to analyze and resolve. Not only is the system to complex for a single person but the architecture must accommodate multiple viewpoints to be successful. You can solve this with a team of architects who bring diverse views, but the collision of diverse views brings difficulties of its own.

A design by committee usually looks that way. It tends to result in everything being added, even the kitchen sink! (Try to get a picture of the Denver Public Library here.)

Committees are inherently less efficient than individuals (see Solo Virtuoso (4.2.5) for example.) Yet there is safety in a team; it makes it possible to keep a Moderate Truck Number (4.2.24).

The entire organization will need to accept the architecture. The more people that are involved in the architecture, the better chance one has of “selling” the results. But the more constituencies involved, the more difficult it is to come to agreement in the first place.

Therefore:

Create a small team of resonating minds to define the initial architecture, in such a way that the team covers the expected partitioning of the system. The key idea is that most or all the team members should come away with a piece of the system for which they have architectural responsibility. While this may appear to be trying to predict the future, one can usually easily identify the areas of grossest partitioning beforehand. For example, it is probably easy to guess a system might have a user interface, back-end storage, and internet communication areas. The careful selection of the team is aimed at preventing the "designed by committee" look.

Other representatives may be needed to round out the team. Luke Hohmann notes the difference between the technical architecture and the marketing architecture; the marketing viewpoint may be very valuable in this team.

The ARCHITECTURE TEAM's task is to create a high level partitioning. There remains much architectural work to be completed at lower levels. Charles Weir designates the high level architecture team as the "Master", while "Journeyman architects" take on the design of the smaller pieces. The Master-Journeyman (10.5.17) pattern also suggests typical partitioning of core architecture, architectural vision, interfaces, and specification control [Weir1998].

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Legitimizing this activity as a team, with organizational structure, lends support to the social interaction necessary to forming and sustaining the shared vision (see UNITY OF PURPOSE (4.2.12)).

The team should have a periodic STAND UP MEETING (5.2.7) to maintain the architectural integrity of the system. Early in the project, these meetings can take place daily.

Note that an architecture team focuses on the *initial architecture*. The result should be a gross partitioning of the system, allowing members of the architecture team to be architects of their own subsystems (see also CONWAY'S LAW (5.1.7).)

The best way to accomplish a shared architectural vision is probably through the use of LOCK 'EM UP TOGETHER (5.2.5).

HOLISTIC DIVERSITY (4.2.19) is a pattern that ties together the multiple teams such as infrastructure teams and other teams relating to individual domains and technologies. The ARCHITECTURE TEAM may either be such a team or contribute to a cross-disciplinary team that goes beyond architectural issues into issues of business and implementation.

This pattern is a refinement of Harrison's "Diversity of Membership" [Harrison1996].

This pattern draws heavily on Gerard Meszaros' ARCHITECTURE DEFINITION TEAM (10.5.4). Gerard further suggests that there be a separate ARCHITECTURE ORGANIZATION that *owns* the architecture. Here, we propose that ownership and function be tied together. This pattern also arises in Alistair Cockburn's analysis of the interaction between HOLISTIC DIVERSITY (4.2.19) and SUBSYSTEM BY SKILL (4.2.23). See also ARCHITECT CONTROLS PRODUCT (5.2.3) and ARCHITECT ALSO IMPLEMENTS (5.2.10).

5.2.5 Lock ’em Up Together *

...you have an Architecture Team (5.2.4) to pull together the initial structure of the project, and need to get off top dead center and move toward production.

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A team of different people must come up with a single, coherent architecture.

A product needs a single architecture that is self-contained and consistent. But programmers have a (strong) tendency to work separately. Each person’s design bears that person’s unique signature; many people working on separate parts of an architecture will produce parts that do not necessarily work well together. Designs by committee usually look that way. You can allow a single person to create the architecture, but then not everybody will understand it (and follow it), and you are vulnerable to that person getting hit by a truck.

Therefore,

Gather everyone together to work out the architecture (or some other strategic issue). Put them all in the same room (literally.) Every person must commit to total participation until the architecture is complete enough that a clear picture has emerged.

There are two keys to this pattern. The first is that everyone must be physically together, in the spirit of FACE TO FACE BEFORE WORKING REMOTELY (5.1.10). This is necessary to ensure good communication at this critical time. Teleconferences are not sufficient.

The second key is that the architecture team must commit totally; the team members must be insulated from distractions and interrupts. In effect, a temporary organization is created for the architecture effort: previous responsibilities are suspended, and existing collaborations are broken for a time.

Both these keys are critical to provide continuity of ideas, so that the architecture can coalesce.

Note that like ARCHITECTURE TEAM (5.2.4), this work is only to create an *initial architecture*, resulting in a gross partitioning of the system.

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This pattern is superficially very similar to FACE TO FACE BEFORE WORKING REMOTELY (5.1.10), but they are essentially different, and both are vital. The purpose of FACE TO FACE BEFORE WORKING REMOTELY is the establishment of roles, allegiances, and building teams. The purpose of LOCK 'EM UP TOGETHER is to hammer out technical issues. However, the two might happen at the same time.

This pattern works best when UNITY OF PURPOSE (4.2.12) is in effect, although the LOCK 'EM UP TOGETHER patern can help achieve UNITY OF PURPOSE.

Variants of LOCK 'EM UP TOGETHER can bring teams together in other development phases, too. In Western Geco (a Schlumberger company) the development team sometimes spends days together in cramped quarters at their deployment site: a ship at sea. This experience inevitably helps team members to get to know each other better, and leads both to team binding and a binding between the team and its end-user constituency on the boat.

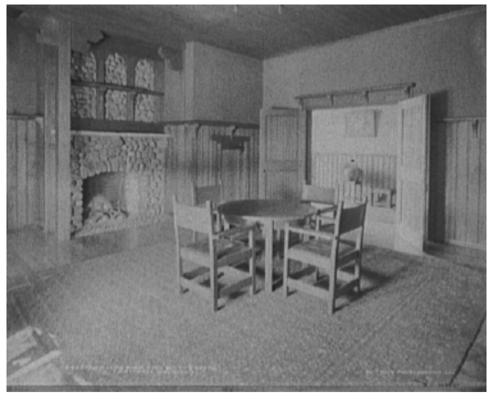
This approach also works well for other combinationss of constituencies: not only architects and coders, but architects and users, marketing folks and customers and end users, and so forth. This approach is central to Joint Application Development (JAD, [Kendall2002], p.

132). See also ARCHITECT ALSO IMPLEMENTS (5.2.10). PATRON ROLE (4.2.15) helps make this happen.

SMOKE FILLED ROOM (5.2.6) is a dark variant of this pattern.

5.2.6 Smoke Filled Room

Alias: Brown Bar, Cabale



Smoking room, Paul Smith's Casino, Adirondack Mountains

...as in Lock 'em Up Together (5.2.5), an enterprise comprises a diverse group of people with varying positions, and find themselves in a context where they are a bit afloat with respect to their assumptions about going forward. This may be precipitated during the early stages of a new group or as a result of a externally imposed policy change.

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An organization must make a timely decision about urgent strategic directions.

You would like everyone involved to have a say in the decision, and in particular, would like all stakeholders to have a say in the decision.

However, in organizations where accountability does not naturally align with authority and responsibility, a consensus process is not favorably viewed. For example, if team members are not viewed as having the legal power, or positional authority, or even the experience to make a key business decision, their participation in a consensus process is viewed as that of a "loose canon on deck."

And sometimes the need for expediency thwarts a consensus process, or even a socialized accounting of the decision process. And additional political forces can cause individuals or groups to want to keep secret the rationales for a given decision, or to eliminate some people from the decision process because they may be affected by the decision in ways that power holders feel would weaken their objectivity.

Therefore:

Make the decision among power brokers as in the storied smoke-filled rooms stereotypically associated with tycoon businessmen. Publicize the decision, but either keep the rationale private or rationalize why selected stakeholders were prevented from being part of the process. Note that having to keep the rationale private because of political concerns indicates significant problems in the culture.

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This is a pattern to be used sparingly in the right context to balance the right forces. Overuse of this pattern strains patterns such as ENGAGE CUSTOMERS (4.2.6), DOMAIN EXPERTISE IN ROLES (4.2.22), ENGAGE QUALITY ASSURANCE (4.2.29), ARCHITECT CONTROLS PRODUCT (5.2.3), etc.

Examples include most decisions about corporate takeovers and mergers, which are viewed more as business phenomena than as domain phenomena. Another example is project cancellations, for the same reason.

5.2.7 STAND UP MEETING **

Alias: DAILY MEETING

...a project is in the early architecture stage, a period of high stress, or a period of quick change. Or it might just be a period of high stakes, even though you don't expect things to change rapidly—but change must be dealt with responsively, as during the end game.

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At times of fast change or high stress, it is essential that all members of the organization receive the same information.

When a project is changing quickly, information gets out of date almost instantly. People must have the latest information, or else they risk making obsolete or incorrect decisions. Early in a project; during initial architecture, decisions are made that have lasting impact on the product. These decisions tend to be based on incomplete information; on assumptions which must be validated with others. Because these architectural decisions tend to build on each other, an early incorrect assumption can cause significant directional errors.

At times, the change is dictated by stress or a crisis. Crisis management demands quick response. But quick response demands a coordinated effort—things can go terribly wrong if people don't have the latest information. Architects as well as individual developers can develop tunnel vision, and the low-level decisions can be just as important as the more visible "architectural" ones. As Ed Yourdon said, all things are deeply interwingled. Interdependencies affect both the long-term integrity of the product functionality and structure, as well as the smooth day-to-day functioning of a team that has a shared vision.

Some organizations simply operate at a high change velocity. This requires very tight communication coupling, or else chaos ensues. The most productive organizations we have seen operate this way, although this not their only distinguishing characteristic.

Yet in all these cases, because the need for communication is high, the communication overhead will also be high. And this overhead detracts from the very thing you are trying to accomplish. How can you balance this?

Therefore:

Hold short daily meetings with the entire team to exchange critical information, update status, and/or make assignments. The meetings should last no more than 15 minutes, and generally happen first thing in the morning.

The focus of the meetings is on the technical progress in the architecture and the work plan. Obviously, these work best with small teams comprising mostly developers and architects. If the project is too large for a single meeting, sub-teams may meet instead. The project is probably already partitioned appropriately. However, the STAND UP MEETING is as much an opportunity to revisit the organizational structure as to revisit the system architecture, after CONWAY'S LAW (5.1.7). For this reason—and because resource reallocation is also a concern in these meetings—regular management presence at these meetings is also important.

Early in the project, these meetings may be held for the purpose of reviewing the architecture. Architectural decisions may be examined, tweaked, and re-reviewed very quickly. If the architecture team is "sequestered" with LOCK 'EM UP TOGETHER (5.2.5), the daily reviews can be used as a sanity check, and to allow them to come up for air. Or it can be used instead of LOCK 'EM UP TOGETHER (5.2.5), if the team prefers.

Near the end of the delivery cycle, these meetings can keep the team focused on the delivery, and they can help the project to shift assignments quickly to meet project needs. Near the beginning of a project, the code changes quickly; near the end, you may want to be able to shift assignments quickly as the product starts to move toward the shipping dock and out the door, and roles may shift accordingly (developers become testers, connections with beta sites intensify, etc.)

Such meetings can be used for other technical decisions as well. One team reported having meetings almost daily with human factors engineers and SURROGATE CUSTOMERS (4.2.7) as part of an iterative approach to user interface design.

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Other daily meetings are used for status and assignments. Beedle et al. describe these as “SCRUM” Meetings [Beedle1999, 644-649], daily meetings to report progress, make assignments, and replan if necessary [Rising2000, 147]:

> To control an empirical and unpredictable development process, meet with the team in a short daily meeting where participants say: (1) what they have done since the last meeting, (2) what roadblocks were encountered, and (3) what they will be doing until the next meeting.

SCRUM meetings mention technical issues as forces, but provide only project management solutions. A STAND UP MEETING deals with all these issues as inseparable, but its first focus is on the most volatile element of change and the project component closest to the largest numbers of technical staff: the artifact being delivered to the customer.

This is reiterated almost exactly in Extreme Programming [Beck1999]. In the Borland Quattro Pro For Windows project [Coplien1994b], the architecture team met in the morning to socialize problems from the previous day. The system was updated to reflect the meeting decisions and implementation and testing proceeded the remainder of the day in preparation for the next morning’s meeting.

This is similar to the meetings held at the beginning of every shift in hospitals and police stations. (“... be careful out there...”) Note, though, that in these cases, there is an explicit hand off of work from one shift to the next. It might exactly match meetings of the postulated international software teams, where teams in different locations in the world take advantage of time zones, and work on a piece of software 24 hours a day. However, the authors are unaware of any team where this has actually worked (and see, for example, Architecture—and ORGANIZATION FOLLOWS LOCATION (5.1.8).)

A short daily meeting is an efficient way of transmitting information to the entire team with the minimum communication overhead. This helps overcome some of the tunnel vision problems that can come from CODE OWNERSHIP (5.2.13).

Beyond the benefits of communication, it has a salutary effect on morale. It is a slightly institutionalized form of HALLWAY CHATTER (5.1.15), while being an informal form of GROUP VALIDATION (4.2.32), and helps maintain UNITY OF PURPOSE (4.2.12).

But there is a potential danger with such meetings. In some organizations, particularly where such tight communication is not the norm, daily meetings are instituted in response to a crisis. While the meetings give morale a temporary lift, they are subject to — and contribute to — burnout. Conversely, one must be careful that the purpose of regular daily meetings is to exchange information, and not to create an artificial crisis mentality in order to elevate performance. Such a purpose is not only unsustainable, it is a little bit dishonest.

When should the meeting take place? In California shops, where people can wander into work any time from 8:00 A.M. until noon, you want to schedule the meeting carefully.

Use MERCENARY ANALYSTS (4.1.24) to make a record of the fast-paced changing decisions.

Ward Cunningham's Episodes pattern language [Cunningham1996] suggests weekly, personal interviews over the full meeting format. The pattern WORK QUEUE REPORT suggests "Collect status in regular personal interviews conducted at weekly intervals. Solicit days of remaining effort estimates using contrasts with Comparable Work." It presents the following example:

> *"I put two full days into the new tax calculations, and one day with Joe on his U/I."*
>
> *"How many uninterrupted days do you think you need to finish the calculations?"*
>
> *"Oh, say two. It's no different from the accruals."*

> *"And, working with Joe?"*
>
> *"Well, we didn't get to the real work. I had three down last week? Must still be three days."*

Ward then goes on to say:

> Use these estimates along with individual dilution factors (how many uninterrupted days of development does the individual have access to a week) to predict elapsed days to completion for each assigned deliverable. Compute and publish COMPLETION HEADROOM (4.1.10) from this data. Include a cover page with a few sentences explaining numbers that might have shifted in an interesting way.

This pattern derives from the above citations as well as from REVIEW THE ARCHITECTURE [Coplien1995]. Luke Hohmann's input in particular is greatly appreciated.

5.2.8 Deploy Along The Grain **

Alias: Deploy People Along The Grain Of The Domain, One Person / Many Hats

One person, many hats.

... in the past, the roles of analysis, design and implementation have been split among different people.

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Some of the most powerful design insights come late in the design cycle, particularly during the phase we affectionately call "maintenance." But traditional staffing profiles deploy the most skilled designers at the front-end of the life cycle, leaving the later phases to "maintenance engineers."

Valuable architectural insight tends to emerge late in the life cycle, as a result of having addressed requirements from concrete, successive problems drawn from a given domain. It is then that a system can be refactored to consolidate design insight and polish reusable artifacts. (More can be said about this, but that's another tale.)

Such insight can best be harvested if people are deployed along the grain of the domain, and a given individual has responsibility for a well-defined part of it. Organizational categories like Analyst, Designer, Coder, Maintainer, and Reuse Expert can cut across the grain, and greatly increase organizational communication overhead and inertia. However, when responsibility for all these functions for a given part of the system is vested in a single person, the communication overhead for redesign with that part of the system can be largely intracranial. This is a one person / many hats strategy. A single individual can cope far more quickly with on-going bi-directional tensions between top-down elegance and bottom-up detail than can a functionally partitioned organization. Such a person can develop a more comprehensive sense of the possibilities that the design space allows, and exploit these to develop more genuinely durable artifacts.

A reusable API or object-oriented framework is, in many respects, a domain-specific language. Given this, Wirth's classic admonition that language design is better done by a single guiding intelligence, rather than by a committee, applies. (See the Pascal quote in ARCHITECT CONTROLS PRODUCT (5.2.3).)

Small teams deployed along the grain should be able to glean similar benefits. Team members would be responsible for distinct parts of their team's domain. Metafunctions like pure management and documentation might be factored and assigned to additional individuals. Interpersonal communication would primarily be concerned with interface negotiation, and not become mired with approving changes to internals.

The key here is committing talented designers to a part of the system, and keeping them there until late in the life cycle, when hindsight is available from addressing a range of design issues.

There is some commonality between this and Alexander's Architect / Builder notions as well, as in ARCHITECT ALSO IMPLEMENTS (5.2.10). This sort of personnel deployment strategy is a de facto favorite in academic environments and in some small organizations, both of which often exhibit marked productivity advantages over traditional industrial organizations. If an organization really wants to get truly reusable software, it will have to be willing to budget time and talent in such a way as to exploit the insights that lead to it at the point in the life cycle where they become available. But reuse isn't something that can itself easily be factored into its own department. The people who build and maintain something in the first place have the best, most intimate knowledge of how to generalize it.

There is certain amount of Alexandrian wiggle room with regard to the question of how one knows where the grain is, especially at the onset of a project. Often its something people settle into.

Therefore:

Deploy people along the grain of the domain. That is to say, give them dedicated, long term responsibility for a manageable piece of the system, thereby enabling them to exploit opportunities to consolidate and improve the reusability of their parts of the system as experience accrues.

Frequently, there will be significant degree of *self-selection* at work when this patterns is employed, a variation on SELF SELECTING TEAM (4.2.11). Managers should keep a watchful eye open for the emergence of new roles, as people elect to spontaneously fill them.

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This pattern plays out in specializations such as OWNER PER DELIVERABLE (10.5.19) and more specifically CODE OWNERSHIP (5.2.13). It should be contrasted with the approach suggested by Extreme Programming [Beck1999] advocates, though the effective divisions of labor may not be as different as a simple-minded comparison might suggest.

This pattern is constrained by the forces of CONWAY'S LAW (5.1.7); or perhaps it is the embodiment of it. You also need to take people's skills into account, as stated in SKILL MIX (10.5.28) [Cockburn1996] or as in SUBSYSTEM BY SKILL (4.2.23).

This pattern originally appeared as Brian Foote's DEPLOY PEOPLE ALONG THE GRAIN OF THE DOMAIN at PLoP 2000. The material was drawn largely intact from a discussion of Reuse Teams that took place in early December of 1993 in either *comp.object* or on an early incarnation of the patterns mailing list.

5.2.9 Subsystem By Skill

See Section 4.2.23.

5.2.10 ARCHITECT ALSO IMPLEMENTS **

Architects of a housing development working on-site, 1942.

...an organization is being built to serve an identified market (ORGANIZATION FOLLOWS MARKET (5.1.9)) or markets. Going forward, the project needs the necessary architectural breadth to cover its markets and to ensure smooth evolution, but it can't be blindsided by pragmatic engineering and implementation concerns. Furthermore, the project needs to carry through a singular architectural vision from conception to implementation if it is to have conceptual integrity.

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A software project must broaden the scope of leadership without sacrificing depth and attention to pragmatics. Though developers are good at making individual design and implementation decisions, a project needs an overall guiding strategic technical direction. This usually comes from the architect. However, too many software architects limit their thinking and direction to abstractions, and abstraction is a disciplined form of ignorance. Too many projects fail on "details" of performance, subtleties of APIs, and interworking of components—or, at best, they discover such problems late.

If an omniscient plan were possible, one could solve this with totalitarian control. But even if that were possible, totalitarian control is viewed by most development teams as a draconian measure.

The right information must flow through the right roles; in particular, the developers must latch onto the strategic vision and carry responsibility for implementation. The architect, and to some degree the developers, must also understand the application needs and what they portend for the long-term structure of the system. But there should be a more centralized locus of strategic direction that keeps the project from floundering, makes sure the necessary details are attended to, and keeps track of the emerging “fit” of all the pieces into a whole. Sometimes this “fit” requires understanding low level details of component interaction, protocols, APIs, performance, or reliability concerns.

Therefore:

Beyond advising and communicating with Developers, Architects should also participate in implementation.

The Architect should be organizationally engaged with Developers and should himself or herself write code. The Architect may implement along with a developer using Developing In Pairs (4.2.28).

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If the architect implements, the development organization perceives buy-in from the guiding architects, and that can directly avail itself of architectural expertise. The architects also learn by seeing, first-hand, the results of their decisions and designs: an important place for feedback in the development process.

The importance of making this pattern explicit arose recently in a project I work with. The architecture team was being assembled across wide geographic boundaries with narrow communication bandwidth between them. Though general architectural responsibilities were identified and the roles were staffed, one group had expectations that architects would also implement code; the other did not.

One manager suggests that, on some projects, architects should focus only on the implementation of a common infrastructure, and that the implementation of non-core code should be left solely to the Developer role. This may work in some projects; however, it is crucial that the architect have a strong feel for the application needs. It is by understanding recurring application needs that the architect can build long-term robust frameworks. If architects work only on infrastructure without an engaged appreciation of application needs, there will be a disconnect between the infrastructure (framework, middleware) and the application.

> "It would be convenient if architecture could be defined as any building designed by an architect. But who is an architect? Although the Academie Royale d'Architecture in Paris was founded in 1671, formal architectural schooling did not appear until the nineteenth century. The famous Ecole des Beaux- Arts was founded in 1816; the first English-language school, in London, in 1847; and the first North American university program, at MIT, was established in 1868. Despite the existence of professional schools, for a long time the relationship between schooling and practice remained ambiguous. It is still possible to become an architect without a university degree, and in some countries, such as Switzerland, trained architects have no legal monopoly over construction. This is hardly surprising. For centuries, the difference between master masons, journeymen builders, joiners, dilettantes, gifted amateurs, and architects has been ill defined. The great Renaissance buildings, for example, were designed by a variety of non-architects. Brunelleschi was trained as a goldsmith; Michelango as a sculptor, Leonardo da Vinci as a painter, and Alberti as a lawyer; only Bramante, who was also a painter, had formally studied building. These men are termed architects because, among other things, they created architecture—a tautology that explains nothing." — [Rybczynski1989, p. 9].
>
> [Vitruvius1960] notes: "...[A]rchitects who have aimed at acquiring manual skill without scholarship have never been able to reach a position of authority to correspond to their pains, while those who relied only upon theories and scholarship were obviously hunting the shadow, not the substance. But those who have a thorough knowledge of both, like men armed at all points, have the sooner attained their object and carried authority with them."
>
> John Thomas [mail of 18 Mar 1997] writes: "C. E. Walston and C. P. Felix did an extensive multiple regression study of software productivity — reported in the IBM Systems Journal,

> vol.16, 1977, pp. 54-73 'A method of programming measurement and estimation.' [WalstonFelix1977]
>
> John continues, "As I recall, the proportion of architects who were also on the implementation team had a very large coefficient. It was a much more powerful variable, e.g., than use of a high level language or use of structured programming."

Though the architect should be able to understand the minutiae of development, it is not necessarily the architect's business to deal with detail day in and day out. Much of what the architect does is to be the keeper of the flame, the owner of the principles that the project follows: principles that in turn shape structure. Much of the structure can come out of a consensus process guided by the architect; in fact, in practice, that's much of what architects do. [CoplienDevos2000]

A related pattern is GURU DOES ALL (10.5.15) from the collection of Don Olson [Olson1998a, 153-154], which states [Rising2000, 130]:

> A newly formed team is given a project with a tight schedule, uncertain requirements, uneven distribution of skills, and new technologies. Let the most skilled and knowledgeable developer drive the design and implement the critical pieces. This can be an antipattern.

The important element of this pattern is to give the critical pieces to the most skilled and knowledgeable practitioners (DOMAIN EXPERTISE IN ROLES (4.2.22) and, of course, ARCHITECT ALSO IMPLEMENTS). But it also has elements of SOLO VIRTUOSO (4.2.5), and can be thought of as an interim application of SOLO VIRTUOSO in the context of a project that will mature out of the need for such a pattern. This pattern should be tempered with APPRENTICESHIP (4.2.4), PHASING IT IN (4.2.3), DAY CARE (4.1.23) and others to move toward more of a peer team over time. (DAY CARE, in fact, talks explicitly about problem of people starting to say that "a few experts could get the project done faster"). Putting too much burden on one developer can lead to early burnout (see THE OPEN CLOSED PRINCIPLE OF TEAMS (6.1.4)). It is sometimes difficult for a lead developer to give up the SOLO VIRTUOSO behavior on a given project once having filled that role, so this pattern should be applied with care.

5.2.11 Generics And Specifics

Erecting a framework.

...most projects, particularly early in the development cycle, have a mix of novices and experts. Of course, even the novices are expected to come up to speed quickly and contribute to the project.

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Novices, even when mentored, tend to produce weak designs and cut and paste code.

One does not acquire design prowess overnight; it takes years of experience. Even expert designers look back on their early work and shudder at how bad it was. Design, like every other skill, requires practice to attain proficiency.

But we need the novices. Few projects have the luxury of being staffed entirely by highly experienced people. And even if it is possible, is that what we want? Novices come in with fresh ideas, unencumbered by narrow viewpoints honed through years of experience. And they will eventually become the experts; lack of novices now means a dearth of experts in a few years.

Like everyone else, novices do the best they can. They try to learn from what they see. Unfortunately, this leads to cutting and pasting code, a maintenance nightmare. And where there is no guidance from existing code, their designs tend to be weak.

Therefore:

Separate generic from specific parts of problems. Use an expert, a framework designer to design generic parts. Let the novice programmers design the specific parts.

GENERICS AND SPECIFICS (5.2.11) is derived from SUBSYSTEM BY SKILL (4.2.23), and SUBCLASS PER TEAM (5.2.18). It is applicable to any technology, such as object orientation, that permits plug-in frameworks.

A framework can provide a generic solution to a problem, which can be completed, extended or tailored in the specific by subclassing. The generic solution, residing at the higher level of the class hierarchy, is considerably more difficult to design than any one specific solution. Once programmed, it is considerably quicker and easier to complete than the specific solutions would be to design.

Therefore, use the experts' extra skill to design a generic framework solution, and use the novices to use and tailor it for a specific solution. This fits well with the SUBCLASS PER TEAM principle, since the expert will be optimizing using slightly different concerns than the novice.

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Generics were used in all the OO systems. In a UI system, it was used for generic displays, search collection, transaction backout, and error handling. In the domain, it was used for generic transaction, error, persistence and model behavior. In the infrastructure, it was used for error handling and the persistence mechanism. In each case, novices were able to use the generic/specific structure to accomplish their tasks in less time, and keep to a more subtle architecture than they would have thought up.

This pattern was originally written by Alistair Cockburn, in SOCIAL ISSUES AND SOFTWARE ARCHITECTURE [Cockburn1998].

5.2.12 Standards Linking Locations **

Standards in cartography allow people in different nations to use the same maps.

We once worked with a project doing a wireless communications architecture. The project was spread across three states and two countries, though most of the work centered in two states. Each of those two locations built software for the locations' respective hardware boxes, and those boxes communicated closely with each other. There of course was a standard message protocol, but it wasn't articulated anywhere: each location used its own C language structures to define its understanding of the messages. Each location emphasized the message fields most of interest to it; in some cases, one location would give a field one name while another location gave it another name. It doesn't take much imagination to envision the confusion that ensued.

...a product must be developed in several different hallways, on different floors of a building, in different buildings or at different locations. Their code must interact.

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It is difficult for geographically distanced teams to find opportunity or time to meet and interact for reasons of geographic distance. Yet the system must act as a system, and to do that the parts must talk to each other. There must be a common convention for the parts to talk to each other. The many parties could come to an agreement in a common meeting, but that is too much master planning and doesn't build on experience enough, and also doesn't leave much room for correction and iteration.

Communication patterns between project members follows geographic distribution. Local groups should be as autonomous as possible. Coupling between pieces of software must be sustained by analogous coupling between the people maintaining that software. People avoid communicating with people who work in other buildings, other towns, or overseas (see below). People in an organization usually work on related tasks, which suggests that they communicate frequently with each other.

Therefore:

Use standards to express architectural concerns that cross geographic boundaries. The technique may extend to organizational boundaries, which can be as severe as distant geographic location. It might extend to organizations separated only by one floor in a building; small geographic distances can loom large if the building architecture doesn't support close interworking.

One of the good things about standards is that they are almost context-free. They at least give the illusion of a shared context across organizations that otherwise can find little in common.

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This is a variant of CONWAY'S LAW (5.1.7). There is low cultural context between locations, so the interaction between locations is mediated at a technical level using the most vernacular approach: industry or corporate standards.

Local groups have higher context and more effective communication within themselves. Use of standards within a location or within groups can actually reduce understanding, add overhead, and complicate communication.

Be sure to use FACE TO FACE BEFORE WORKING REMOTELY (5.1.10) to temper what can too easily become a sterile exchange of standards-based communications.

The problem described in this pattern might, in extreme cases, extend to work between adjacent cubicles—but in that case, there may be nothing that can help, and such a technological solution to this certainly won't solve the underlying organizational or personality problems.

Example:

A project might use standards like XML and RM/ODP to communicate between corporate subsidiaries working on a project. But to use a standard within one of the subsidiaries would be counterproductive. For example, reducing *all* inter-object communications to use CORBA would both complicate architectural understanding and put system performance at jeopardy.

Standards such as protocols and conventional data formats can provide cultural context that lowers the need for communication between remote sites.

5.2.13 Code Ownership **

Box Elder County Utah, 1940. Ownership of his farm allows E. O. Stenquist to build a chicken coop with his own labor.

Paul Bramble relates, "Code Ownership: Boy, can you say that again. I have been in a place without code ownership. We had token code ownership in that we were generally held responsible for some products—and hence the code. But others could and would change the code to add new features provided that you weren't updating the code during a release cycle. Part of that was nice, as I would be busy doing other things, and didn't need the aggravation of figuring out the details necessary to implement their changes (which could be complex). But this positive effect was far less than the havoc these changes could wreak. While my general framework was only adequate (it could have been better), it became rather disjoint with several encapsulation and abstraction problems once other developers finished changing things—beyond repair, short of a major refactoring effort involving several people."

...a project is underway, and mechanisms are in place to document and guide the software architect, and to support coding and unit development activities. The project is too large for one person to comprehend. No single developer can keep up with the changes being made across the system.

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Something that's everybody's responsibility is no one's responsibility.

You want parallelism between developers, so multiple people can be coding concurrently.

Most design knowledge lives in the code. Navigating unfamiliar code to explore design issues takes time. Beyond that, changing unfamiliar code is dangerous; one does not know what the impact of the changes are.

Provisional changes never work.

Not everyone can know everything all the time. Even the architect does not know the code well enough to be proficient in all corners of the project (although an architect should understand some coding issues through ARCHITECT ALSO IMPLEMENTS (5.2.10).)

Therefore:

Each code module in the system is owned by a single Developer. Except in exceptional and explicit circumstances, code may be modified only by its owner. Anyone else wanting changes must approach the owner and get approval.

Note that ownership implies responsibility for the quality and architectural integrity of the module. This encourages the owner to gain a deep understanding of the module. For an owner new to the module, this means learning the code in depth, usually quickly. Paul Taylor, in his pattern ARRANGING THE FURNITURE (10.5.1), suggests that new owners can gain familiarity and confidence by starting with making cosmetic changes to the code [Taylor1999]. (As authors of this book, we noticed the same phenomenon working with this manuscript!)

How large should a project be to use CODE OWNERSHIP? Gerhard Ackermann points out that it doesn't matter: code ownership is a principle of honoring another person's work. We have seen benefits in projects as small as two persons. In such cases, ownership may not be formally conferred, but each person knows who owns what, and consults with the other before changing the code (see also DEVELOPING IN PAIRS (4.2.28)).

This pattern is very similar to OWNER PER DELIVERABLE (10.5.19). There is, however, a subtle but significant difference. Ownership of deliverables is for the duration of release; its purpose is for accountability in project management. Ownership of code modules, on the other hand, is for long term; ideally the duration of the software. Its goal is to maintain quality and architectural integrity, and to improve speed by reducing discovery costs. This can be helped by the related pattern, Deploy Along The Grain (5.2.8).

Arguments against code ownership have been many, but empirical trends uphold its value. Typical concerns include the tendency toward tunnel vision, the implied risk of having only a single individual who understands a given piece of code in-depth, and breakdown of global knowledge. Other patterns temper these problems:

The pattern Stand Up Meeting (5.2.7) helps keep Designers and Architects from developing tunnel vision from strict application of this pattern.

Code Ownership can lead to bottlenecks, as all changes to a module must funnel through the owner. Furthermore, Code Ownership can tend to focus critical information in individuals, violating Moderate Truck Number (4.2.24). Both these can be counteracted by Developing In Pairs (4.2.28), as well as practices such as design reviews and code inspections. In addition, one can implement Code Ownership with some flexibility to allow exceptions if needed to resolve bottlenecks (with approval by the owner after the fact.) Gerard Meszaros also notes that the owner may be an single person or a group, with a designated “group head”. This is especially helpful in large projects. (Note that ownership by a group should not be construed to be the same as “Collective Ownership”, as advocated by some [Beck1999]. Ownership by everybody is ownership by nobody.)

Empirical support for this pattern is strong, although the most striking examples are the problems encountered when there is no Code Ownership.

Neil Harrison describes living a “nightmare” with a code module that nobody owned. Because everybody could — and did — refactor the code at will, the architecture changed constantly. Keeping up with changes that others made became a significant chore. Ironically, the project had a policy of code ownership, but nobody had taken on ownership of this module. “At length,” he notes, “we volunteered to take ownership of the module, even though we were not part of the project it belonged to.” At the time of this writing, the offer is being considered.

Lack of code ownership is a major contributor to discovery effort in large-scale software development today. Note that this goes hand-in-hand with architecture: to have ownership, there must be interfaces.

This is a form of Conway's-law-in-the-small (see also ARCHITECT ALSO IMPLEMENTS (5.2.10)).

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The architecture and organization will better reflect each other (CONWAY'S LAW (5.1.7)). Related patterns include ARCHITECT ALSO IMPLEMENTS (5.2.10), ORGANIZATION FOLLOWS MARKET (5.1.9), and INTERRUPTS UNJAM BLOCKING (4.1.25).

Tim Born argues that there is a relationship between code ownership and encapsulation, in the sense that C++ protection keeps one person from accessing the implementation of another's abstraction.

One can tie this concept all the way back to philosophy of law. In *L'Esprit des Lois*, Rousseau argues that law is property, and the lack of identifiable property leads to anarchy [Rousseau1972].

It has been argued that code ownership should be applied only to reusable code. Such a constraint would be worthy of consideration if someone comes up with a good distinction between usable code and reusable code.

GERARD MESZAROS wrote a related pattern called ARTIFACT OWNERSHIP [Meszaros1999].

People can abuse code ownership to protect their artifacts from inspection by colleagues or to take unilateral control of system level issues whose changes fall into their domain. Temper these problems with COMMUNITY OF TRUST (4.1.1) and DEVELOPING IN PAIRS (4.2.28). FEATURE ASSIGNMENT (5.2.14) brings a review perspective that cuts across the code partitioning, and that, too, can help avoid blindsidedness on the part of the code owner.

5.2.14 Feature Assignment *

Day laborers waiting to be assigned work, Raymondville, Texas, 1939.

...in a multi-person project of medium size or larger, one gets to the point that the work must be partitioned among team members. The initial architecture is complete; where do we go from here?

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For every non-trivial project, it is impossible to partition the work cleanly.

You have to get the work done; you need to get the new release out the door. And you need everyone working on it. Yet no matter how you slice the work, people will find themselves working on the same piece of code. The essential complexity of the problem (see [Brooks1995]) means this will happen in all but the most trivial developments.

The partitioning of the problem through the architecture is mainly for people's benefit — the code doesn't care. We maintain the integrity of the architecture in order to attempt to maintain the comprehensibility of the problem, and we do this through Code Ownership (5.2.13). But to a greater or lesser extent, features cut across the architecture. So Code Ownership is not the right model for developing the features.

Take, for example, the canonical example of an automatic teller. There are natural architectural entities such as the display subsystem, the input subsystem, and the communication layer, among others. Yet the feature "Display Account Balance" cuts across all of them.

Therefore:

Assign features to people for development. A feature development has a finite duration, and is therefore an assignment, not a role.

Feature assignment works together with the role of CODE OWNERSHIP (5.2.13) to develop the product and maintain its architectural integrity. The developer of a feature will consult with the code owner about changes.

The owner of the code affected most by a particular feature is often the natural person to receive the assignment of that feature, although it doesn't have to be.

Features may be assigned to more than one person, or better still, developers may choose to work together to accomplish it (see DEVELOPING IN PAIRS (4.2.28).)

There is some danger that FEATURE ASSIGNMENT (5.2.14) and CODE OWNERSHIP (5.2.13) together will tend to encourage excessive management bureaucracy, but that doesn't need to be the case. Features are a natural unit of project tracking, and CODE OWNERSHIP (5.2.13) need not add anything substantial to the project overhead.

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The temporary nature of FEATURE ASSIGNMENT (5.2.14), coupled with the role nature of CODE OWNERSHIP (5.2.13) strikes a balance between maintaining architectural integrity and getting the work done. Note how they together complete DEPLOY ALONG THE GRAIN (5.2.8).

Note that some project methodologies advocate making assignments every day, with chunks of work that can be completed in a single day. If the project is small, and the work can be appropriately partitioned, this approach may work well. FEATURE ASSIGNMENT (5.2.14) is broader; it encompasses this approach, but extends to large complex projects, and those where work is so complex that it cannot be broken into such small chunks.

5.2.15 VARIATION BEHIND INTERFACE **

Identical houses on the outside, but you can be sure that the interior decoration varies.

...the architecture has been established, and CODE OWNERSHIP (5.2.13) has been put in place. Features have been assigned. Now the easy part is over.

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Once you start developing software, you find that things change. And these changes can affect not only your software, but software written by others as well.

A typical scenario plays out like this: You are working on a feature, and you need to change a certain file. Unfortunately, someone else is working on a different feature, but needs the same file. Good configuration management and work space tools can use file locking to prevent one of you from undoing the other's work, but there is still a problem with merging your modifications together. Or perhaps you just wait for the other person to complete before you start your work on that file.

A similar problem is this: You are working on a feature, and call a function that someone else is working on. When you build against the official base, you find that the function has changed, and you need to change how you call that function.

We can turn that problem around: You are working on a function that others call. When you build against the official base, you find that your changes cause build errors in others' code — where they call your function.

These problems illustrate the technical problems that arise from multiple people working on a software project.

Even worse, you may be waiting for someone to check in their code so you can make your own changes to it. After they check in their copy and you check out the image for editing, you find out that they have added some things you would like to use and have deleted some things you need, both in the same unit of editing. This is a fundamental dilemma that tools and technology alone cannot solve.

Therefore:

Create interfaces around predicted points of variation.

Note that this requires one to predict, or at the very least, make educated guesses about what will change, and what will remain constant. This can be called commonality and variability analysis, or domain analysis, and is described in various places such as [Weiss1999] and [Coplien1999].

In spite of our best efforts at analysis, it will be necessary to change the interfaces on occasion. These changes impact others; to minimize the impact, use NAMED STABLE BASES (4.1.4) to manage these changes.

This is really nothing more or less than information hiding, as originally described by Parnas [Parnas1978]. Here the motivation for information hiding is to insulate others from expected changes. It was also behind Alan Kay's work in object-oriented programming.

This pattern forms the basis for SHEARING LAYERS (10.5.26) [Foote2000], which states that you should factor your system so that the artifacts that change at similar rates are together. One difference is that SHEARING LAYERS (10.5.26) is often applied at the system level, rather than the module level, as this pattern is.

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So what does this pattern have to do with creating effective software development teams? Quite a bit, actually. Of course, a project is partitioned among team members. The team members depend on each other's software; therefore the connection points of the software — the interfaces — must change as seldom as possible. Otherwise, people find themselves spending much time rewriting parts of code that once worked. And people begin to get testy with each other. The way to minimize interface changes is to hide variations behind interfaces.

Don't get too carried away. Too many interfaces cause the system to be slow.

Designers sometimes try to anticipate all variations. The extra interfaces slow down and complicate the software. Often the situations they hoped to anticipate never happen, so the interface serves no useful purpose. The trick in good design is to correctly anticipate the changes, or the cost of the interface against the cost of the change.

See HIERARCHY OF FACTORIES (5.2.19) and PARSER BUILDER (5.2.20) as examples of this approach.

5.2.16 Private Versioning **

"Solitude", an outhouse on the property of Frank Weeks, Willston, North Dakota, 1937. A place for anyone's private version...

...a developer should have a way to checkpoint changes without making these changes available to the development team at large. We want to implement *Code Ownership (5.2.13)* but subsystems never work entirely in isolation.

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Periodic integration of a developer's work with that of other members of the development team is important for ensuring stability.

Checkpointing only after completing major changes can make it difficult to back off of one phase of a change. Using the revision control area for this can lead to changes being "published" before they are ready for integration. Also, publishing intermediate changes can lead to a deceptive number of revisions listed in the SCM system. It is necessary to be able to save intermediate steps in a change in case a coding step results in an error. This is particularly important when:

- The mechanism for specifying that a version is ready for integration is primitive, and another developer has access to a version as soon as it is checked in.
- There is a desire to keep the revision history database "uncluttered" with only significant changes logged.

Therefore:

Developers should be provided with a mechanism for check pointing changes at a granularity that they are comfortable with. This can be provided for by a local revision control area, Only stable code sets are checked into the project repository

Add a private repository to the developer work space so that a developer can save intermediate versions before checking them in to the repository. The private repository can use the same mechanisms as the project repository (i.e., RCS) or can simply be a means of maintaining copies of intermediate files.

The key point is to provide a way for developers to use revision control to save changes in increments which make sense to them, *without* any risk of the changes being available to other developers until the developer decides to publish a consistent and correct version. Some SCM tools support this without a need for physically separate repository area.

It is important to make sure that developers using PRIVATE VERSIONING remember to migrate changes to the shared version control system at reasonable intervals.

The revision control mechanism could also provide a means for restricting access to checked-in versions that are not yet ready for use by others, and could also provide a mechanism for filtering log messages to eliminate trivial changes.

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Note that PRIVATE VERSIONING works together with VARIATION BEHIND INTERFACE (5.2.15) to help prevent developers step on each others' toes, but they come about it in very different ways. Code owners (CODE OWNERSHIP (5.2.13)) can work together to do coordinated development and testing of private features before they are released to the project as a whole.

5.2.17 LOOSE INTERFACES **

Cattle exiting through a "loose interface".

...sometimes architecture and organization are aligned in a particular manner (CONWAY'S LAW (5.1.7)) because of geographical and organizational constraints.

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To avoid development bottlenecks, we need to be able to limit the effect one team's work will have on another.

To help development of a system with many teams proceeding at a reasonable pace it is important to keep interfaces between systems somewhat flexible. This is particularly important in a situation where there are teams of developers that are geographically distributed (ORGANIZATION FOLLOWS LOCATION (5.1.8)) and where rapid turnaround time for design and development is important. As an example, consider a project trying to build a prototype for an early customer demonstration to support a tender for bid.

Communication is difficult. If requirements are changing and the teams are located in a variety of places then the poor communication can stall a project. This can be particularly problematic when an organization does not have an architectural center, such as described by ARCHITECT CONTROLS PRODUCT (5.2.3).

This is particularly applicable in a research, pilot, or new technology application where teams are small, requirements are changing, and the potential for gridlock is great if dependencies are too high.

There is typically an *administrative* or organizational center of the architecture, but does not always have the capability to design a complete system.

Therefore:

Limit the number of explicit, static, interfaces. Define large grained interfaces which allow developers to code against interfaces defined early, but which do not overly constrain functionality. Use LOOSE INTERFACES (5.2.17) like Callback, PARSER BUILDER (5.2.20) and HIERARCHY OF FACTORIES (5.2.19) to achieve this.

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Decoupling interfaces in this way will also simplify the development of EARLY AND REGULAR DELIVERY (10.5.11), since it makes it easier to build incremental systems. It can also make it easier to set up an environment where DEVELOPER CONTROLS PROCESS (4.1.17) by defining independent features at a small enough scale that they can be controlled by a developer or group. The end result is that as long as the components meet interface, quality, and other requirements, teams in different organizational units can implement them using any microprocess which suits them.

Take care that the empire that supports the interfaces doesn't itself become a dominating focus that can drain project energy or create accidental coupling across the project. Brokers and other large communication frameworks have this danger. Keep the interfaces simple and in concert with business needs.

Related Patterns: SUBSYSTEM BY SKILL (4.2.23) addresses a similar situation, where the driving force is the skill set of the various teams.

5.2.18 SUBCLASS PER TEAM

A small team of students with a common interest in photography

...dividing up work among different teams is less straightforward than it looks. It is simply impossible to partition the work perfectly; teams will always have some overlap in each others' work.

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Subsystem teams have differing interests and design points.

When two teams work in the same class definition, they will be optimizing for different maintenance and performance characteristics. Besides being in conflict as to which way to optimize, they will also lose track of which parts of the module are used by whom (see OWNER PER DELIVERABLE (10.5.19), above).

Therefore:

Where two subsystems collide in one class, factor their code into separate classes that separate development teams' interests. Each class can be owned by its respective team (OWNER PER DELIVERABLE) and the classes can be combined with inheritance and design patterns to integrate functionality.

Object-oriented programming gives a particularly nice way to split a class along lines of separate interests—the class hierarchy. It is appropriate that different interests reside in different places (VARIATION BEHIND INTERFACE (5.2.15), since a change to one team's module should not damage the other teams' modules). Where inheritance is not available (in non-OO development), it sometimes can be mimicked using call delegation.

Various design patterns can be used to support flexible and convenient combination of such classes; in particular, see TEMPLATE METHOD in [GOF1995].

An example of teams' interests mixing is at the root domain class. Here is where the domain team puts its generic behavior. Here also is where the persistence team puts generic transaction behavior. Ideally, the two are independent. Further, by job description and expertise, the domain class person is different from the persistence mechanism person. The teams will be making changes to their interfaces and implementations concurrently. They have different interests, and different ideas as to what is best. Introducing layers of subclassing allows the groups to hone their designs with minimal impact on each other. HIERARCHY OF FACTORIES (5.2.19) [Berczuk1996] illustrates a specialization of this pattern for the case where the application is a creational system where different subsystems control the format of different types of products. PARSER BUILDER (5.2.20) is an example of providing a single base class interface to variant implementations in derived classes.

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Beware of over-applying this pattern: excessive levels of inheritance make the system harder to understand and potentially slower.

The principle would make a wonderful, universal argument mediation technique, except that addition of a new level of subclassing for every disagreement would produce a system difficult to understand.

This pattern was originally written by Alistair Cockburn in SOCIAL ISSUES AND SOFTWARE ARCHITECTURE, published in [Cockburn1998].

5.2.19 Hierarchy Of Factories

Alias: Composite Factory

Making cheese in a small rural cheese factory.

Cheeses in a larger cheese factory.

...once we decide that the Parser Builder (5.2.20) is the right way to create objects, we need to partition the details of how to construct objects of various classes into the various groups responsible for this construction, in other words we need to have Loose Interfaces (5.2.17). We want to complete Form Follows Function (5.1.11) or Organization Follows Location (5.1.8). On a lower level we want to implement Developer Controls Process (4.1.17) for a system which creates objects of various types.

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In a distributed work group it is important to divide responsibilities for creational systems as cleanly as possible and reduce coupling.

Sometimes the secrets of classifying elements in a data stream are divided between various groups. The reasons for this partitioning can involve company politics, or simply that the knowledge of the telemetry formats is distributed and there is a strong desire to reduce coupling. We need a way to partition the responsibilities for classifying the telemetry packets, while maintaining a centralized client interface, and keeping VARIATION BEHIND INTERFACE (5.2.15).

In a telemetry application, various instruments can generate telemetry which is then fed into one stream. The instruments are developed by different teams (at different institutions, for example), and these teams have control over the format of the telemetry that they generate (after taking some standard headers into account).

We want a way to isolate the details for identifying each team's objects, while at the same time allowing the objects to be identified and created in a single application. The scheme that we develop should be layered so that the main factory needs to know only of the existence of a class of objects, but need not know how deep the hierarchy below that class is. Packets created from the hierarchy are processed in a generic way, perhaps by using virtual functions.

One way to address the classification problem is to put all the classification / dispatch logic into a single PARSER BUILDER (5.2.20) (combining the *Interpreter* [GOF1995] pattern with a *Builder* [GOF1995])—perhaps by using a big switch statement—and rely on communications between groups to ensure that the details make it into the master code through some communications method. This is error prone, and subject to delays. We could also divide the processing into a number of factories and have the client call each in turn. This violates our requirement of transparency, and the client needs to know when a new class of object is added.

It would be useful to have a way to have the client interface emulate a single Factory, but hide the details of the construction hierarchy.

To summarize the forces:

- Division of responsibilities (ORGANIZATION FOLLOWS LOCATION (5.1.8)).
- A need for a central interface for parsing data streams and building objects.
- A need to add objects to the construction hierarchy in a manner transparent to clients.
- The ability (or requirement) to process entities by virtual functions.

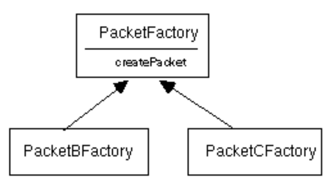
- Each class of object can know about its immediate derived classes.

Therefore:

Use a hierarchy of factories, each of which understands the criteria for making a packet of its type, and knows about the immediate subtypes. The client invokes the make method with the base class factory instance. That factory checks to see that there is indeed an object of class packet in the stream, based on some attributes. The factory then passes the data stream to the factories of each of its immediate subclasses, which check the appropriate data fields in the manner of the PARSER BUILDER (5.2.20) pattern.

The *Singleton* pattern [GOF1995] can be used to access the factories for the derived classes, or the members of the hierarchy can be registered with the master factory at run time.

While this pattern violates encapsulation to some extent by requiring that a base class know about its immediate subclasses, it can be made acceptable by agreeing on generic interface classes (say, one per team) and allow each team free reign to subclass these interface classes. Also in this application this requirement is not terribly limiting, since the top level operations team knows about the basic instrument team interfaces and the number of instrument teams is fixed by contract when the project begins.



Hierarchy of Factories

An example implementation in C++ is:

```
    //Base class factory method
Packet* PacketFactory::make(Stream* dataStream){
Packet* pkt=0;
if(isAPacket(dataStream) {
        if(! pkt = APacket::factory()->make(dataStream))
                if(!pkt = BPacket::factory()->make(dataStream)) {
```

```
                pkt = new Packet(dataStream);
            }
        return pkt;
    }
```

The result of applying this pattern is that each class needs to know only:

- The criteria for what constitutes a member of that class in terms of elements in the data stream.
- The immediate subclasses.

It is possible to use a *Registration* mechanism to inform the base class of what the subclasses are rather than hard coding the relationship. (This pattern is not yet written, but would specify a mechanism for notifying a base class factory that a derived class factory has been created. The basic idea would be similar to the View / Model connection in a Model / View / Controller mechanism, but would also address issues of uniqueness (only one instance of each derived class can notify a base class) and guaranteed notification: The construction of any object / factory of the derived classes would generate a registration event automatically).

It is also possible to implement this pattern using containment rather than inheritance.

Other uses:

This pattern is also useful for isolating the definition of packets for which a single team is responsible, so the information can be encapsulated, making it easier to work on a project with large or widely distributed teams.

Related Patterns

This is similar to the *Builder* [GOF1995] pattern in that it has a hierarchy of "factories." It is different in that the data stream defines what is made rather than the application explicitly specifying what objects to construct by arguments to the factory.

It is also similar to *Chain Of Responsibility* [GOF1995]. This pattern specializes *Chain Of Responsibility* for a creational system, and uses the different *handlers* to facilitate separation of design responsibilities.

This pattern helps us realize Organization Follows Location (5.1.8) and Code Ownership (5.2.13) [Coplien1995]. This pattern implements Subclass Per Team (5.2.18) for a creational system.

5.2.20 PARSER BUILDER *

Fort Riley, Kansas. Decoding a message at the message center which was established by the Signal Corps during a field problem. (Parsing is a form of decoding.)

...many systems need to read data from a stream and classify elements on the steam as objects. Many times the knowledge of how to interpret a stream is know by a different group than the knowledge of how to use that stream, making LOOSE INTERFACES (5.2.17) advantageous.

Given a data stream, we want to interpret it, classifying the elements into the appropriate class of object. The data stream contains tags that can be used to identify the raw data, and we want to convert the stream into object form, so we can process the data.

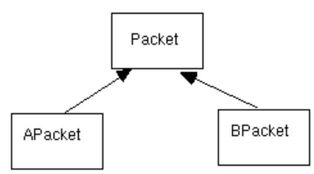
We need a way to create arbitrary objects based on tokens in the data stream.

✣ ✣ ✣

For example consider the problem of reading in raw UNIX files and classifying them into types of files based on their “magic number” —

as in the tags in the /etc/magic file. You could create the appropriate subclass of File and then invoke its virtual edit() method, bringing up the appropriate editor.

In a telemetry processing system each telemetry packet has identifying information in its header. The telemetry processing system design requires that an object, once created, knows how to process itself (i.e., we will not use a dispatch table, or a switch on type—this is to satisfy the ORGANIZATION FOLLOWS LOCATION (5.1.8) pattern). At the lowest level objects will be created using a FACTORY METHOD [GOF1995]. Each class of packets will be processed differently; some will assemble themselves into larger units, others will issue messages. Consider the following hierarchy, for a spacecraft that there are two subclasses of *Packet:APackets* and *BPackets*:



Sample Packet Hierarchy

We want each *Packet*, once created, to process itself by using a virtual method, process(). If we pass a data stream into a factory, we want to return a pointer to a Packet that has the appropriate type. To summarize the forces:

- There is a need to interpret a raw data stream.
- There is a generic way to process the packets once they are returned from the factory.
- The raw data contain tags which can be used for classification.

Therefore:

Use a PARSER BUILDER which reads the identifying information from the header of the packet, and creates an object of the appropriate type, removing only one object's worth of data from the stream.

An example of a client interface in C++ is:

```
while (!dataStream.empty()) {
    PacketFactory f;
    Packet* p = f.make(dataStream);
    if(p) p->process()
}
```

This is a variant of Abstract Factory [GOF1995] but the object to be created is defined in the data stream, rather than by the client. Hierarchy Of Factories (5.2.19) and Parser Builder can be used to implement Loose Interfaces (5.2.17) by providing a means of separating clients from producers of data (assuming that data producers also define the factories).

Other uses:

In some object persistence mechanisms, objects are assigned class Id's which are placed in the storage stream. These Ids are restored first to allow the system decide what class object to make from the restored stream.

Parser Builder is used in in the pattern Query Objects [BrownWhitenack1999] to convert SQL statements to QUERY objects. (Query Objects addresses the problem of handling the generation and execution of SQL statements in an object-oriented way, when you are trying to use a relational database to store objects.) [Riehl1999] discusses similar issues, building objects on a desktop using specifications.

The distinction between this pattern, *Builder* [GOF1995] and Factory Method [GOF1995] is that in this pattern the factory reads from a stream and the client does not know which type of object will be returned. For text interpretation, Parser Builder can be a front end to the *Interpreter* [GOF1995] pattern.

5.2.21 Incremental Integration

See Section 4.1.5.

5.2.22 Private World

See Section 4.1.6.

5.2.23 Named Stable Bases

See Section 4.1.4.

PART III. Foundations And History

Anthropology can't claim to be the oldest profession, or even the second oldest, but people have been thinking about the structure of human organizations for thousands of years. Many of the ancient texts on organizational structure deal with military organizations, and most of them are rooted in hierarchy.

In the next two sections, we investigate principles behind organizational structure. These sections will give you a deeper appreciation of how organizations work and of how organizational change happens. The first section, ORGANIZATIONAL PRINCIPLES, gives some practical insights that will help you use these patterns more effectively. The second section, ANTHROPOLOGICAL FOUNDATIONS, looks at the ties between our work using patterns and CRC cards, and the classic techniques and models of anthropology.

CHAPTER 6 *Organizational Principles*

This chapter offers some practical advice and insight that will make it easier to apply the patterns. You need to know when an organization is ready to try out patterns and, once it has started, you need to know how to apply the patterns. You need to know what to do when a pattern doesn't seem to be working. This isn't just an academic exercise: your organization is on the line. Success often comes in the details. Here, we offer some insight on the most important contextual factors that contribute to the long-term success of the patterns themselves.

6.1 Priming The Organization For Change

All patterns build on the ability to reflect on the state of the world and to take reasonable steps of progress. The organizational patterns in this book probably feature that property more strongly than any software design patterns or perhaps even more than Alexander's patterns of urban design, because the structure undergoing evolution is human structure, the structure of an organization. An organization has to have reached a certain baseline of organizational health to do this and, in fact, a large fraction of the organizations out there do not have this ability. How do you know whether you're ready to use these patterns? And, if you're not yet there, how do you get there?

If you're not ready to deal courageously with your shortcomings and to embrace organizational change, then you need to get to a space where there is enough mutual trust and respect to lay a foundation for introspection and dialogue. Without trust and respect, there cannot be deep enough communication to get beyond discussion about process (which often reduces to blaming the role or person responsible for a given step of the process) to discussion about structure and ultimately about principles. Structure is about relationship. Principles, which generate these structures and relationships, relate directly to the organizational value propositions and what they portend for trust between roles and individuals. See BEYOND PROCESS TO STRUCTURE AND VALUES (7.2).

To increase trust and respect means to engage people who are not currently in dialogue; to engage them, you need to persuade them to become involved in something they currently aren't involved in. Block [Block1983] defines politics as the attempt to have influence over that which one cannot control directly. So this problem is fundamentally political in nature.

There are two major attacks on this problem. The first attack would have your organization go through team-building exercises, would suggest changes in reward mechanisms to encourage risk-taking, or might suggest a change in management. The second approach assumes that such a core exists somewhere *within* the structure of the larger organization, and uses it as the target for the patterns, with hope that the health can spread to neighboring organizations.

Yet before any positive change can happen, the organization must be ready to change. In our studies, we have seen organizations in various states of readiness for change. Let's explore the most common conditions that prime an organization for change.

6.1.1 Dissonance Precedes Resolution

In the timeless play, "Fiddler on the Roof," Tevye comments about his daughter and son-in-law in Siberia, "They're so happy, they don't know how miserable they are." Many organizations are not sufficiently self-aware to realize the problems they have. More commonly, though, there are individuals in the organization who are aware of the shortcomings in the organization. They may or may not know exactly what the problems are, but they do know that something is wrong. But unless enough key people in the organization acknowledge the organization's problems, things are unlikely to change.

In some cases, such as ParcPlace, the problems are already apparent. But other organizations need prodding to face up to their problems. The TEAM BUILDING (6.1.5) exercises help people come face to face with their problems. In effect, the TEAM BUILDING (6.1.5) exercises create a crisis in the organization. The dissonance of a crisis is often a prerequisite for large scale cultural change. In Virginia Satir's model of organizational change, such a stimulus is called a *foreign element* [Satir1991]. It takes a foreign element to get an organization off of top dead-center.

One organization we studied was mired in cumbersome processes and overly focused on management. It was clear that most of the troops chafed under their development processes, but the manager roles did not see the problem. The team building exercise made the managers see things as the developers saw them; it removed a blindness to a reality they couldn't see. This resulted in serious introspection among the managers. It wasn't clear whether they changed their organization, but it did provide a golden opportunity to do so.

While we don't advocate looking for trouble, dissonances that present themselves may lead to opportunities for improvement. Dissonances that are vague, such as feelings that something somewhere isn't right, invite introspection exercises to help sharpen the focus of pattern application.

6.1.2 Team Burnout

One of the biggest problems with teams is burnout. Organizations experiencing burnout may be particularly ready to change: they are looking for relief from *any* source. Yet the path to organizational improvement for the team in burnout is fraught with danger: the very conditions that make the team open to change may sabatoge such change. Let's explore burnout in more detail, and consider some patterns that might be useful for teams that are burning out.

The Psychology of Burnout

Sometimes ill feelings can arise across the scope of an entire group or team, and the dynamics can often be laid at the feet of first- and second-level management. If a team as a whole or the team's manager feel threatened, the team is in danger of succumbing to two near-term countermeasures that often go hand in hand. The first is: *work harder.* Hard work, overtime, and shortened schedules are a common reaction to a wide spectrum of threats. The second is: *hunker down.* A team will close in on itself in the interest of *completely* shutting off detractions that could sap its time and energy or in any way detract from a focused effort to *maintain control.* It is an over-application of the pattern FIRE WALLS (4.2.9). This can put the team at odds with influences that it should be heeding but which it feels it can resist. It can become a spiral that leads to increased desperation, harder work, and more overtime. These are the dynamics of *burnout.*

An organization that is burning out can't learn. It doesn't take the time to learn; all the time is focused on the deliverable. It may make stupid mistakes for failing to step back and see the big picture. This is why patterns like COMPLETION HEADROOM (4.1.10) and RECOMMITMENT MEETING (4.1.12) are crucial to a healthy organization. They keep the organization *open* to other individuals and teams—both teams they depend on, and teams that depend on them.

A group in burnout often tries to take control of everything it can because its members need the comfort of being in control. It may overstep its domain of authority and claim ownership for parts of the system outside its usual domain. A dysfunctional services group may rewrite parts of the operating system because it feels it can't trust the operating system people to do it right or to do it fast enough; in these scenarios, no one wins.

A worrisome sociological configuration arises in cases of extreme burnout. One strong team member—usually, but not always, a manager or lead technical person—takes charge, usually by creating a culture of fear, intimidation, co-option, or coercion. The resulting configuration, fed by the controlling individual, discourages social discourse, openness, and interactions outside the group. The group turns inward for all of its needs. In the most extreme cases of burnout where people are now spending much of their lives at the office, the team-centeredness extends beyond professional relationships to personal relationships. People start deriving their *personal* identity from work and from the team. Work relationships displace family relationships. The organization becomes ingrown, and incest becomes a good metaphor for what happens to the organizational family. The health of the organization and its individuals deteriorate, and there often is no turning back. Family and personal lives suffer. Eric Fogelin, a developer on the first release of Windows NT, had this experience [Zachary1994]:

> In the final push for the July release, however, he ... worked every day during the month of June, some days as long as twenty hours. He took most of his meals at Microsoft; the cafeterias on campus served breakfast and lunch, and a special meal was prepared for those working late on NT in building Two. Since he lived on an island about ninety minutes away, requiring a ferry ride to and from work, Fogelin never went home for thirty days during the height of the push. He slept on a cheap green cot he'd bought. It was nothing more than a piece of canvas stretched over a narrow metal frame. By day it stood upright near his desk, a sturdy reminder of the forfeiture of creature comforts for the soul of a computer program.

There is a small body of fascinating literature on this phenomenon to which we refer the interested reader; in particular, see the analyses by Bill White [White1997], [White1986]. You've probably heard the term: "get a life." People working in healthy organizations have "a life." They have outside interests, and their identity doesn't draw solely from work. A healthy work environment—one that can sustain its employees, learn, and grow—gives people the time and freedom for this individuation.

Crisis Management and Burnout

Ask a software professional about burnout, and crisis management or "death march" projects often come to mind. Some projects are poorly managed, particularly with respect to matched expectations between the customer and provider, and that can lead to obvious burnout.

However, some organizations manage by crisis. It is exactly this mentality that Deming railed against: to drive fear from an organization, to take the power of crisis away. Some popular methods today, such as Extreme Programming, offer this fear of fear as one of their prime drivers. But if one looks deeper one can find a deeper form of crisis management.

A protracted crisis mentality creates burnout, even in the absence of a real crisis. For example, daily status meetings are a hallmark of organizations in crisis. However, if the organization adopts a policy of daily status meetings, it perpetuates the crisis mode, or even creates a crisis mode. This can incent people to work harder. Even when not at work, the people will have work on their mind so they can look good at the morning status meeting. Other aspects of XP—such as the ability never to work alone, but to always have your thought processes open to a pair programmer—help sustain the crisis mentality.

Our studies have shown that crises strengthen management roles. In crises, managers tend to move toward the center of the organization, displacing the domain expert roles that carry the organization through everyday business. (You can see a social network diagram depiction of this phenomenon in the section STABILITY AND CRISIS MANAGEMENT (6.1.3), below).

6.1.3 Stability And Crisis Management

Stewart Brandt [Brandt1995] describes "sheer layers" of change in a building that evolve at different rates. The foundation changes rarely; the plumbing and wiring change exhibit similarly seldom change; the wall paper and paint change quite a bit more frequently, and the interior decor is almost always in flux. Each one of these layers is part of the system we call a building. A crisis is perhaps a change that happens at a deep enough level to go beyond routine experience where it touches the structure of the building—or organization—but a shallow enough change that it doesn't stop the organization dead in its tracks. Moving the furniture wouldn't be construed as a crisis; fixing a leak in the plumbing would.

A crisis is almost always a surprise: an unforeseen glitch in the stability of the organization. What makes a crisis a crisis is that it upsets stability, and that it does so precipitously. (We sometimes talk of the "software development crisis," but something that has gone on for 30 years can hardly be called a crisis!)

In the same sense that you want to build a new organization on the stable core inside the existing organization, you want to hold the environment stable while you are making change. You don't want constantly to be changing the foundations. If the environment is noisy, and if the organization exhibits arbitrary behaviors, then you can never know whether a given change resulted in an improvement or made things worse, or neither! This is a fundamental principle of organizational change; it is one of the deepest principles of Deming's approaches to organization management [Deming1986] and one finds it at the foundations of ISO process improvement methods.

The pattern approach to organizational improvement is attentive to the stable parts of an organization and attempts to detach itself from noisy, day-to-day variations. Part of this stability comes from attentiveness to the deep structure that ties to values and relationships; these tend to change less frequently than practices, policies, and processes. Part of this stability comes from role normalization.

Crises can and will arise, and some of the patterns (e.g., SACRIFICE ONE PERSON (4.1.22), DAY CARE (4.1.23)) specifically address contexts with a crisis component. However, these crises are relatively small relative to the overall organizational structure and to the goals of the enterprise. Most of the patterns instead strive to head off crises; most of the scheduling patterns (e.g., COMPLETION HEADROOM (4.1.10)) are of this nature as are some of the structural patterns (FIRE WALLS (4.2.9), ENGAGE CUSTOMERS (4.2.6)).

Software development, like mountain climbing, is an inherently risky undertaking. Yet there are two types of risks: there is risk that you won't reach the summit, or that your product is a flop in the marketplace. These are risks we must take; in fact, we not only take them, we enjoy these risks! We view them as opportunities rather than risks. On the other hand, though, there are risks that the whole undertaking will go to ground because we didn't plan for the weather, or more significantly, the team doesn't function well in the face of unforeseen difficulty (see, for example, [Krakauer1997]). These are the true risks we must avoid.

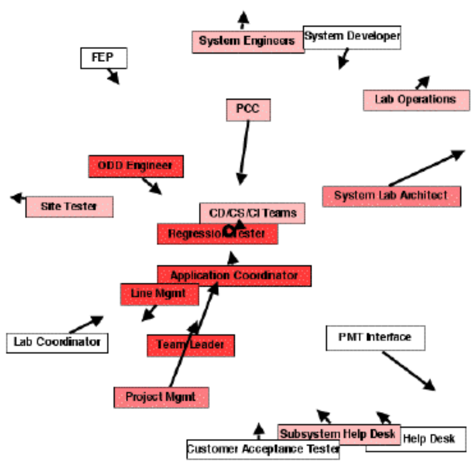
There is no pattern—or pattern language—for risk management. Risk averseness is an *emergent* property of healthy organizations. As in Alexander there are no patterns for "safe house", safety is an *emergent* property of houses built around concepts of appropriately joined spaces that draw on human context. We have provided this one section on Crisis Management in the book to tie together this popular concern and to draw out the principles we believe address the concern. Most of the solutions to so-called crisis management are distributed through the patterns:

- COMPENSATE SUCCESS (4.2.25) talks about the problem of rewarding people who excel under crisis situations

- The Open Closed Principle Of Teams (6.1.4), above, talks about the danger of a crisis becoming a way of life (because in a culture where everything is a crisis, nothing is a crisis, and that's not healthy!)
- The same section talks about the psychology of burnout, which is closely tied to crisis management styles.
- Stand Up Meeting (5.2.7) takes a current crisis as its context.
- Team Per Task (4.1.21) is one way of isolating crises.

There are some things to be aware of in crisis situations.

- Contraction of organization and stronger management influence during crises. Consider this sociogram of a regression testing organization showing the relationships between roles under "normal" operations (connections between roles have been removed for clarity):



: The arrows depict how the roles are displaced in the social network diagram when the organization goes into a crisis. Note that local control roles take over (Project Management, the Program Change Committee (PCC), Team Leader), while technical roles (like the Lab Architect) and even Line Management get out of the way. The process gurus (the Process Management Team or PMT) are among the first to go! Coupling between roles skyrockets under stress, and the organization's "diameter" sharply decreases. We find this is a typical pattern, and it is a great expediency *as long as it does not become the norm for day-to-day business*. Note that one way this is accomplished is through a STAND UP MEETING (5.2.7), where managers get frequent status from everyone. That pattern highlights the dangers of allowing ongoing daily meetings to perpetuate the crisis mentality. Such meetings are fine for redressing short-term crises—but prolonged recurrence of very frequent status meetings can create a crisis mentality: a problem that every developer can relate to.

- Suspension of the normal organization, replaced by artificial temporary one. For example, a "firefighting" team might be organized to deal with a sudden serious quality problem in the software. Note that firefighting can easily become a way of life: firefighting teams usually get special rewards, which make firefighting desirable. Before long, the team is lurching from one crisis to another. Instead, you want to isolate fire-fighting; see TEAM PER TASK (4.1.21).

Last, crisis can be a good thing. We don't believe that organizations should *seek* crises, but neither should they be so risk-averse that crises create fear. Crises create opportunities for learning; a postmortem of a crisis can sow seeds of great organizational learning.

- Crises can create opportunities for large-scale culture changes. A perceived (and probably real) crisis at ParcPlace Systems precipitated a focused introspection and post-mortem exercise that led to organizational renewal [Gabriel1996].
- Crises create learning opportunities. A crisis in a healthy organization provides an "opportunity" for a retrospective [Kerth2001].

In summary: crises can and will happen, and they provide opportunities for learning. The learning should drive the organization into a better sense of order and stability, but not to the point where other changes can't surprise the organization into learning again!

6.1.4 The Open Closed Principle Of Teams

Change is disruptive, yet most people adapt to new situations extremely well. However, change is more disruptive to teams than to individuals, because there is an additive effect of the disruption to the individual members of the team. When change violates the Open/

Closed Principle of Teams, the team may be ready for positive change with these patterns.

Or not. Read on.

Bertrand Meyer teaches a rule of object-oriented design called the *open/closed principle* [Meyer2000]. It combines two ideas:

- that a class should be closed so that other classes don't come to be preoccupied with or otherwise depend on its internals
- that a class should be open to extension by inheritance, so it can evolve into a new entity with both new structure and behavior.

Team evolution is the same way. If a team does not have final say over its membership (SELF SELECTING TEAM (4.2.11)), focus (TEAM PER TASK (4.1.21)), and direction, resentment will build and the team will lose its sense of identity. Teams of course must sometimes negotiate with other individuals and organizations and sometimes must compromise, but as a rule teams should conduct their own business.

This is why CONWAY'S LAW (5.1.7) is such a key pattern in two of the pattern languages in this book. Teams and groups are built around domains of specialization and expertise. And teams are staffed with the people who can serve that discipline (DOMAIN EXPERTISE IN ROLES (4.2.22)). Meddling from the outside only detracts from the team's focus.

So a team enjoys some autonomy in reaching a healthy steady state. But what about dealing with growth and dysfunction? And how about dealing with change? The outside world is always changing: the market, the technology, everything! The team must be open to external communication.

We can talk about this openness at two levels. As the software evolves, the architecture inevitably evolves and the teams must align their software to track architectural creep. (Actually, each team's software *causes* the collective architectural creep, but from the perspective of any single team it appears as though it is the *rest* of the world that is changing things out from underneath them.) So though the team is *closed* to meddling with the invariants related to its core competencies, it must be *open* to changes in interactions with other parts of the system. Such architectural changes may change the organization's communication network.

For example, let's say that you're working on a telephone switching system and your company is incorporating a new integrated circuit to accommodate market demand for a new protocol. The expertise about that chip resides in the heads of some people somewhere, and if you are going to be developing software that interfaces with that chip you're going to be talking to those people. Conway runs rampant in dynamic projects.

That's a simple example based on software change. Organizational change can be much more subtle. Technological change (like adding the new integrated circuit) doesn't hit people very deep with respect to their averseness to change. Organizational change, on the other hand, can be a strong threat. It can make people feel that their power base is threatened if they are made to report to a new manager. It can make people feel their job security is challenged if a new person is hired into the same area of specialty.

Empowerment

Sometimes the best laid plans of mice and men go astray. In complex systems such as human organizations, cause and effect can be far from each other in time and space [Senge1990, 63]:

> ... a fundamental characteristic of complex human systems ... [is that] "cause" and "effect" are not close in time and space. By "effects," I mean the obvious symptoms that indicate that there are problems—drug abuse, unemployment, starving children, falling orders, and sagging profits. By "cause" I mean the interaction of the underlying system that is most responsible for generating the symptoms, and which, if recognized, could lead to changes producing lasting improvement. Why is this a problem? Because most of us assume they are—most of us assume, most of the time, that cause and effect are close in time and space.

Introducing an *empowerment* program is supposed to increase the energy level, to remove constraints that will free people to do what the enterprise needs to have done, and to give people a sense of control over their destiny.

Think about this from the perspective of the open-closed principle. Empowerment increases the degree of closedness of a team. Giving a team autonomy might cause the team to weaken its interactions with important stakeholders and with sources of information and constraints that are important to the successful operation of the team.

Empowerment might be particularly effective in diluting information exchanges with roles that exercise control in general, and with management in particular. In theory, this might create problems with respect to the open closed principle. Unfortunately, that is exactly what we find in practice. We have seen this in some of our organizational studies, but there is also research from Rutgers that concludes that this is a general outcome of empowerment programs [Yates1995].

Empowerment is an attempt to achieve an effect (increasing individual leverage) by directly attacking its cause (the "distractions" of coupling and communication that "get in the way of work"). But this is not a system view; the solution cuts off the very nurturing that may have powered the team to its level of performance in the first place. Empowerment is a possible contributor to burnout.

Schismogenesis

We have also seen a lighter but almost equally deadly form of this phenomenon which we describe as *schismogenesis*. The term dates back to the work of Gregory Bateson [Bateson1958] in 1936 in his work with tribes along the Sepik River in New Guinea. *Symmetrical schismogenesis* occurs when two factions each rise in power, or fear or distrust of each other, and form cliques or splinter groups that tend to focus inward rather than resolve issues in dialogue with each other. This is also a natural outgrowth of efforts to merge separate companies: the separate groups already exist with different values and cultures. The merger, with the spectre of job cuts, sows fear and distrust just at the time the organizations need to learn to work with each other.

Complementary schismogenesis occurs when a stronger side is compelled to actions by its fear of being taken down by a weaker side. We have seen this in organizations under the stress of an impending downsizing program, where the core members of the organization become disconnected from the support arms of the organization. It also occurs in mature organizations, where power structures have become entrenched. This is the main reason for the patterns RESPONSIBILITIES ENGAGE (5.1.14) and HALLWAY CHATTER (5.1.15), which came out of an earlier pattern named "Buffalo Mountain" that was designed in part to address schismogenesis. The pattern THE WATER COOLER (5.1.20) can also help reduce tensions between constituencies by creating a "place" for new social structures that are allowed to violate institutional structures. The HALLWAY CHATTER pattern gives an example of an organization exhibiting schismogenesis.

It may be obvious at this point, but such organizations are not candidates for the patterns in this book. To apply the patterns requires dialogue and interaction; that's the "open" part. It also requires focus and a *healthy* sense of team pride (see UNITY OF PURPOSE (4.2.12)). There is of course no black and white here. The balance between open and closed is subjective. It is also true that burnout is a spectrum: of course organizations put in long periods of hard work. But to go more than a month with consistent 60-hour weeks is a real danger sign. Even if the organization is not going into burnout, individual effectiveness and efficiency wears down very quickly after too long of a death march.

Many of the patterns in this book address this issue, keeping the organization vibrant and healthy *so that it can adapt to change.* A closed organization has difficulty changing effectively. Look at PUBLIC CHARACTER (4.2.17), who helps information flow efficiently. Or at GATE KEEPER (4.2.10), who explicitly breaks down walls around the organization, and helps balance the FIRE WALLS (4.2.9) pattern. HALLWAY CHATTER reflects an informal social infrastructure of both technical and friendly exchanges in the workplace. Even DEVELOPING IN PAIRS (4.2.28) can be a useful pattern for the exchange of ideas and information across groups if the pairing is done across team and organizational boundaries. And of course it's important to keep in contact with the people who pay the bills through patterns like ENGAGE CUSTOMERS (4.2.6).

6.1.5 Team Building

There is an aspect of team building in every organizational intervention we've done. After all, the goal of an organizational study is to analyze the communication in the organization, and such communication is the foundation of team dynamics. Team building can have the unanticipated side-effect of pointing out the necessity of change: hidden wounds come to the surface, where they can receive the treatment they need.

As described above in HOW THE PATTERNS CAME TO US (CHAPTER 2), role playing is a staple of our research technique. We bring the organization together in one room where they role-play one of their processes: the design-coding process, or the testing process, or the acquisition process, or the analysis process, or the field support process, or whatever it is the organization believes needs attention.

One goal of the role-play is to put the team members into the psychological roles they play on a day-to-day basis. If one succeeds in doing this in a large group, it helps the group as a whole see itself in action and see the patterns of interaction that emerge. Reflecting on those patterns, those communication structures in the group, is the main foundation of organizational growth and renewal.

But the formal role-play can sometimes be the key to more powerful modes of introspection or to ways that are more suitable to the organization's culture or comfort zones. At Allianz, we did some initial role-play exercises with two of the development teams. Those exercises supported a bit more dialogue and interest in the groups on organizational issues but themselves did not cause major changes in ways of doing business. However, those initial studies led to follow-up work to explore the application of DEVELOPING IN PAIRS (4.2.28) and other ideas from Extreme Programming [Beck1999] under the leadership of Thomas Tik of Allianz, Jim Coplien, and Laurie Williams of North Carolina State University. We decided to have an off-site meeting with the engineering teams, where we created an environment for open, constructive criticism of management and a lot of unstructured time. In addition, we spent time teaching them about DEVELOPING IN PAIRS. Those activities led to some management insights and realizations. Later, we were able to act on that experience to leverage change at the next higher level of management, and that broke a logjam that opened the floodgates of dialogue at the next level. Organizational improvement followed in its wake.

Similarly, at ParcPlace Systems [Gabriel1996], we held a team role-play exercise. The vice-president of engineering, Richard Gabriel, had already started creating history time lines and having other forums that built on the team's frustration with its state and its desire to return to the environment of its glory days. The role-play was a watershed event to the extent that it underscored much of the dysfunction in the organization at that time and provided an external corroboration of the state of the organization. It also provided a forum where the team members could start thinking about patterns and talking about their dysfunction in terms of patterns. While the role-play exercise was only a fraction of the introspection, it was one of the main introspective events that involved the *entire* team, and offered foundations to support ongoing dialogue and organizational renewal. Yes, they even used some of the patterns in turning the organization around. But more important, they wrote their *own* organizational patterns and took charge of their destiny. This sense of ownership and taking charge, tied with the creation of a tangible body of patterns that they stood by, were perhaps the centerpiece of the organizational turnaround.

Techniques such as the organizational role-play can help develop the models and shared perspectives that can be seeds for the dialogue that strengthens a team. A *retrospective* [Kerth2001] is a powerful team-building tool that yields both explicit and implicit benefits; the role-playing exercise described above is a form of retrospective. Most importantly, retrospectives help build a foundation for trust between the members of an organization. Seeing one's self in relationship to others helps people establish models of expected behaviors. These models either open communication paths or show where communication paths have broken down because of mistrust, environmental factors, temperament mismatches, and other factors. Team dialogue alone can identify environmental factors and some of the other factors, but it can actually strengthen the first and most important factor: trust. Using patterns such as those in this book can offer a rallying point for the team and can offer vocabulary for talking about the team's problems and potential solutions. But there are many other team-building techniques that can be equally effective.

6.1.6 Building On The Solid Core

Awareness of the need to change does not mean that the organization is ready for change. The team (not just the individuals) must be willing to change. Many teams are lucky enough to have a solid core of people. This tends to make it easier to change: the team members are more secure in each other; less worried about the impact of change.

In the case of both ParcPlace Systems and of Allianz, we found a solid core of people to start working with. This is almost always a preferred mode to doing team building for its own sake, because the structures are already in place to support the communication and dialogue necessary to reason about *improving* communication and dialogue!

In the case of ParcPlace Systems, the engineering group was drawn together by a common sense of disappointment and by a desire to have a feeling of control. From one perspective it wasn't an ideal organization for the application of organizational patterns. But on the other hand, desperation can drive out fear. One thing we did when we visited the organization for the role-playing exercise and initial round of evaluations was to leave them with the thought that they were indeed in very bad shape. It wasn't an exaggeration, but coming to grips with that fact perhaps gave the group courage to do things it otherwise wouldn't have done.

In the case of Allianz, the engineering group was one of several groups that had difficulty integrating their processes in the work environment. There was strong support for organizational work in second-level management and to some degree in third-level management, while first-level management (team leaders) were more focussed on technical solutions than organizational solutions. But the support for organizational work was stronger in engineering than in the other organizations. This concern for human issues was evident in the engineering work environment; a high degree of camaraderie and interworking could be found within the engineering team—and with their colleagues in the other teams—and their concerns about organizational health related more to the interactions between teams than to the dynamics within their own teams, as they had already reflected on those and had come to a point of satisfaction with their operation.

In both cases, the adoption of patterns in the small cohesive teams gave those teams tools for dealing with other organizations in the enterprise. This gave those teams a firmer foundation for congruent, productive relationships with the other organizations instead of the more contentious and sometimes combative (either openly or subversively) behaviors of the past. The congruence was a face-off of sorts: it provided a hard wall of integrity and well-reasoned behavior that was more difficult to subdue than in the past. That, in turn caused behavior changes and even doubts in the other organizations, and led to the eventual spread of the change culture to those organizations as well.

The key in both cases was to start with the healthiest team—in terms of its ability to introspect and learn—and to nurture it.

6.2 Piecemeal Growth

Once your organization is primed for change, where do you go from there? How do you start applying the patterns?

The answer is simple: pick a pattern to start with, and then apply the patterns one at a time. We will go into more detail in a few moments, but first a warning: Do not attempt to apply these patterns at once! Do not sit down with the pattern book in one hand, and your organizational plan in the other, and attempt to design your whole organization. These patterns must be applied in a piecemeal fashion. In fact, that is the only way an organization can change effectively; it must grow and mature organically.

There is a style of organizational design that believes in formalism, repeatability, and control. This school of organizational design is typified by ISO 9001 compliance programs as they are usually carried out. Perhaps Osterweil's (now quite out-of-vogue) Process Programming [SuttonLernerOsterweil1997] is the epitome of this school of organizational design. Such approaches suggest that if we get everything right up front, all else will follow.

Unfortunately, it is impossible to foresee the complexities that beset even the healthiest organization. Human behavior is one of the most pernicious things to predict because it emerges from thousands of considerations and inputs, each weighted differently, that feed the decision processes behind organizational evolution. This makes it difficult to plan organizational structure. Changing economic conditions and markets, changes in the employment roll, in the law, and even the national mood can upset organizational design.

Some organizational structures change slowly and can be depended on as foundations for the evolution of an organizational design. These structures come not from an analysis of the future, but from an analysis of the past. Such structures can be formalized using techniques such as domain analysis and, in this case, one can make an analogy between domain analysis and patterns. Some of the patterns in this book are like that; more so those in the PROJECT MANAGEMENT PATTERN LANGUAGE (4.1) than those in other parts of the book.

But most of the time, successful organizational growth takes place in a piecemeal fashion, in real time. One of the pattern chapters is called PIECEMEAL GROWTH PATTERN LANGUAGE (4.2), which contains patterns about how an organization grows and develops — gradually.

Note, however, that although you apply the patterns one at a time, they do not operate in isolation from one another. You must consider applying *all* patterns in a process of piecemeal growth.

In a piecemeal growth environment, the focus is on ongoing *repair* rather than on forecasting and anticipating. In fact, all design is in some respect an act of ongoing repair; we employ the feedback that comes to our senses from the emerging design to modulate the direction of design from that point on. So much the better that one is dealing with a live system and receiving its feedback than when working in the abstract with just "a design." Nature works the same way. Organizations, and their evolution, seem more to follow the laws of nature than the laws of modular design of design in any field with human-created artifacts. And nature works in the now, with feedback, employing repair.

The piecemeal growth philosophy comes from Alexander's vision of how patterns should be used, and pervades his work. The 6-step process below is derived from his yet unpublished work *The Nature of Order.* (Volume one has been published so far [Alexander2003].) But piecemeal growth also surfaces frequently as a key management strategy. One of the main principles of organizational change in AT&T organizations in the 1980s was that one shouldn't try to change more than three things at once. Culture can change, but it loves stability.

More broadly, the pattern philosophy of piecemeal growth is a broadening of the popular notion (particularly during the late 1980s) of *organizational learning.* There are several excellent books on organizational learning; our favorite is "Becoming a Learning Organization: Beyond the Learning Curve," by Joop Swieringa and Andre Wierdsma [SwieringaWierdsma1992]. There are strong parallels between the organizational learning field and patterns. For example, each believes in building on a small number of principles that generate rich emergent behavior; complex systems of rules don't work [SwieringaWierdsma1992, 9].

A pattern-based piecemeal-growth repair process is robust for two major reasons. The first reason is that we don't do random things at random times. The patterns encode wisdom born of experience and follow sequences that have repeatedly worked in the past. Second, the patterns build structures which themselves offer a degree of resiliency under change. Domain Expertise In Roles (4.2.22) and Function Owner And Component Owner are good examples of patterns that help an organization ride through common changes. If one organized around expertise related to a given product, the organizational structure would be sensitive to changes in the market. The market can be fickle and tends to change much more rapidly than the expertise associated with a given domain. FUNCTION OWNER AND COMPONENT OWNER honors the tradition of giving focus to the marketable item; after all, that's where the money is. At the same time it guards the long-term stable structure of the system, its underlying knowledge, and the organization that sustains it by *also* according ownership on the basis of components. DOMAIN EXPERTISE IN ROLES helps the organization build foundations around core competencies rather than around current market (or management) fads. The organizational patterns encode that robustness and experience.

The PROJECT MANAGEMENT PATTERN LANGUAGE can be an *inspiration* for principles and structures to get you started. It offers many long-term stable domain structures having to do with organizational structure, certainly for software development. Rough forms of these patterns will fall in place early in the formation of a new organization, and these patterns can be honed, fine-tuned and polished over months or maybe years to make them really shine. While DEVELOPMENT EPISODE (4.1.15) can be an almost methodological construct, one that can be implemented almost overnight, patterns like WORK FLOWS INWARD (4.1.18) have more emergent results that come about over time. And even the seemingly simpler patterns like DEVELOPMENT EPISODE are cultural changes that will breed discomfort and take some getting used to. Each pattern is a small foreign element—an upsetting even—in its own right (see DISSONANCE PRECEDES RESOLUTION (6.1.1)). Still, the PROJECT MANAGEMENT PATTERN LANGUAGE is a good "starter set" for *most* organizations. But your mileage will vary, and you should *defer to your instinct and insight.*

That foundation in place, you can slowly make improvements by applying one, or maybe two, patterns at a time. Fundamental to the nature of patterns is that each can be applied in its own right without undue consideration of other patterns. Each pattern encapsulates a set of forces, or trade-offs (see WHAT ARE PATTERN LANGUAGES? above) that are as independent as possible from the forces in other patterns. Ideally, each can be applied in isolation. Ideally, there is no backtracking.

There are of course limits to this idealism. An organization is a system and a system view can be important to keep you from being blindsided. There is no formula or recipe for combining pattern application with insight; it is indeed your deeper insight that will tell you what the proper mix is. We as authors of this book trust you as shepherd of your organization to build on that insight. We provide some hints in the form of patterns, some insights on how the world tends to work well, and trust that those will serve as inspiration for you. This book is not a medicine cabinet. Patterns are not magic remedies to cure ills (more on this in ORGANIZATIONAL PATTERNS ARE INSPIRATION RATHER THAN PRESCRIPTION (6.3.2)).

6.2.1 The Fundamental Process

There is a rhythm to the application of patterns and people tend to underestimate the *process* that makes patterns work. That process is a process of piecemeal growth. One follows a *sequence* through the pattern language to increase wholeness, one pattern at a time. How, basically, does this work? Here is a synopsis of the process:

1. Consider your organization as a whole; get a feeling for how the entire enterprise (development group, department, etc.) is working. Get a feel for its "weak spots." Maybe you just applied another pattern. That left you in a new *context*. What forces are unresolved in that context, either from incompleteness in the pattern you just applied, or from other forces in the system that have now become visible or of higher priority?
2. Focus on what can be done to increase wholeness. "Wholeness" here reflects your personal and corporate values. Are you striving for profitability? Then what are the weaknesses in your organization related to profitability? And is profitability *really* what's killing you right now, or is morale affecting productivity which is in turn affecting profitability? Dig deeper. Reading through the patterns—and particularly their forces—can help you sort this out. Reflection is key: it is important to focus on *recurring* issues and to avoid reacting to immediate concerns or ones that bear a high priority in the moment.
3. Find a place where the application of a new pattern—the creation of a new role, the addition of a new group, the restructuring of things — will achieve that goal. Will any of the patterns help that? Do *you* know of other techniques that will help that—

whether they bear the pattern banner or not? (We don't get paid by how many patterns we sell; our satisfaction comes from helping organizations succeed!) Don't get stuck in pattern tunnel vision. But if you do this, take good notes—today's odd heuristic might be tomorrow's pattern, and we want you to write it down.

4. Apply that pattern or technique *locally*: think locally, act locally [Gabriel2000]. *But* do it in a way that might also increase the wholeness at the next level in the organizational structure, or in the next larger context or scope.
5. Strive for balance. Most of the patterns here are communication patterns. Communication is rarely a one-party phenomenon; it affects at least two loci. That means that when you apply most of these patterns there will be some kind of local symmetry. Be attentive to the symmetry and make sure both sides of the communication, structure, or other facet of the pattern are attended to.
6. Reflect—does it feel right? Does it work? Filter the feedback from the organization; people will generally resist change, but are structure and behavior trending in a direction that increases the wholeness? **If not, back out.** It is much better to back out at this local level, with respect to the application of a single pattern, than it is to forge blindly ahead and do more damage. Eventually, a good pattern will lead you to a new context—and a new set of forces to balance, and problems to which you can attend.

This process iterates after the pattern has had time to settle in and gain acceptance in the culture. That might take days; it might take months. Again, use your judgement.

Piecemeal growth is guided by *sequences.* A pattern language is a graph, and there are almost innumerable useful paths through it. There are two cues you can use to know which pattern to apply next. One is to look at the structure of the pattern language. The individual patterns tell about what patterns should come next as refinements and progressive steps, and the numerous figures of the pattern language graphs can also be a guide. The other guides that are useful are the sequences that other organizations have followed. The section on CASE STUDIES looks at the paths followed by several organizations on their rough road to success. They are stories. Stories can offer powerful insights into business choices, and we offer them to you for that reason. Read them through and look for things that hit home.

6.2.2 When do I apply these patterns?

If you are familiar with Design Patterns in software architecture, you probably feel it is obvious when to apply a pattern: when a problem arises during design or implementation. When do you apply organizational patterns?

Remember that the *system* you are building is more that of a human organization than a software artifact. Change upsets organizations. Good change comes from a process of consensus, and it takes time and focus to develop consensus. Project retrospectives [Kerth2001] are an opportune time to consider the new application of organizational patterns to the organization. Retrospectives are an opportunity to sit back and consider the organization as a whole, to find the pressure points of change that will give rise to the right kinds of emergent structure and behavior. Making changes during a consciously planned retrospective helps avoid making decisions in the heat of battle; it can help lead the team to changes that are more systemic and less reactionary in nature.

It is better to introduce organizational patterns between development cycles than in the middle of a cycle; this may coincide with a project delivery, or a change in technology, or perhaps an externally imposed change in organizational structure. Remember to make changes piecemeal and local.

The patterns in the chapter People And Code Pattern Language (5.2) might be applied as problems arise during development cycles; they are a hybrid between organizational patterns and software design patterns.

6.2.3 Writing your own patterns

Each organization has its own patterns of effective communication and development. There are many different kinds of software development organizations: an organization that develops embedded software is likely to be quite different than one that develops in-house interactive tools. Each of these organizations is typified by its patterns.

The patterns in this book are neither universal individually, nor complete as a set. Each organizational can augment this book's patterns with their own patterns. Again, retrospectives provide an opportunity to capture good patterns and add them to the repertoire of good organizational practices.

See the story of the resurrection of the ParcPlace Systems team in [Gabriel1996] for a story of a team that rebuilt itself around a pattern-writing effort.

6.2.4 Master Planning And The Theory Of Constraints

One contemporary management fad is Goldratt's Critical Chain and Theory of Constraints [Goldratt1999] which has some similarities to the process mentioned above, but which also has some stark differences. It is similar in that the focus at any given time is local, at a particular juncture of problems. But the pattern approach differs from Goldratt's approach in that there is a broader theory and structure guiding the process, a structure based not only on action / reaction but on encoded experience. Goldratt's techniques are more applicable to industrial and inventory processes that are less tainted by human emotion and dynamics. The pattern process is more suitable to organizations, which have a life of their own.

The greatest danger is to try to take control and to foresee exactly how patterns will work together, and to plan now in a way that anticipates how you will plan in six months' time. The world is more complex than that (see PEOPLE ARE LESS PREDICTABLE THAN CODE (6.3.6), below). An organization is an ever-evolving structure and organizational process improvement happens in the now. It pays to know history, and one shouldn't ignore the market and technological trends coming over the horizon, but to plan structure based on predicting human behavior is usually a mistake. This is a difficult thing for most managers: it requires a "letting go." Let go; think locally and act locally; trust your instinct and experience and the experience encoded in the sequences of the pattern language for the rest.

6.2.5 Communication and Organizational Learning

We mentioned above that organizational learning is a key property of effective organizations. Many of the patterns in this book concern effective communication in an organization. But communication can't have long-term impact unless there is group learning. That takes introspection. So the second main component of long-term viable teams is that they take time to introspect. That, of course, builds on good communication skills—and leads to UNITY OF PURPOSE (4.2.12), which is one of the core properties of any effective team.

6.3 Some General Rules

We wish organizational science were a science, but it's not. Organizational improvement is an art. It requires craftsmanship in building the right structures. It requires a fine human touch. And it requires innovations — some of which have come to us in dealing with organizations over time.

In this section we offer some brief, general rules for how to apply the patterns. Most of these have come from our experience of the past ten years, but others come from more general principles of patterns.

6.3.1 Make Love Not War

The great Chinese generals observed that he who achieves his goals without fighting is the most victorious. When one starts a war, there are few winners and less winning than if things are dealt with peacefully. Most people are well-intentioned, given reasonable hope of a secure future, and are driven by seeing their needs met. The art of negotiation is to bring as many peoples' needs, and then desires, into alignment as possible.

Sometimes there are circumstances that make it impossible to avoid fundamental conflict. If the enterprise is cutting staff, it is rare that any amount of negotiation will be able to save everyone's job and position in the company. In these situations people are driven by needs lower on the Maslow hierarchy and will act in ways that others may find less civilized. These situations call for particularly strong leadership and tough decisions. These situations call for constructive action: inaction is sometimes worse either than going to war or avoiding war. The worse thing that can happen is that people sit around and plan their investment strategies for survival and life after the organization goes bankrupt; it is important for leadership to keep a vibrant focus on solving the problem. The goals of this leadership and of these decisions is to get to a place where dialog can take place among people who are concerned about their joint welfare all at the *same* level of the Maslow comfort hierarchy. If one can build on health at lower levels of the hierarchy and carry on this dialogue at higher levels, so much the better.

Having achieved that level of stability, the process of inclusion and dialogue can start. It needn't always be genteel and high-brow; perhaps *everyone* is worried about the company going bankrupt within a few months, or about the parent company firing all of the employees. Such desperate measures have, in fact, proven to be great rallying forces in the organizations we have worked with. Desperation is the mother of invention—or it can be, under leadership that can rally such a group to introspection and dialogue. But success comes from dealing constructively with the problem rather than by making war on a shared enemy.

6.3.2 Organizational Patterns Are Inspiration Rather Than Prescription

The first thing to remember is that these organizational patterns, like all patterns, are not to be applied blindly or exactly. The patterns are synthesized from many experiences, no one exactly like the other. And your situation will surely be different than those we have observed. Therefore, the patterns serve as inspiration, rather than a blueprint to be followed exactly.

Most of us tend to be solution-oriented, and we naturally focus on the solutions in patterns. Yet the *problem* in a pattern is as important as the solution. The insights we gain about the problem—captured most often in the forces—can be just as helpful as the solution itself. In many cases, once we understand the problem thoroughly, the solution becomes clear.

As you read the patterns, look for problems that are similar to problems you now have or once had. But don't look for exact matches; they won't be there. You unleash the power in the patterns when you learn to adapt them to your own situation.

6.3.3 It Depends On Your Role In Your Organization

As you read these patterns, it will soon be apparent that there are many patterns that you can do nothing about. For example, few of us are in a position to do something about COMPENSATE SUCCESS (4.2.25); we don't hold the purse strings of the organization. Frankly, many of these patterns have management overtones, and non-managers are relatively powerless to change them. Furthermore, many of the "non-management" patterns apply to specialized roles; ARCHITECT ALSO IMPLEMENTS (5.2.10) applies to only a few roles.

You can react to this fact in one of two ways. One way is to become angry and frustrated. You identify yourself with Dilbert, and begin to see your boss with pointy hair. "Why can't my company's upper management get a clue?"

There is a much better way, though. Instead of focusing on what you can't change, focus on the patterns that may apply to you. That set varies depending on your role. For example, you might find it useful to ENGAGE QUALITY ASSURANCE (4.2.29), or ENGAGE CUSTOMERS (4.2.6). Perhaps you see yourself as a GATE KEEPER (4.2.10) or a MATRON ROLE (4.2.18). It may be worthwhile to strive to become so good at what we do that we eventually become a LEGEND ROLE (4.2.20).

In reality, we will react both these ways; we're human. The trick is to try to let go of the things we can't change. Or at least, they become filtering mechanisms when we consider taking a position in a new organization.

6.3.4 It Depends On The Context Of The Organization

Obviously, every organization is different. Therefore, every organization will use these patterns somewhat differently. For a given organization at a given time, certain patterns may be very important, others may be only somewhat useful, while others may not apply at all. But given this fact, how do you use these patterns to best advantage?

Note that every pattern has a context, which defines the boundaries of usefulness for that pattern. The context generally shows up at the top of the pattern, although some context is buried in the exposition of the problem. It is often difficult to separate the context and the problem. So you should read the context and problems with an eye to how they fit your particular organization. Note that the context of an organization changes over time. In particular, consider the following:

How large is your organization? In addition, how large and complex is the software you are working on? Several of these patterns apply best to large or small organizations.

How mature is your the organization? How long have people worked together? In mature organizations, the roles tend to be well understood. New organizations will be find the patterns of piecemeal growth of the organization more useful.

How mature is the software under development? This is different from the maturity of the organization. Mature software is more appropriate for HUB SPOKE AND RIM (5.1.17), for example.

What is the culture of the organization? Sometimes, the organization's culture makes easier — or harder — to apply certain patterns.

6.3.5 Organizational Patterns Are Used By Groups Rather Than Individuals

There are many things we can do as individuals to become more effective. We can improve our knowledge through study and practice. We can improve the way we do things; we might, for example, follow Watts Humphrey's personal software process [Humphrey1995]. Applying organizational patterns is not something we do alone.

There are indeed some patterns that are oriented toward individuals. The GATE KEEPER (4.2.10) and MATRON ROLE (4.2.18) patterns, for example, describe single-person roles. Yet on closer examination, these roles are useful because of how they interact with others — they cease to exist in isolation. Even a SOLO VIRTUOSO (4.2.5) is set up and managed by another person. Furthermore, and this is important, one of the keys to the power of patterns is that they establish a shared high-context vocabulary. That's a group thing.

So the question becomes not only how to disseminate knowledge of the patterns throughout the organization, but to also how to get people to use them. While nothing replaces the hard work of old-fashioned evangelism, we can offer a few specific suggestions.

One approach is to spread the word pseudo-subversively. Remember the description of Dick Gabriel leaving the patterns by the printer. You can also call out the patterns as you see them (or see their need) in your organization. People will become curious what CONWAY'S LAW (5.1.7) is, and ask questions.

The most effective way we have seen to introduce these patterns is through the organizational studies. This not only provides a natural forum for introducing the patterns, but also exposes the need for them. We heartily recommend this experience.

6.3.6 People Are Less Predictable Than Code

Perhaps the biggest challenge of organizations is that they are made up of people. And people are not as well behaved as computers are! Although we may not like to admit it, computers do pretty much what we tell them to. But people on the other hand don't necessarily do what we want, or even expect.

This means that the results of applying organizational patterns are going to be inherently less predictable than applying object-oriented design patterns, for example. Imagine that your organization uses the RESPONSIBILITIES ENGAGE (5.1.14) pattern to help communication. But perhaps two people involved simply don't like each other? Personalities play a large part in organizations.

Organizational patterns have everything to do with the culture of the organization. Remember that applying these patterns requires, in many instances, changing the organization's culture. And because culture is deeply ingrained in organizations, this can be difficult and sometimes even painful.

6.3.7 The Role Of Management

Managers are in a unique and paradoxical position with respect to organizational effectiveness. On the one hand, they have little or no direct impact on the product being developed. Manager roles are support roles, rather than PRODUCER ROLES (5.1.3). The only way managers can contribute value to the corporation is through the producers they manage. Management is limited to changing policies and organizational structure in order to influence the behaviors of individuals and groups. They are particularly powerless.

Furthermore, it may be the case that great managers are the product of the great organizations they head as much as organizations are the product of their own talents. Kroeber (see PATTERNS IN ANTHROPOLOGY (7.1)) talks about the role of genius in culture. We think of Aristotle and Plato as exemplifying the greatness of Greek philosophy, and we think of them as having *produced* the philosophy ([Kroeber1948], p. 145). But it is more likely that it is the culture that produced the philosophers, and that the philosophers articulated latent structures and concepts that the culture was primed to deliver. Aristotle and Plato are therefore remembered as great leaders, while the masses fade into collective obscurity.

Along similar lines of reasoning, Kroeber argues that great inventions such as the telescope, logarithms, the calculus, photography, the telephone, and exploration of the North Pole are products of culture and not the individuals usually associated with them. As evidence, he notes that each of these landmarks were achieved by at least two discoverers *in the same era*, and in almost all cases by individuals whose efforts were unknown to each other. The telescope was independently invented by Jansen, Lippershey, and Metius in 1608; logarithms, by Napier in 1614 and Burgi in 1620; the calculus, by Newton in 1671 and Leibnitz in 1676; photography by Daguerre and Niepce, and Talbot, in 1839; the telephone, by Bell and Gray, both in 1876. He lists about 20 other such coincidences known to history ([Kroeber1948], p. 140).

By similar reasoning, great corporate managers—and even great line management supervisors—might be as much a product of the culture of their groups and corporations as the groups and corporations are products of their excellence. It is the patterns and the culture that lead an organization to excellence; the manager is the figurehead, mouthpiece, or icon that serves as the catalyst for the process towards excellence. (This same reasoning has sobering repercussions for common American interpretations of COMPENSATE SUCCESS (4.2.25).)

Therefore, we feel that the best thing a manager can do is to lead a culture where it wants to go. It is true that this role wields a great deal of power in shaping the organization, and helping both individuals and the organization be effective. They can instill vision, they can sponsor the organization, and they can protect the organization from distractions. Although their contributions are indirect, they can be sizeable.

Many of our patterns are best applied by managers. This should come as no surprise, since the creation, care and feeding of organizations tends to be responsibilities of management. Even those applied by individual developers are usually influenced in some way by nearby manager roles.

Managers can use some of our patterns by themselves, or *on* themselves. For example, managers should protect developers from distractions by becoming FIRE WALLS (4.2.9). They might be an advocate of the group and the project as a PATRON ROLE (4.2.15). They can mold roles in their organization with OWNER PER DELIVERABLE (10.5.19), TEAM PER TASK (4.1.21), and SIZE THE ORGANIZATION (4.2.2). To a certain extent, they may be able to effectively COMPENSATE SUCCESS (4.2.25), although some reward policies are dictated from stratospheric levels in the corporation.

Note that most of these activities can be viewed as keeping the organization in its own element, focused on what makes it good, rather than as activities that attempt to bring good or guidance to the organization. That is a guiding principle in these patterns. A corollary for managers is that a great manager probably cannot save a dysfunctional culture, but a poor manager might be able to keep an otherwise viable culture from thriving. We view these patterns as tools that help the manager help the organization to find its way, at the system level, partly by moving the manager away from practices that would stunt organizational growth.

Managers can nurture such critical roles as MATRON ROLE (4.2.18), PUBLIC CHARACTER (4.2.17), LEGEND ROLE (4.2.20), and WISE FOOL (4.2.21), which are outside their own sphere. They cannot force these or other patterns to be adopted by the team, but they might encourage it. Often, a team is primed to make a change and just needs a light to show the way to what then becomes obvious to the team, and one might argue that if major changes aren't already in the soul of the organization, they can't happen, anyhow. Dick Gabriel made copies of an early copy of the patterns in this book and left them by the printer. He encouraged the team to pick them up and read them, and they did so. Then they applied the patterns themselves; Dick didn't (and couldn't) force-feed the patterns to the group.

One key idea is that managers realize the limitations of their influence—exercise that influence when appropriate, but don't try to do more than is possible. We might remember the example of Oscar Hammerstein, collaborator with Richard Rodgers on many Broadway musicals. Once when a friend asked Hammerstein what it was like to work with Rodgers, he said, "I just hand him a lyric and jump out of the way." [Linkletter1968] An internal AT&T management publication once featured a cartoon with a manager standing at the podium of an orchestra, clearly having been called to do something above his station and outside his experience, where we find he has opened the score to find the words: "Wave the baton until the music stops, and turn around and bow."

CHAPTER 7 Anthropological Foundations

Software development *cultures* have *culture*. In fact, most organizations have cultures and styles they can call their own. Yet we can talk about software cultures that map onto technologies or industry segments and which cross organizational, corporate and national boundaries, and we dare even speak of a “software development culture” at the highest level.

Too often, computer people use their own tools—processes, tasks, functions—to describe the structure and practices of their organizations. Since we followed cultural leadings in writing this book, we thought it would be good to build on insights and foundations from anthropology, the formal world of the study of culture.

There is certainly much more work that can be done in this area, and some anthropologists are pursuing study of such organizations (for example, [Brajkovich1994]). There are broad cultural findings that might be turned into relevant insights. For example, we find that most of the patterns we have discovered have a strong element of polychronic culture in them: cultures that value personal relationships over objects, and which value broad social networks over punctuality. That seems paradoxical in a world of introverted engineers working toward deadlines and schedules; the contrast is striking. Anthropological tools can highlight and perhaps explain these contrasts in ways that prior models cannot, and should not.

We look at a few interesting aspects of culture and anthropological foundations in the next few sections. We also look at closely related patterns in other contemporary pattern languages. These sections are supplementary to understanding and applying the patterns, but they offer interesting historical context.

7.1 Patterns In Anthropology

Most software designers ascribe the origins of the contemporary pattern discipline to the building architect Christopher Alexander, whose works (e.g., [Alexander1977], [Alexander1979]) are often cited as the inspiration for software patterns. However, patterns have broader and much older roots than Alexander's work, finding expression in mathematics and the natural sciences. One of the most interesting, and certainly most relevant to our interests here, is the work on anthropological patterns by early anthropologists like A. L. Kroeber [Kroeber1948].

Kroeber writes:

> Patterns are those arrangements or systems of internal relationship which give to any culture its coherence or plan, and keep it from being a mere accumulation of random bits. They are therefore of primary importance. ([Kroeber1948], p. 119)

He talks about several levels of patterns. *Universal patterns* are those that fit a general culture scheme that more or less fits all cultures. *Systemic patterns* talk about broad but more normative groupings around collections of beliefs, behaviors, alphabets, or economics Of systemic patterns, Kroeber writes:

> A second kind of pattern consists of a system or complex of cultural material that has proved its utility as a system and therefore tends to cohere and persist as a unit; it is modifiable only with difficulty as to its underlying plan. Any one such systemic pattern is limited primarily to one aspect of culture, such as subsistence, religion, or economics; but it is not limited areally, or to one particular culture; it can be diffused

> cross-culturally, from one people to another. . . . What distinguishes these systemic patterns of culture—or well-patterned systems, as they might also be called—is a specific interrelation of their component parts, a nexus that holds them together strongly, and tends to preserve the basic plan... As a result of the persistence of these systemic patterns, their significance becomes most evident on a historical view. ([Kroeber1948], pp. 120-121)

This description is of course reminiscent of pattern languages: descriptions of systems, or "wholes", that grow piecemeal from tightly knit patterns. In this book, each pattern is part of a pattern language, a systemic pattern that is part of some whole. It is the whole and the interweaving of individual patterns that corresponds to culture—not just a loose collection of individual patterns.

Our everyday vernacular use of the word "culture" most closely corresponds to what Kroeber calls *total culture patterns* that give a culture its identity, and to *styles* that reflect further localization and specialization. Total culture patterns might be what distinguish C++ developers from Smalltalk developers — not only from the perspective of language, but from consideration of the normative behaviors, beliefs, and practices that relate to the languages and environments of these languages and their associated technologies. Kroeber talks in particular of how style changes over time (for example, clothing style).

Patterns also figure strongly in isolated examples of more contemporary organizational literature. Senge talks about *patterns of organization* in Chapter 6 of [Senge1990]. There are other examples in more obscure literature as well. Our point here is that patterns are not just about software or even building architecture, but have deeper and perhaps even more suitable roots in the human sciences. That is the approach we have followed in this book: not just to capture ideas in pattern clothing, but to apply the systems principles of the human sciences to express the structure and practices of a culture that has been the topic of our study and experience, that of software development organizations.

7.2 Beyond Process To Structure And Values

A good organization isn't just about process, at least not in the sense that the term is used in ISO 9000 series organizational work. Process emerges from *structure*, and structure from values.

Swieringa and Wierdsma are systems thinkers who describe several types of organizations [SwieringaWierdsma1992]. They describe organizations as organisms that exhibit certain behaviors, driven by principles, insights, and rules, with the goal of producing certain results. *Organizational learning* shows up as a change in behavior. There are three kinds of learning: single-loop, double-loop, and triple-loop learning.

In single loop learning, collective learning causes the rules to change ([SwieringaWierdsma1992], p. 37). They note that "[m]any of the measures applied in industry to improve quality, service and customer relationships take place at the level of single loop learning." But they note that it is a surface effect: "No significant changes take place in the strategy, the structure, the culture or the systems of the organization." It is a question of changing the *how*, but hardly ever the *why*. There is a hope to improve, largely by doing more of the same, but doing it better.

In double-loop learning, the focus is on *learning at the level of insight*. Now the focus moves to *why*, on knowledge and understanding rather than just "improving." They also call this *renewal learning* since it relates to a renewal of insights in the organization.

Last is triple-loop learning, which is about the organization's *identity*, which they call *organizational development*. It asks: what kind of business do we want to be? It asks: what are our values and principles?

All of these modes can be beneficial. The deeper one goes into learning, the longer it takes (single loop can take place over days, double loop over months, triple loop over years.) Whereas single loop is about process and reaction, the other levels deal with the structure of the organization and with learning how to learn.

Learning is a process, and one must learn how to learn. The patterns in this book are learning tools, and moving from pattern to pattern is a learning experience. Most of the patterns tend to be double-loop. At the core of this learning process is the Fundamental Process of Piecemeal Growth (6.2). This focus on organizational learning distinguishes organizational patterns from other organizations such as Extreme Programming [Beck1999] which, though rooted in principles, imposes the principles from without instead of from within the organization. And it offers no process for “learning” one’s way to success, supposing instead that the incorporation of all of the principles and practices (in some unspecified order over some unspecified amount of time) can lead to success. Patterns put the organization and its members, and their collective talents, insights and intelligence, at the center of the learning process.

7.2.1 The Shortcomings of Process

Many traditional approaches to software productivity have focused on *processes*; what steps are taken, and how they are executed. Indeed, the implication is that if the process is followed, then the software will be high quality, and will be developed efficiently. Let’s examine this premise in more detail.

If following the process produces high quality software, then what is the cause of failures in the software? It must be either that the process is not being followed, or that the process is deficient somewhere; the process missed something. If you think this is far-fetched, think again: one of the authors once attended a briefing session for an upcoming ISO 9001 audit. The leader stated that everyone should remember that the person was not being audited, but rather the process and compliance to it. This statement was given to reassure people, and it probably did provide comfort—temporarily. For after all, if processes can be tweaked to handle every eventuality, then developers stand in grave danger of being replaced by programming robots.

But we all know that software developers are in no danger of being replaced by robots, because software design is such a highly creative activity, done by highly intelligent people. And this makes process much less relevant. In fact, highly intelligent people have been known to ignore or subvert the official process when it does not apply to them. Every organization has two processes: the official process, and the one actually followed. One of the authors once interviewed a group of key developers from several different projects. Although used processes that called for design documents and design reviews to precede coding, each one admitted that they completed the code first, and then wrote the design document and reviewed it — “so we can check off the design review box." They had found that for them, design documents were not relevant, and it was easier to write them once the design was instantiated in the code.

7.2.2 Structure

So if process has little impact on organizational effectiveness, what does? It turns out that the structure of the organization is more stable over time, and is a better indicator of effectiveness. This is the break between single-loop learning and higher order feedback loops. One reason for this is that the structure of an organization reflects its values, or principles, and values drive the organization. Some examples illustrate this.

Prior to the breakup of AT&T in 1984, the Bell System was a monopoly, and one of its core values was to provide telephone service to everyone, all the time, at a reasonable cost. This philosophy led to groups dedicated to extremely high availability hardware and software. On the other hand, because cost and speed were non-issues in a monopoly, organizations became bloated, and were not structured for speed.

In 1993, Borland was in the midst of developing QuattroPro for Windows (QPW). Risk taking, hard work, and individual closeness were important, even to the point that employees played jazz with Philippe Kahn, the president. Not surprisingly, the QPW team showed some of the tightest communication coupling we have ever seen.

Organizations that have a strong commitment to satisfaction of customers often have customer, surrogate customer, product support, and customer service roles that are tightly coupled to the rest of the organization. A thread that runs through all our patterns, and which is fundamental to the principles of the pattern languages presented here, is that the focus is on *product*. Neither the development processes, nor the internal documentation are delivered to the customer. The customer does not pay for elaborate project plans or architecture documents or, if they do, it is probably a sign that something is more deeply wrong than such measures can ever address. These patterns don't focus on the development of a process, nor do they advocate having a process organization. The patterns strive to manage the resources that go into internal documentation. The focus is always on product. A product has strong structural elements, and that structure reflects itself in the organization. Aligning these structural elements through good communication practices is what we believe offers the key to effective development.

7.2.3 Values: The Human Element

Heeding the communication problem implies attentiveness to human issues. While individuals sometimes stand out in history for their accomplishments, most great things are done in groups, teams, and societies, guided by cultural or societal norms. To the degree the group has a common goal, a common vision — a UNITY OF PURPOSE (4.2.12) — the organization can come together to do great things. This is perhaps the deepest hallmark of a great organization: it works as one mind, to some purpose: triple-loop learning. Perhaps the second deepest hallmark is the dedication and care with which they pursue this vision, including a dedication to learning and improvement.

Once in a great while, great minds think alike. But for the rest of us, it takes communication to align minds, motives, and methods to build an effective team. Communication is a complex human activity, filled with social context, psychological complexity, and emotion. So building a *communication* structure that supports the building of a *product* is also a complex activity. It requires a cultural setting conducive to effective communication. There is no guarantee that any set of guidelines can produce such an environment. However, these patterns can provide one foundation for an effective communication environment by defining a development culture suited to the needs of software development, taken from projects attentive to human needs. They also provide structures that can contribute to reduction in time to market, in solving the right problem, and in meeting other customer expectations. The patterns can contribute to a high(er) context culture where there are shared patterns, and therefore a shared vocabulary and shared culture, rather than a mechanical or bureaucratic environment full of rules that are either inhuman or arbitrary.

The focus explicitly is *not* on process. Process is a good tool in mature domains with predictable steps. In other domains, it's not clear what good process portends for product quality. A *flexible* process can reduce interval and contribute to good communication in a domain that must deal with change. But one can't just install a process; a process must emerge from the structures of communication and production beneath it. And the structures, in turn, are held in place by the values of the organization. Thus the values of an organization are the foundation of not only *what* is done, but *how* it is done.

Some organizations' values are rooted in making money. If such values are pervasive, the organization may have strong links to marketing or sales roles. Customer roles are likely to be present, but less central than customer satisfaction-oriented organizations.

Many organizations we see value management highly. Manager roles show up in the middle of organizational diagrams, sometimes even trumping the critical producer roles such as developer. When we probe, we often find that people are rewarded more for management than for development.

It shouldn't be surprising that most of our patterns have a strong, although not obvious impact on the values of the organization. They go beyond the superficial processes to get at the heart of an organization. Yet changes at this level do not come easily. It may take years, or perhaps a crisis, to shake the foundation of the organization—its values.

7.3 Roles And Communication

> *All the world's a stage, and all the men and women merely players: They have their exits and their entrances; And one man in his time plays many parts, His acts being seven ages.*
>
> — As You Like It, act 2, scene 7.

Within every organization, every person plays one or more roles. We have found that the roles people play are very significant: they are an important indicator of what *really* happens in the organization.

Why are roles so significant?

First, the roles define *what* is done in the organization. This is more important, and lasting, than *how* things are done, which is captured in the organization's processes. This *what* helps shape the organization's identity. It also illuminates the organization's values.

Second, people identify with roles. You may hear someone say, “I’m a developer,” or “I’m a tester.” They occasionally may change roles, but there is generally a great deal of stability among roles. People often carry roles from project to project; in that sense, roles are more stable than the projects themselves. It is through these roles that people use their creativity to develop software.

Third, communication flows among roles, thus information is linked to roles. Information flow is one of the biggest factors in an organization’s success — or failure.

We have learned much about organizations by examining their roles and communication among those roles. Presence or absence of certain roles tells a lot about the project. Occasionally we notice that a role is missing; this may indicate that the organization does not see that role as important. For example, a few organizations have not included “Customer” as a role. One wonders how responsive such organizations are to customer problems. Some organizations have no “Architect” role. And they probably feel that software architecture is unimportant.

Amount of communication, and to whom, among roles, is significant. A “Developer” role should be well connected to other roles. But a “Manager” role that is too well connected may indicate an overly meddlesome manager. A “System Test” role that has few connections to the rest of the project may spell trouble. It could even indicate that the development organization does not see the value is rigorous system testing — bigger trouble.

Communication among roles can form groups — cliques, if you will. Sometimes those are optimizations of communication, but other times they are tantamount to social cliques. And such cliques can be very damaging to the organization in a number of ways. We can gain clues as to which they are by examining the particular roles involved in the communication groups.

Many of the patterns in the patterns chapters describe the characteristics of roles. Some describe communication among roles. Each of these can be vital to the success of an organization.

7.4 Social Network Analysis

Once we identified the roles, we elaborated the relationships between roles using a group role-play exercise based on CRC cards [Beck1991]. We then built organizational models based on these data, drawing heavily on social network theory and social network analysis. Social network theory was first developed by Moreno [Moreno1934] to build models of the structure of interacting groups of people. We sought patterns across the models of numerous organizations, and that is the basis for the material in this book.

We presented an overview of the social network analysis techniques earlier in the book (How The Patterns Came To Us (Chapter 2)). In the following sections, starting with Distilling The Patterns (7.5), we describe our research methodology in more detail.

7.5 Distilling The Patterns

When we set out to write this book, we were determined to make a pattern language—not just a list of patterns. Why?

- An organization is a system. Most organization problems are system problems. Pattern languages are about systems; individual patterns don't rise to the system level
- Patterns *need* each other. No pattern stands alone, but must be tailored by smaller patterns. A pattern language is a structure that guides the reader through the patterns
- A pattern language implies choice. Users of a pattern language can choose patterns that fit their needs and can skip others. They can tailor patterns to their needs with confidence.

7.5.1 CRC- Cards And Roles

Sociometric modeling can be based on several varieties of network relationship data. These differences correspond to properties of formal graphs in graph theory. The relationships between roles can be labeled (e.g., with a number that indicates the strength of the interaction) or unlabeled, directed or undirected, and so forth. During the CRC interview, we collected only dichotomous network data: in other words, a relation either exists between two roles, or it doesn't. We take care to capture directed lines to support studies of information flow. A directed line is called an arc, and a graph of arcs is called a digraph. Participants annotate the arcs at the end of the interview, giving them strengths so they become valued arcs.

CRC cards had some unanticipated benefits as well. They can be used as a therapy session that helps an organization introspect about itself in real time. Our CRC sessions usually served as mirrors in which organizations could see themselves in a new light. As such, the data gathering technique itself played out the sociodrama and laid the seeds of group therapy.

CRC cards have some drawbacks as well, including groupthink, consistency, and granularity. Perhaps the most serious problem is the opportunity for groupthink: the tendency for a group to fall into modes of social conformity [Janis1971]. Most of the organizations we visited had a diverse collection of strong personalities that avoided many of the problems of self-censorship found in organizations dominated by groupthink. We avoided the problems of "mindguards" (those who protect the power holders in the organization from painful truths) by asking that the subject organizations not send process professionals from their organization, since they usually perform a policing function and frown on departures from stipulated practice. Most groups viewed the exercise as an opportunity to help their self-improvement efforts, and didn't seem to be blind-sided by illusions of invulnerability. We observed rationalization-based groupthink in some groups that participated in these studies because they perceived an allied group—such as the organization that created or managed their development process—as an "enemy". While we feel these factors would have affected our results if we were explicitly looking for process compliance, we don't feel that it affected our models of role relationships within these organizations. For more on groupthink, see [Janis1971].

The second problem is consistency. Each group has its own culture that colors the meaning of common role names: Is it fair to compare the "Developer" role in a start-up company to the role of the same name in a legacy organization? Is there a commonly understood meaning for "role" itself? Different organizations produce different products that solve problems of widely varying difficulty: Is it fair to compare otherwise similar teams if one produces aerospace software and the other produces biomedical engineering control software? Such problems plague most software studies; the number of control variables is large.

Granularity is another issue. A complete understanding of process incorporates roles, actors, artifacts, and other dimensions; we are focusing on roles. It is difficult to define a role formally (we “define” them in terms of their responsibilities). A given person may play several roles, and a given role may be played by more than one person. For example, one person might be both a Developer and a Tester, and of course several people may adopt the Developer role. The Pasteur tools (see SOCIAL NETWORK THEORY FOUNDATIONS (7.5.2)) has an option to combine selected roles, which helps us evaluate some actor-to-role mappings. The general problems of granularity and mapping remain research issues.

7.5.2 Social Network Theory Foundations

For those of you interested in the social network theory foundations and techniques for analyzing the data, we provide a short summary here.

We collected the CRC data in a database, and created an environment called Pasteur [CainCoplien1993] to analyze the data. The data were stored as a digraph representing a social network. Each node in the graph corresponds to an organizational role as characterized by a CRC card. Each arc in the graph corresponds to a collaboration between roles, starting from the role that initiates a collaboration and terminating on the “helping” role of the collaboration. Subjects in the organizational studies assign a weighting value to each arc to express how dependent one role is on the other with respect to the corresponding interaction.

Pasteur supports a variety of network data visualization techniques. The visualization techniques rely on graphical placement algorithms, each of which accentuates different organizational characteristics. The technique we used most often is a natural force-based placement technique. The technique employs a simple relaxation algorithm:

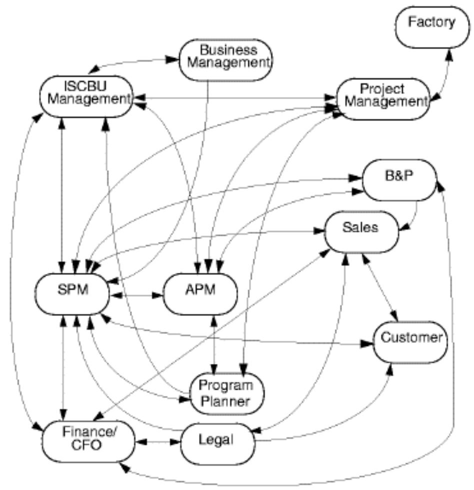
1. All nodes are assigned random coordinates on a segment of a plane.

2. A repelling force is set up between all pairs of nodes, following an inverse square law.
3. Arcs exert an attracting force between the nodes they connect; the stronger the interaction between a pair of nodes, the stronger the force.
4. The graph reaches a stable state when all the nodes migrate to positions where their forces balance.

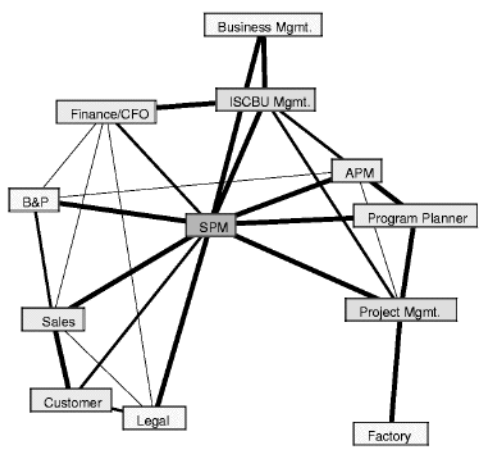
(The parallels to the use of the term "forces" in pattern parlance here is striking, and though unintentional, is certainly no coincidence.)

There are other fine points of the algorithm that avoid anomalous "cornering" of nodes that suffer an unfortunate initial placement. This algorithm creates a spatial representation of an organization's interaction graph in two-dimensional space (so far, we have not resorted to multi-dimensional scaling). Pasteur supports other placement algorithms as well, such as two-dimensional hierarchies (created by a topological sort that employs heuristic cycle-breaking techniques) and automatic graph partitioning around selected "seed" roles. The framework accommodates customized rendering techniques for individual experiments, using a rich programming environment based on the experimental languages GIL and Romana-I [Burrows1986].

Pasteur displays the graph on either an interactive graphical display or a color printer. Nodes are color-coded according to their intensity of interaction with neighboring nodes, relative to the organization as a whole. The graphical interface allows researchers to directly interact with the model. A user can interactively remove nodes or arcs, create annotations, merge graphs, or invoke any placement algorithm. While analytical techniques can be applied to sociometric data to discover cliques, cutsets, cutpoints, and the like, visual techniques offer the researcher quick intuitive insights into many facets of organizational structure at once. Social psychologists use a pictorial social network called a *sociogram*, a network analysis technique developed by Moreno in the 1930s [Moreno1934]. Like our visualizations, sociograms graphically depict network data. This is a sociogram as used in the social sciences:



Sociograms lack the spatial cues of the visualized placement algorithms. The placement techniques amplify the sociogram data, presenting it in a format where patterns can be directly observed by the organizational analyst. We call these diagrams *amplified sociograms* for that reason. The Pasteur social network visualizations depict interactions as simple lines rather than directed arcs, focusing on the coupling between roles rather than on the flow of information:

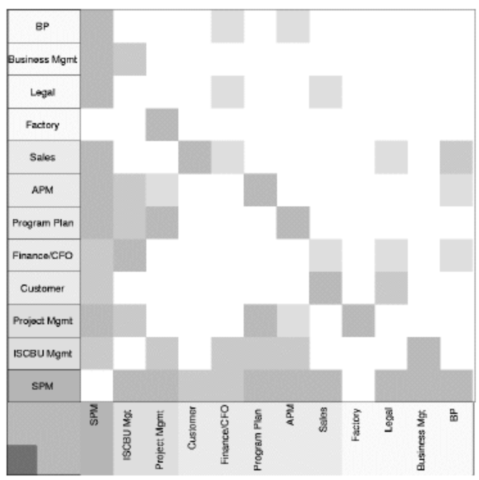


Few human interactions are truly directed, but usually involve “dialogue” or “meetings”: the Pasteur diagrams emphasize that aspect of organization structure. Whether the interactions are directed or not, they are a good depiction of the major highways of interaction between roles. One powerful way to interpret sociograms is as *work-flow diagrams.* Workflow models have been around for a long time as ways of studying a wide variety of processes. Workflow has recently resurfaced in the contextual design discipline as exemplified in the book *Contextual Design* by Beyer and Holtzblatt ([BeyerHoltzblatt1998], p. 92). Their workflow models are striking similar to the sociograms that we used. Their models are in fact based on several of the same principles and concepts that underly our work: individuals (which become *roles* in their “consolidated models”), responsibilities of the role, and flow (which for us are helping relationships). To these concepts they add five more: groups, artifacts, communication topic, places, and breakdowns. Our models took this aspects into account only informally. We commend *Contextual Design* to practitioners seeking a more extensive taxonomy of flow model properties than our roles and responsibilities alone provide. Workflow considers the same structures we examine in social network analysis. It is perhaps not a coincidence that *Contextual Design* claims that "[w]ork flow is the rich *pattern* [emphasis ours] of work as it shuttles between people, the interweaving of jobs and job responsibilities that gets the work done." (BeyerHoltzblatt1998], p. 91)

We also employ interaction grids, a technique inspired by the work of Church and Helfman at AT&T Bell Laboratories [ChurchHelfman1992]. Each of these diagrams is reminiscent of the structure of a sociomatrix: a square matrix whose columns are the roles that initiate collaborations, and whose rows are the roles receiving the collaborations. Here is a simple sociomatrix for the same organization as depicted in the sociogram above:

	SPM	ISCBU Mgmt	Project Mgmt	Customer	Finance/CFO	Program Plan	APM	Sales	Factory	Legal	Business Mgmt	B&P
B&P	3				1		1					
Business Mgmt	3	2										
Legal	3				1			1				
Factory			3									
Sales	3			3	1					1		2
APM	3	2	1			3						1
Program Plan	3	2	3				3					
Finance/CFO	2	3						1		1		1
Customer	2							3		3		
Project Mgmt	3	2				3	2		3			
ISCBU Mgmt	2		2		2	2	2				3	
SPM		3	3	2	2	3	3	3		3	3	3

Here is the corresponding interaction grid from the Pasteur tools:



The sociomatrix—and hence the interaction grid—has information that is isomorphic to that in the social network diagram. The sociomatrix and interaction grid communicate patterns of directed interactions, something that is present but difficult to read in sociograms, and which is missing entirely in the force-based network visualizations. Shading makes it easier to recognize patterns in the interaction grids than can be found in the numbers of the sociomatrix. The ordinate axis of the interaction grid enumerates roles that initiate interactions; the coordinate axis enumerates (the same) roles as they are the targets of interactions.

Visualizations are an intuitive presentation of more formal underlying concepts. We can analytically measure the centrality of an organization using several formal definitions. The centrality of the organization is often given as a number: let's say, 5.76. Which do you find more convincing: the number or the picture? Instead of explaining sociometric vocabulary to team members (particularly to managers), we appeal to their intuition and imagination with these organizational portraits.

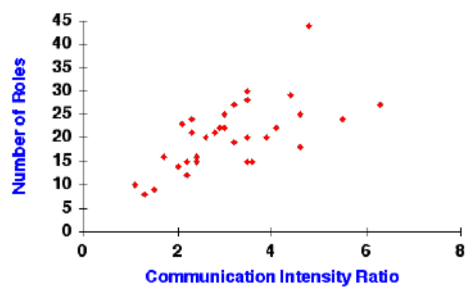
These visualizations support the second phase of introspection by the subject organizations: they are data that help the organization face and understand its problems. The location of key roles in the diagram usually confirms the development team's expectations or helps team members explain exceptional or problematic behavior. For example, one organization immediately noticed the remoteness of its architectural role in the social network diagram, and explained that was one of the reasons for the lack of product focus in the organization. A crucial point here is that an individual sociogram or interaction grid alone doesn't pinpoint organizational problems; it is a mirror in which team members can see themselves better, and thereby better understand their problems.

We collected pictures into a catalogue and categorized them. Following Gamma's [Gamma1992] studies of recurring, re-used patterns of code in software systems, we wanted to find the recurring patterns of communication in software organizations. One goal of the study was to collect and catalog typical recurring patterns from a wide spectrum of organizations: a social anthropology of software development. Such studies would form an empirical basis for models of contemporary software development as it really happens, as opposed to ideal models built from first principles.

We were particularly interested in finding the patterns peculiar to successful, productive organizations, to investigate whether any organizational "shapes" correlated to productivity or success. We quantified "successful" or "productive" only informally or through very coarse-grained metrics. For example: Like everyone else, we used thousands of non-commentary lines of code (KNCSL) per staff-month as raw productivity data, but we thought of these data in terms of metrics like $\log_{10}(\text{KNCSL})$ / staff-month. We also took note of remarkably short development intervals. Patterns did emerge over time; that is the bulk of what we present to you in this book. At about the same time, we started extracting sociometric parameters from the sociograms. These parameters include standard sociometric data such as graph density and graph centrality. Some of these data correlated well to productive organizations, and some of the data are interesting in their own right.

7.5.3 Scatterplots And Patterns

Many of the patterns in this book came from insights offered by a tool called Dot, a public domain tool authored by Steve North [is this true?]. We used scatterplots to find patterns in the data. For example, we could plot the Communication Intensity Ratio against the number of roles in the corresponding organization, against the number of communication links, against other sociometric quantities—anything and everything. We created dozens of these plots for many data sets and then looked at them to find patterns. Some scatterplots showed a roughly linear correlation, as in this plot of the number of roles as a function of Communication Intensity ratio:



Other plots showed polynomial trends; many others showed linear trends.

PART IV. Case Studies

The patterns in this book were drawn from empirical studies of about a hundred organizations in dozens of companies in several countries around the world. To bring the patterns more down to earth, this chapter looks at two actual case studies of organizations we have worked with.

The first organization is Borland Quattro Pro for Windows. Much has already been published in the literature about this study; we include the same information here for convenience and completeness.

The second organization is a project in Lucent Technologies called SNAP. It is probably the second most productive organization we have studied.

Yes, these case studies are old in terms of Internet years. But they reflect a culture of using timeless practices. We believe that today's organizations, a few years later, would demonstrate no major departures from the practices of these organizations if they were operating at these levels of effectiveness. Furthermore, the distance of time allows us to reflect on these organizations and their practices in the context of history, rather than in the heat of the moment. Such consideration bears out the conclusions and findings. Last, we continue to find similar configurations and practices in the few high-productivity organizations we work with in the years closer to the publication of this book (200 - 2003), and find that most organizations that follow these agile practices also enjoy a level of success far above average.

CHAPTER 8 *Borland Quattro Pro For Windows*

Adapted from an article in Dr. Dobb's Journal of Software Tools, written by Jim Coplien [Coplien1994].

8.1 Introduction To The QPWCase Study

> *Jim — Thanks again for speaking at BIC '93. I'm also glad you could stop by Borland and experience what we call Borland Software Craftsmanship. We are a young company, started by a Frenchman, with young bright and excited developers. In my 8 years at Borland I have been in the center of it all and can't imagine another place to be. — David Intersimone, Director of Developer Relations, Borland*

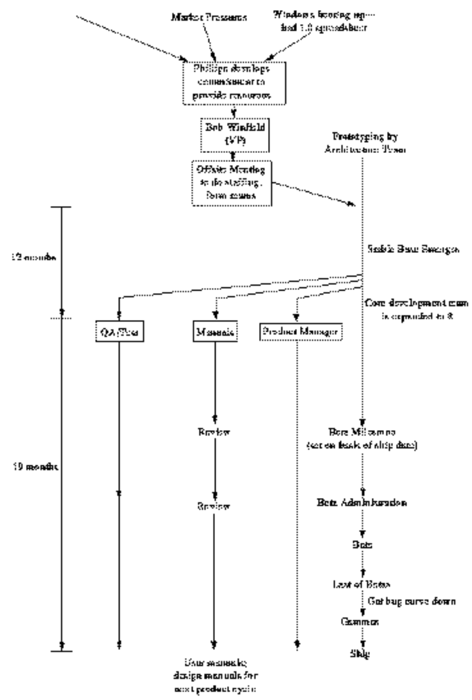
In 1993, Borland invited me to speak at the Fourth Annual Borland International conference in San Diego, California, and to visit their location in Scotts Valley, California. I made arrangements with David Intersimone, Director of Borland Developer Relations, to speak at the conference in exchange for access to one of their development organizations. Interviews with such development organizations have helped the process community better understand the high-level characteristics of software development organizations. We can use this understanding to help projects assess their development methods against those used in other development cultures. I was enthusiastically received and graciously hosted, a harbinger of other positive signs of the Borland culture that I would observe that day. I was treated to insights into one the most stunning development efforts I have had the pleasure to study.

In this chapter, I relate what I learned while meeting with the development team for Borland's Quattro Pro for Windows 1.0 (QPW) on May 20, 1993, in Scotts Valley. I feel there is much to be learned about their process, technology, and organization that we can apply to projects across the industry, including large projects and perhaps even embedded and real-time system developments such as we have in AT&T. This chapter is distilled from a paper published in Dr. Dobb's Journal in 1994 [Coplien1994]—before the organizational patterns were first published!

It is important to understand that this is a retrospective on the development of the software for the initial offering of QPW. There was little or no embedded base, and the project didn't face the constraints one finds in the legacy code projects common in large, traditional telecommunication projects. Even so, the phenomenal productivity of this group and the factors contributing to that productivity are thought-provoking. Most organizations should be able to take a page from Borland's book as a basis for their own process improvements.

This chapter starts with a high-level description of the project and describes the personalities in the development effort. Analyses of the data from our process analysis technique follow in the next section. Subsequent sections of the paper describe aspects of the QPW development that stood out as contributing to its success.

8.2 Origins And Description Of QPW



HIGH- LEVEL Business Flow of the Borland QPW Development

Borland launched development for QuattroPro for Windows as a natural follow-up to their DOS spreadsheet offering. QPW offers spreadsheet and database functionality in the spirit of most spreadsheet products on the market today. The team I interviewed created QPW 1.0, the so-called base generic development for the product.

The initial development was to be heavily loaded with features. The project goal was to produce a product with the maturity and feature richness of a third- or fourth-release product. The team felt they had achieved that goal when the product shipped.

Like most Borland products, QPW is designed to be a self-contained deliverable that is compatible with other members of a product family. Its human interface is consistent with other Borland products. Its database interfaces allow it to interwork with other Borland products. Borland views itself as a vendor of individual business solution components, from which a customer can select combinations to meet their needs. The total code volume of all Borland products, expressed as original source lines, is huge: tens, if not hundreds, of millions of lines of code (my estimate). Products are largely independent of each other, yet share common infrastructure and look-and-feel (and, conjecturally, the code providing this functionality).

QPW had a small core team—four people—who interacted intensely over two years to produce the bulk of the product. Prototyping was heavily used: Two major prototypes were built and discarded (the first in C; the second, called "pre-Crystal," in C++). Four core developers defined an architecture, built early prototypes and the foundation code for the product, and participated in implementation through its delivery. Additional programmers were added after about six months of intense effort by the core of four. This is experience was one of our initial substantiations for the pattern BUILD PROTOTYPES (4.1.7).

The methodology was iterative. Except for the architectural dialogue, the core developers worked independently. Early code can be viewed as a series of prototypes that led to architectural decisions, and drove the overall structure of the final system. This supports not only BUILD PROTOTYPES (4.1.7), but also patterns outside the language like Cockburn's EARLY AND REGULAR DELIVERY (10.5.11) [Cockburn1996].

The programming language was C++. The final implementation stages of QPW stressed their C++ compiler—which was being developed in parallel with QPW—to its limits. There was uncharacteristically tight coupling between the QPW group and the language group. QPW was one of the largest and earliest projects to stress their C++ compiler release. Cooperation between the two allowed each to contribute to the quality of the other.

After the product took shape (after about a year), additional roles were engaged in development activities. *QA* (quality assurance), testers, and others were at last allowed to see and exercise copies of the code that had been kept under wraps during early development. These roles had been staffed earlier, but engaged in development only when the developers felt they had something worthy of testing. This gave us foundations for patterns such as ENGAGE QUALITY ASSURANCE (4.2.29) and APPLICATION DESIGN IS BOUNDED BY TEST DESIGN (4.2.30).

While the *QA* organization conducts its own testing, there is an active beta program to uncover bugs as only real users can. This is a luxury that tool purveyors enjoy to a greater extent than most telecommunications companies can (and that we enjoy to a greater extent than some contractors in, say, the aerospace industry). Beta programs are a form of ENGAGE CUSTOMERS (4.2.6) and, specifically, of SURROGATE CUSTOMER (4.2.7). Beta customers are "surrogate" because they are not paying customers and aren't really in a position to *expect* any level of performance or quality.

The QPW product entered the market to high acclaim. *PC Source* s said, "Borland International Inc's Quattro Pro for Windows spreadsheet software package makes better use of the Windows graphical user interface (GUI) than any other spreadsheet package to date" [OMalley1993]. *PC User* says that "Borland International's Quattro Pro for Windows (QPW) is the world's best spreadsheet software" [Whitehorn1992]. *Computer Shopper* quips, "Borland International Inc's Quattro Pro for Windows spreadsheet software outperforms the standing champion of Windows spreadsheet management, Microsoft Corp's Excel 4.0" [Bonner1992]. *INFO WORLD* [Walkenbach1992], *PC Magazine* [Stinson1992], and many others also offer positive reviews, which dominate the press perspective on the product. I found other reviews that are more balanced, but uncovered no reviews that found the product lacking in key areas.

The team members I interviewed included:

- Charlie Anderson, the Director of Applications for Borland, who was one of the QPW architects. He is experienced and thoughtful, the apparent "spiritual leader" of the group, but only in a subtle sense.
- Weikuo Liaw, a renowned expert on spreadsheet engines and one of the QPW architects. Wei is a highly revered developer, almost to the point of inspiring awe, but rather shy and among the most introverted of the group.
- Murray Low, an energetic, darting, bright and witty engineer who worked on the QPW/UI side (user interface stuff) and who was a QPW architect.
- David Intersimone, Borland Developer Relations, who facilitated my appearance at Borland but who was not part of the QPW development.

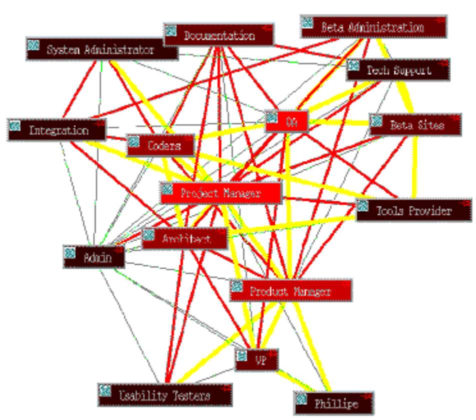
- Dan Horn, also from Developer Relations. He helped put me in touch with the Borland people while I was at the conference to make final arrangements.

From almost any perspective (except gender) we found this to be a diverse team, with variation in experience, chronological age, ethnicity, and domain expertise: both DIVERSE GROUPS (4.2.16) and HOLISTIC DIVERSITY (4.2.19). In particular, there was a very strong sense of DOMAIN EXPERTISE IN ROLES (4.2.22).

8.3 Analysis Of QPWData

We most frequently use a *natural force-based* network analysis to analyze organization data collected in the Pasteur data base. This analysis produced an *adjacency diagram*. In these diagrams, a default repelling force is established between each pair of roles. There is also an attracting force between pairs of roles that are coupled to each other by collaboration or mutual interest; a stable placement occurs when these forces balance.

Here is the picture that results by applying this analysis to QPW:



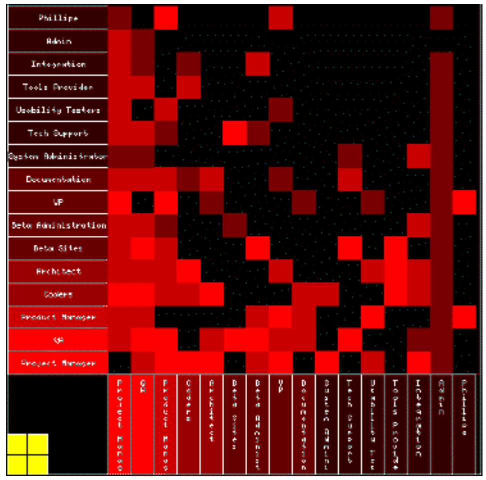
Each rectangle represents a role. Each role is colored proportional to how much it is coupled to the rest of the organization as a whole. Roles are connected with lines that indicate the strength of interaction between the respective roles. The thick, yellow lines indicate strong interaction; medium red lines are moderate interaction; and thin, green lines are the weakest interaction. Roles are grouped so that the ones that interact most closely with each other are closest to each other on the diagram, while those with the least mutual coupling are the furthest from each other in the diagram.

There are several things worth noting in these pictures that set them apart from most other organizational process models we've made. Here is a summary of those properties:

- *The QPW process has a higher communication saturation than 89% of the processes we've looked at.* The adjacency diagram shows that all roles have at least two strong connections to the organization as a whole. The project's interaction grid is dense. The coupling per role is in the highest 7% of all processes we have looked at. This is a small, intensely interactive organization. We find patterns like THREE TO SEVEN HELPERS PER ROLE (5.1.21), COUPLING DECREASES LATENCY (5.1.22), FEW ROLES (5.1.2) and PRODUCER ROLES (5.1.3) in this structure.
- *There is a more even distribution of effort across roles than in most other processes we've looked at.* The roles in the adjacency diagram are shaded according to their intensity of interaction with the rest of the organization. In the QPW process, *Project Manger* and *QA* glow brightly; *Coders* a little less so; *Architect*, *Product Manager*, and *Beta Sites* are "third magnitude stars"; and *Tech Support*, *Documentation*, and *VP* still show some illumination. Most "traditional" processes we've studied show a much higher concentration of interaction near the center of the process. That is, most other processes comprise more roles that are loosely coupled to the process than we find in QPW. That may be because QPW is self-contained, or because it is small. It may also be because the process was "intense": a high-energy development racing to hit an acceptable point on the market share curve. We see the patterns DISTRIBUTE WORK EVENLY (5.1.13) and FEW ROLES (5.1.2).
- *Project Manager and Product Manager are tightly coupled, central roles in the process.* These managerial roles were filled by individuals who were also key technical contributors to the project (they

wrote real code), which contributed to their acceptance and success as process hubs.

- *Product Manager* was a role that was employed only after a year of development.
- *Quality Assurance is a tightly coupled and central role.* Many organizations consider QA to be an external function, outside their organization and process. At Borland, QA becomes a way of life after development has converged on a good design and a stable user interface. For QPW, this was about 12 months into development. Again, this is ENGAGE QUALITY ASSURANCE (4.2.29).
- *The CEO (Philippe) figures strongly in the organization.* In a company of thousands of employees, it is unusual to find the CEO as tightly coupled to development as we find in QPW. It is instructive to examine the responsibilities associated with Philippe Kahn's role: Ensure product is commensurate with current market environment; ensure product market coordination is done in a timely and cost-effective manner; determine pricing, product positioning; shape public perceptions and handle PR for the product prior to and after ship; determine cosmetic changes to keep consistency among all Borland products and to call out certain features (in other words, usability testing); playing jazz to avoid press questioning on ship dates. This is a combination of PATRON ROLE (4.2.15), LEGEND ROLE (4.2.20) (Philippe Kahn was an icon of 1980s software culture), and FIRE WALLS (4.2.9).
- *The overall interaction grid pattern is uncharacteristic of what is found in other processes*:



Interaction grids show patterns of interactions in an organizations, and are particularly useful when the organization is large or when its interactions are dense. We most often use an interaction grid where roles are ordered on both axes by their degree of coupling to the organization as a whole. The most integral roles are placed near the origin. Most other processes exhibit a characteristic pattern of points along the axes, with lower point density and lower intensity for increasing distances from either axis. In QPW, there is a general lessening of density and intensity as one moves toward the northeast quadrant of the interaction grid. The northwest and southeast quadrants of the Borland grid remain more dense than we've seen in other processes. This is a combination of Distribute Work Evenly (5.1.13) and Responsibilities Engage (5.1.14).

Between 30% and half of the processes we've studied exhibit a pattern called *schismogenesis* ([Bateson1958]; see also The Open Closed Principle Of Teams (6.1.4)). To summarize, schismogenesis is a term from classic anthropological literature that describes a tendency for societies to stratify into sociological "comfort zones." This phenomenon appears in interaction grids as a clustering of points around the diagonal. For organizations where this phenomenon is present, the effect is particularly pronounced in the northeast quadrant of the interaction grid. It indicates that organizations contain splinter groups.

The QPW process is characteristically "anti-schismogenetic." That is, there is *blank space* around the diagonal of the interaction grid, particularly in the northeast quadrant. While we have seen graphs with random scatterings of points, the QPW graph is the first where the points seem to abhor the diagonal, yet fill out the rest of the graph.

8.4 Personal Excellence And Integrity

The initial QPW development team comprised highly productive professionals who viewed each other with the highest respect. These perhaps sound like hollow words that most managers would apply to their organizations, until one looks more deeply into what "highly productive" and "respect" mean.

The QPW development team has chronologically mature membership by industry standards. "We have professionals, not hired guns" noted one member of the development team. People are brought into the team for their recognized expertise in domains of central importance to the project: spreadsheet engines, graphics, databases, and so forth. No one is viewed as a warm body, or general engineer, or interchangeable employee: Each brings special talents to the effort: DOMAIN EXPERTISE IN ROLES (4.2.22). Implicit here is that developers were trusted to conduct their business: DEVELOPER CONTROLS PROCESS (4.1.17).

QPW had a small core team—four people—who interacted intensely over two years to produce the bulk of the product (ARCHITECTURE TEAM (5.2.4); ARCHITECT ALSO IMPLEMENTS (5.2.10)). Prototyping was heavily used: Two major prototypes were built and discarded (the first in C; the second, called "pre-Crystal," in C++). Additional programmers were added after six months or so of intense effort by the core of four (BUILD PROTOTYPES (4.1.7)). These prototypes drove architectural decisions that were discussed in frequent (almost daily) project meetings (STAND UP MEETING (5.2.7)). Based on feedback from these meetings, the team made architecture and implementation changes and reintegrated and tested before the next meeting—usually the next day. This cycle closely approximates the patterns surrounding PROGRAMMING EPISODE (4.1.19) and, in a broader sense, DEVELOPMENT EPISODE (4.1.15). A million lines of code were written over 31 months by about eight people: that's about 1000 lines per person per week. And that doesn't include the code in the prototypes.

The trust level is so high that developers felt code reviews are unnecessary. But while reviews are rare, group buy-in and trust are important. Each project member must *personally* sign off on a set of project delivery media before they can be released to the next stage (e.g., beta test or to the "street"). This is a strong sign of CODE OWNERSHIP (5.2.13) and OWNER PER DELIVERABLE (10.5.19); both of these were strong in the project, partly because of the high degree of specialization, and partly because of a high degree of personal pride in craftsmanship. Personal evaluation of the software, as well as informal dialogue, build the confidence for such a sign-off.

There is a complex and highly non-linear relationship between project productivity, programmer skill, and project organization. There will always be debate about how much of the phenomenal productivity of QPW owes to its culture, how much to its choice of staff, and how much to other factors.

8.5 Do One Thing And Do It Well

The phrase "Do one thing and do it well" is an admonition from C language expert Brian Kernighan about how to write good functions (and more recently from Arthur Riel's heuristic that each class should manage one key abstraction [Riel1996], in addition to what are doubtless many other parallels). Analogous advice is starting to appear for classes in object-oriented systems. And the same might apply to the people who write those classes.

QPW is organized along lines of domain specialization. Domains important to QPW are dependency registration software, human interfaces, databases, and a few others. An individual was identified for each of those domains.

In their domain, each individual does what they are good at. They excel at bringing their domain expertise to the table in architecture meetings. They know what the right abstractions are. They know how to implement those abstractions. They bring C++ or DOS or Windows proficiency to the project, or quickly develop it (through analogy to related domain experience).

Equally important is what these individuals are *not* good at, and that they are not expected to take responsibility for domains not related to their specialization. Instead of working *in* these domains, hey work *with* these domains. One good example is *documentation*. Developers are supported by a documentation organization that develops internal and external documentation. The time spent by developers in conveying this information to the documentation organization is far less than it would take for them to commit it to writing, put it into an acceptable format, and have the work edited for linguistic elegance.

By contrast, we knew that most of our AT&T developers wrote most of their own memos. It's not clear whether this owes to our history, our organizational boundaries, the nature of our business, or to reward mechanisms. Nevertheless, a deeply rooted cultural behavior at AT&T is that engineers draft their own memos. Developers spend much time (roughly 13% of total development time creating and refining memos in AT&T). In Borland, that job is deferred to people who are expert at it. (AT&T information from process researchers Larry Votta and Nancy Staudenmayer (MIT), 1993.)

8.6 A Piecemeal Architecture Process

QPW development was highly iterative. To understand the nature of the iteration, one must understand its ramifications for architecture and implementation. One must also understand the culture by which changes were approved and how decisions were made. This takes us into the realm of project meetings, always a topic of interest in a large development organization.

The core architecture team met daily to hammer out C++ class interfaces, to discuss overall algorithms and approaches, and to develop the basic underlying mechanisms on which the system would be built. These daily meetings were several hours in duration; from what I heard, *the project was made more of meetings than anything else*. Everyone's external interfaces were globally visible, and were globally discussed. The product *structure* was built on the domain expertise brought to the table by domain experts, but it was socialized and tempered by the needs of the product as a whole.

In spite of the intense meeting-oriented development culture the project built around its architectural development, class implementations were fleshed out in private. Individuals were trusted with doing a good job of implementation: after all, project members were acknowledged experts in their domains. Code reviews were rare. The trust and respect engendered by this domain expertise made it possible to focus meetings on system-level issues.

There are three project principles worth noting about the QPW organization's communication architecture:

1. *Meetings are not a bad thing.* While we all cringe at the thought of a project centered on a meeting that carries over from one day to the next throughout early development. But our fear of meetings likely comes more from our memories of the *ineffectiveness* of our meetings, not from their *frequency*. At the First International Workshop on Software Process, I polled several process luminaries with the following question: Suppose I am among the most mature software organizations in the world (a CMM Level 5). [Humphrey1992]. How much of my time do I spend in meetings? Responses from Vic Basilli, Watts Humphrey, and Barry Boehm ranged from 30% to 50%. Project communication, a shared vision, and meetings are important and productive if meetings are properly conducted.
2. *Development takes place on two levels: architecture and implementation.* There is an architectural thread, and a development thread; both are ongoing, and they interact with each other strongly. New implementations suggest architectural changes, and these are discussed at the daily meetings. Architectural changes usually require radical changes to the implementation. The implementors' ability to quickly reflect those changes in their implementation is key to turning around architectural changes quickly; this is due in large part to ARCHITECT ALSO IMPLEMENTS (5.2.10). This is where the outstanding productivity of the project members comes into play: Their incredible productivity supports iterative development. There may be a third development thread—product management and marketing—that goes beyond the scope of this inquiry.
3. *The development interaction style is a good match for the implementation technology the group had selected.* Object-oriented development

> leads to abstractions whose identity and structure are largely consistent across analysis, design and implementation. Classes hide implementations and localized design decisions, though their external interfaces are globally visible. Mapping C++ classes and people close together made it possible for developers to reason about the implementation off-line, away from the meetings that dealt with interface issues.

Notice this is contrary to the commonly presumed model that the object paradigm makes it possible for an individual to own a class, interface and all, with a minimum of interaction with other class owners in the organization. It should be emphasized that classes are good at hiding implementation and detailed structure (e.g., in derived classes) but that they are *not* good at reducing the ripple effect of interface changes. In fact, because interactions in object-oriented systems form an intricate graph, and interactions in structured procedural systems usually form a tree, the ripple effect of interface changes in an OO system can be worse than in a block-structured procedural design.

A question frequently posed to organizations using iterative techniques is: "How do you mark progress or do scheduling?" For QPW, there are two parts to the answer. First, they relied on experience sizing similar jobs, and found the overall estimates to be satisfactory. Second, they kept multiple sets of books internal to Borland to achieve different goals. The hardest of the dates was owned by (and not divulged by) the parts of Borland that own the financial books. A "real" street date was needed so the company could provide planning and resource support to the development. But *internal* scheduling provided incentive, focus, and pressure for development to move ahead. Project management and corporate executives presented deadlines to the development teams that failed to telegraph the business view of the schedule, presenting a more compressed schedule for development than the business case allowed for. You see this approach reflected in the SIZE THE SCHEDULE (4.1.2) pattern.

8.7 Personality And Development

Thomas Allen at MIT has noted the correlation between effective communication skills and prospects for advancement and success in technical organizations. [Allen1977] Individuals exhibiting extraordinary communications skills, and exercising those skills outside their line organization, he refers to as *gatekeepers* (see GATE KEEPER (4.2.10)). They "control"—or, more accurately, facilitate—the flow of information between the development organization and scholastic and competitive sources.

One might expect a team of developers of a highly successful product such as QPW to follow this model. My observations of the QPW team were brief, but I was left with the impression that their personalities run contrary to this stereotype. "Nerds" would be a more apt characterization. However, individuals were able to communicate intensely with each other as a group, with intense stereotypical male-style communication dynamics. Only David Intersimone—an outsider—took the role of posing pointed questions to the group (probably to make sure certain points were clear to me).

While it is unclear exactly what their communication behavior would portend for success in a more structured setting, their technical prowess has earned them the highest positions of esteem at Borland. Perhaps one needs to bring Allen's models into question, at least as they apply to small, inbred developments (most of Allen's organizations were large, government or military contract projects).

One might consider evolutions of the AT&T development culture where such technical expertise could be a better harbinger of advancement. Different AT&T organizations have emphasized different professional qualities at different times as criteria for supervisory promotion: technical ability, coordination and interworking skills, administrative skills, and so forth. There is a common perception that in our current business environment, technical skills don't dominate considerations for reward or advancement to the same extent that they did in the heyday of academia in the 1960s and 1970s. They are clearly key to success in the Borland value system.

8.8 No Wine Before Its Time

QPW used iteration from early in its development cycle through the latest stages of development, increasing the stability of their software and decreasing iteration over time. This iteration took place in what might be described as a traditional corporate context. From its outset, QPW was a strategic, visible product in the company. That meant that all development areas were primed for its deployment, including quality assurance, documentation, and product management.

Though these areas were staffed from the outset, they were denied access to the details of the product until about a year into its development. That gave the architect/developers room to change the functionality, interface, and methodology of the project before interfacing it with the corporate culture and ultimately with the "street." Quality Assurance, Product Management, and documentation were allowed access to the project only after it had "conceptually congealed," about a year into the development schedule.

8.9 Create Rather Than Conform

Even though Microsoft's Excel may have been a significant market motivator to start the QPW program, QPW developers paid it little heed during the design of their code and human interfaces. Functionality and interface were derived from first principles (project members were strongly conversant in spreadsheet issues) and from consideration for compatibility with other Borland interfaces.

One major distinction between QPW, and most of the work done in large telecommunications projects we studied at AT&T, is that QPW wasn't working to a customer requirements document. They simply knew what needed to be done. This owes to DOMAIN EXPERTISE IN ROLES (4.2.22) and can be viewed as a special kind of SURROGATE CUSTOMER (4.2.7).

8.10 California Gold Rush?

One cannot ignore the motivating power of bonuses that are of the same order of magnitude as annual compensation. While much of corporate America is turning more and more to "egalitarian" compensation structures, other companies strive to tie personal financial rewards tangibly to the market success of the fruits of an individual's labor. The stereotype may actually be true that bonuses and rewards for jobs well done are higher west of the Rockies than elsewhere.

While I did not explore this with the Borland crowd, one might imagine that the west coast bonus stereotype extended to the QPW culture. The prospects for such rewards may make it easier for individuals to justify the energy and commitment they must commit to a high-intensity development for it to succeed.

See additional thoughts about this in COMPENSATE SUCCESS (4.2.25).

8.11 *Introspection By The Team*

Can an organization without an explicit, conscious process effort enjoy the same process benefits as an organization with full process certification? Though there may be a tendency for certified organizations to experience stronger process benefits than those lacking any formal concern for process, this Borland project had many of the hallmarks of a mature development organization.

Borland is not subject to the ISO 9000 series process standards, has no concept of its SEI CMM rating, and is not conversant with the software development process lingo being used increasingly in large software organizations. For someone interested in process to visit them was a rare event. Before going through the CRC card exercise, my presence as a process guru was viewed with a range of responses that ranged from intrigued interest, through curiosity, to suspicious doubt. By the time the exercise ended, those involved were able to identify some parts of their value system and culture with what we call process. (By the way, the doubters went away saying, “You know, I think you’ve got something there.”)

So even though the organization has no codified system of process, it is keenly aware of what it does, how it does it, and what works. It views software development as something fundamentally driven by special cases (at least for initial generic development) and repeatability is not an important part of their value system. Members of the organization were nonetheless able to articulate in great detail aspects of their process that demonstrated to my satisfaction that they shared a single model, perhaps based on development rules, of how development should be done.

Many organizations we have interviewed have a weak or confused notion of what their roles are, what the responsibilities of the roles are, and how the roles interact. Most AT&T organizations with a weak notion of process are those who have not gone through an ISO audit, yet developers' notions of their roles even in some ISO-certified organizations are fuzzy at best. Other organizations that do not have any conscious process culture are nonetheless able to articulate their process in explicit terms, at a level of abstraction that transcends technology, tools, or methodology (UNITY OF PURPOSE (4.2.12)). In our other studies, we found that this consistency correlated to organizational health.

Borland's QPW development was one such organization. When I asked what their development roles were (with a short definition of what I meant by role) the answers were immediate, intuitive, and reflected a single model of the organization shared by its members. Team members required little thought to come up with roles. Few roles were added during the role-playing exercise, and only one role was substantially redefined. The organization knew itself well, and was conscious of how people interacted with each other at an abstract level.

In his book, Gerry Weinberg suggests that there is a paradigm shift between Level 2 and Level 3 of the SEI Capability Maturity Model (CMM) [Weinberg1991]. He believes that organizations at Levels 1 and 2 need strong (managerial) direction, while organizations at level 3 and above are self-directing. Borland clearly appears to be in this latter category—though it may not register a Level 3 rating according to commonly accepted criteria.

Charlie Anderson entertained us with a thoughtful monologue on how the project felt about itself and its accomplishments. "We are satisfied by doing real work," he noted as he thought about how the project dovetailed daily architectural meetings with implementation. They learned how to improve the structure of their product, and how to improve their process, as they went through development. "Software is like a plant that grows," he mused. You can't predict its exact shape, or how big it will grow; you can control its growth only to a limited degree. In the same vein, "There are no rules for this kind of thing—it's never been done before." In retrospect, though, he notes that there are a few things that every project should have. At the top of his list was that every project should have a good documentation department. This sounded intriguing to me (as it wouldn't have been first on my list) but I didn't get a chance to follow it up with Charlie (but see DO ONE THING AND DO IT WELL (8.5) above). This, of course, is

Mercenary Analyst (4.1.24) — and, as we'll discuss below, it is arguably a strong foundation for the Borland success.

8.12 Process And Quality

One widely-held stereotype of companies that build PC products (or of California-based companies) is that they hire "hackers" and that their software is magic, unreadable spaghetti. Meeting with this group broke that stereotype for me. Their constant attention to architectural issues (Architect Controls Product (5.2.3), Organization Follows Architecture), their efforts to build an evolvable structure, their care to document the system well (both externally and internally: Mercenary Analyst (4.1.24)), are all hallmarks of the highest professionalism. Those attitudes, coupled with the phenomenal *general-purpose* programming talents of the staff, plus the high level of *domain-specific* expertise (Domain Expertise In Roles (4.2.22)), defined the kind of quality value system necessary to an effective and productive process. There were few gratuitous shortcuts and few novice errors. From what I saw, these people produce *very* high quality code.

If there was any disappointment on the project, it was in their inability to bring down the bug curve in the project end game as fast as they wanted to. They noted that the shapes of software development bug curves are well-known, so there is hope of predicting how long it will take to ferret out an acceptable fraction of the remaining errors. However, the boundary conditions for the curve aren't known at the outset, so it is difficult to predict the exact shape of the curve until developing experience with bug discovery and resolution. Inability to predict the exact shape of this curve resulted in a modest schedule slip (Size The Schedule (4.1.2); Development Episode (4.1.15)).

Other questions about the project can be answered only over time. The process described here was for initial product development. Can a similar process be used for ongoing maintenance? Probably not, though vestiges of the original process will certainly live on. How will maintenance affect productivity? Can the dual-line development continue to support architectural change with rapid alignment of the corresponding implementation? Initial experience is good; the first round of QPW changes earned it a *PC Magazine* Editor's Choice award [PCMag1994]. The editors were astounded by the amount of functionality that had been added so quickly. Maintenance questions will become increasingly important to Borland, as we already recognize them as crucial in telecommunications systems with long service lifetimes.

8.13 Concluding Thoughts About QPW

Many other patterns came out of our understanding of the QPW project. The project got a start even while the compiler was not finished; this is an example of GET ON WITH IT (4.1.3). NAMED STABLE BASES (4.1.4) reflects the daily builds the project did to incrementally add functionality. They had WORK FLOWS INWARD (4.1.18), particularly during testing: information came in from beta users through the Help Desk to the development team. The team was strongly supported by management and other support functions during the earlier periods as well. We find SACRIFICE ONE PERSON (4.1.22) in many instances, the most graphic of which is Philippe Kahn's interactions with the press and market; he also acted as a FIRE WALL and PATRON ROLE (4.2.15) in this capacity.

This was a SELF SELECTING TEAM (4.2.11) with strong UNITY OF PURPOSE (4.2.12). It operated much as a SKUNK WORKS (4.2.14): small and isolated, though strategically its focus was much shorter term.

The team had a very low "truck number" (see MODERATE TRUCK NUMBER (4.2.24)), however, because of the high specialization. But there was very strong commitment to the project and good communications that suggest that there may have been more cross-fertilization than we could see. While architects (and other roles) maintained their specialization, they also maintained an uncharacteristically high level of communication among themselves. This balance is rare in organizations and we have found it only in the strongest, "hyperproductive" organizations. We originally captured this structure in a pattern called BUFFALO MOUNTAIN [Coplien1995] that was later split into RESPONSIBILITIES ENGAGE (5.1.14) and HALLWAY CHATTER (5.1.15). Communication was the glue that held this organization together.

Can we capture the architecture of the Borland development organization and process, and expect phenomenal results if we apply it to large development projects such as we have at AT&T? Probably not. However, its staggering productivity offers a target to shoot for, and some aspects of its management policies and process guidelines may serve small- to medium-sized developments well. To the extent large jobs can be partitioned into small ones, the Borland approach may be suitable for individual parts of large developments.

Borland develops products for a domain and market which, today, has little overlap with the traditional telecommunications market. As large software development organizations move into new markets—such as software development environment platforms and soft human interfaces—the techniques used at Borland will become increasingly difficult to dismiss out-of-hand as irrelevant for large system development.

The software industry has long embraced rationales that dismiss the productivity of stereotypical “Silicon Valley” cultures. We tended to think of PC development efforts of that era as small and simple. We say they have limited markets and don’t need to evolve. Borland defies these stereotypes. The QPW product needed to move into a market supported by Windows, Windows / NT, Pink, and conjecturally others including Macintosh—and maybe even UNIX. It will need to interface to a host of different windowing systems and hardware technologies. It is not small, even by AT&T standards (it was larger than the first release of the flagship AT&T local switching product). Borland was able to coax 1 million lines of production code from about eight people in 31 months. Perhaps a PC-based development environment and PC-based deployment platform make developers more effective, and perhaps QPW doesn’t have the same fault-tolerance requirements one finds in large telecommunications systems. But those considerations alone don’t seem to account for figures that are orders of magnitude above industry norms.

Software maintenance is of critical important to today’s large, complex software developments. One suspects that the same will be true for QPW as it offers new features, runs on new platforms, and adapts itself to new operating systems and windowing environments in the market place. One might guess that foreseeing such evolution is one reason for Borland to have chosen object-oriented development techniques and C++ as the basis for their development.

The Borland process operates at an extreme point in our continuum of development organizations. Having a set of extreme data points can be of use to us in our process research, as it helps bound the models we make. We hope the Borland model will provide data that will help us

calibrate our process models, and help us better correlate properties of other models we study.

A great big thanks to Carol Johnson at Borland for taking care of most of the local arrangements. I'm indebted to Ruby Chu at AT&T for chasing down QPW product reviews. A special thanks to Doug McIlroy and Peter Weinberger for their critical comments.

CHAPTER 9

A Hyperproductive Telecommunications Development Team

This chapter is distilled from a paper prepared in the spring of 1994 shortly after Jim Coplien studied the team in question.

The exact identity of the team is withheld for two reasons. One relates to the propriety of information about the product at the time the study was done. But, furthermore, the team *asked* not to be identified. They were concerned at the time that if they were identified as having built a better mouse trap, that the world would beat a path to their door asking them for process advice. They didn't want to be in that business; they didn't want to be distracted from doing what they enjoyed doing. But other than omitting the name of the product, we've included many particulars of data that we hope will make the group more tangible, and that will answer questions about the viability of the group's approaches.

The report, as originally written follows:

I had the pleasure of meeting with the entire development team for a small network platform being built by a Network Systems organization in AT&T Bell Laboratories on February 17, 1994. This project is among the most interesting I have studied. The organization has some of the best team dynamics of any I have observed anywhere. The people find their work challenging, stimulating, and rewarding. This organization is likewise productive, with 200 KNCSL to their credit at the hands of six developers over 15 months. That interval includes conceptualization and design. That code count does **not** include a similar number of lines purchased externally or reused from existing internal projects.

Many of the tenets, practices, and characteristics of this project are eerily reminiscent of Borland's Quattro Pro for Windows (QPW) team, the most highly productive organization I have studied [Coplien1994]. he project is unique in many of its own ways, too—unique, perhaps, in the sense that the experience could not be easily reproduced elsewhere. Nonetheless, this project provides another data point in our study of hyperprogramming (very productive) organizations (for a current total of two such data points). We noted that the two organizations resemble each other in many ways, ways that perhaps portend high productivity and quality of work life. These factors are worth exploring.

Might their development process have something to do with all this? Contemporary management thinking holds process to be a dominant factor in quality and productivity. The organization's process and organization are indeed the source of their power, but the process is off the beaten path. Our research was attracted to the organization because of its emphasis on parallelism, taken almost to extremes, with astounding results.

9.1 The Culture

This organization has been around in one form or another for about 15 years. They have a long history of prototyping and building small systems. About four years ago, the organization started working on trials to prove in their product concepts. Development started in earnest about two years ago. The development team currently has about 8 people. Most (all but two at the debriefing) have families. The group is demographically diverse.

The project has an excellent history of meeting impossible delivery dates, owing to much hard work. The team typically works 50- to 60-hour weeks, some working 60- to 70-hour weeks over a five-month spurt. The team is egalitarian in the sense that everybody writes code, but is non-egalitarian in that everybody brings their own realm of expertise to the table (which is an important factor we explore later under "Code Ownership.")

People do much of their own risk management. As the meeting got started, Peter told how he was going to add line splitting to the architecture. That was going to make more work for Pat. Pat was playfully unhappy about the change, but it was a design change the team had decided some time ago that it had wanted. The project had been granted a one-month extension in its schedule, and Peter had taken the initiative to do a redesign of the part of the system that had been causing them to use resources inefficiently.

Parallelism is key to the organization's success. The organization got its start when presented with an ambitious scenario: Conceptualize and deliver a system prototype in four to five months. Almost coincidentally, the requirements, testing, and design all converged on the same date. It worked, and converged faster than anyone imagined possible. The small team size, the excellence in systems engineering, and lack of dogmatism among team members were major factors in the success of the prototype. The organization became more introspective about their concurrent engineering approach to development, and turned it into a way of life for themselves. The technique that made the prototype successful was carried into the development of the product itself. It is this way of life that I had come to study.

And the introspection isn't complete. There is still a feeling that part of what makes them successful is purely instinctive. Peter even worried that if I surfaced process understanding into their consciousness, that it would affect the way they worked—because it would establish a new introspection framework—and potentially damage the delicate balance of magic that propelled them to success. While there is a slight chance that the Heisenberg phenomenon could take them in that direction, there is equal or greater probability that such a discussion could open their eyes to possibility for improvements.

The programming language is C, the development environment is UNIX. (Note that they use neither object-oriented approaches nor C++, staples that have become stereotypically associated with high productivity and best current practices.) The product has performed well in the field. Three installations have been running for 7 months, with only 3 unplanned outages to their credit totaling less than 8 hours: better than 99.94% uptime. The total number of faults found in the field has been about 25, out of which 20 have been addressed at this writing.

The organization's culture, self-image, and process have a rich human element that precipitates from the small team environment. These issues merit their own section later in this chapter.

9.2 The Development Process

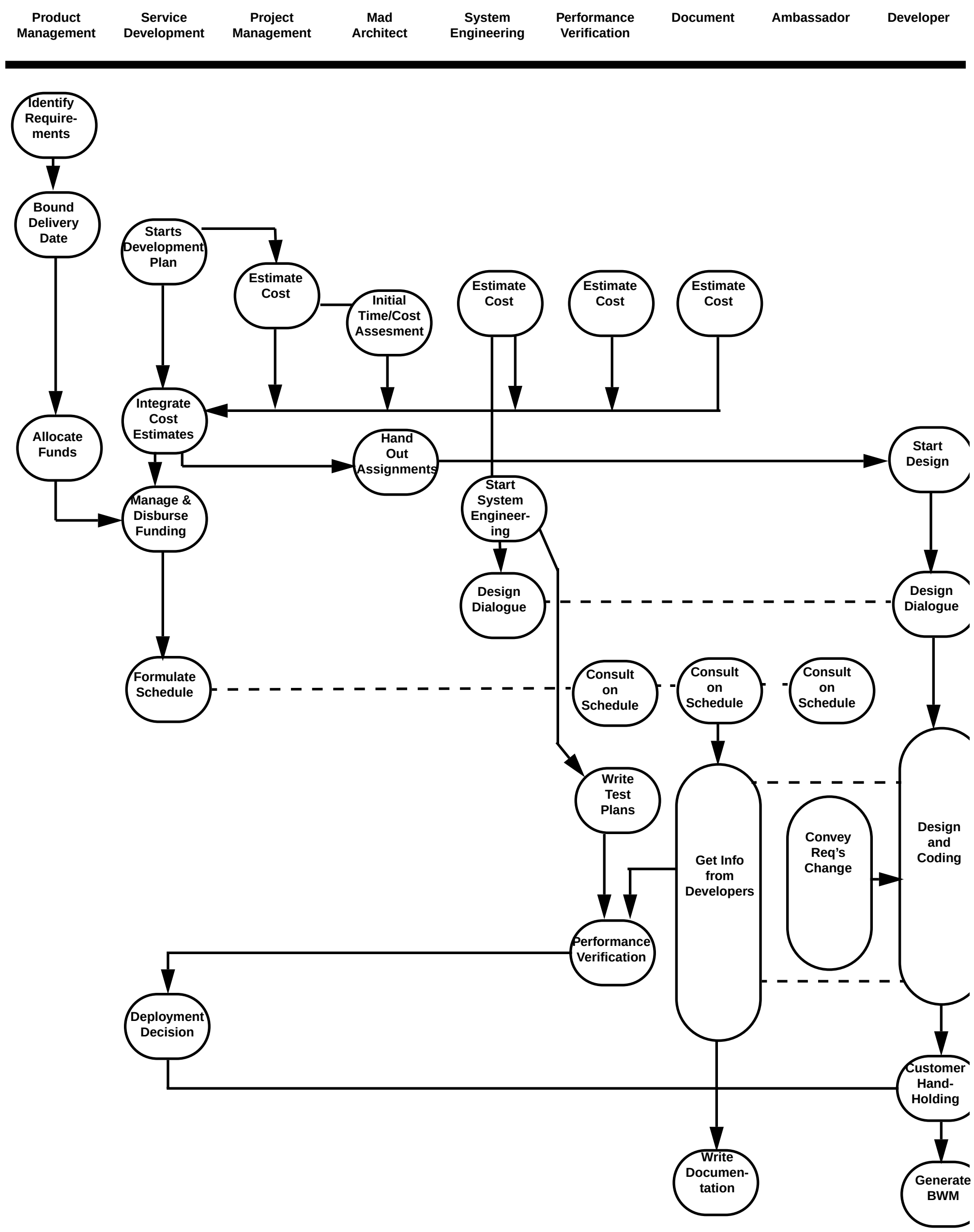

Product Management
Service Development
Project Management
Mad Architect
System Engineering
Performance Verification
Document
Ambassador
Developer
Identify Require-ments
Bound Delivery Date
Starts Development Plan
Estimate Cost
Initial Time/Cost Assesment
Estimate Cost
Estimate Cost
Estimate Cost
Integrate Cost Estimates
Allocate Funds
Hand Out Assignments
Start Design
Manage & Disburse Funding
Start System Engineer-ing
Design Dialogue
Design Dialogue
Formulate Schedule
Consult on Schedule
Consult on Schedule
Consult on Schedule
Write Test Plans
Get Info from Developers
Convey Req's Change
Design and Coding
Performance Verification
Deployment Decision
Customer Hand-Holding
Write Documen-tation
Generate BWM

Figure 1: RAD of the Process

Figure 1 shows a structured flowchart of the process, called a ROLE-ACTIVITY Diagram or RAD. The diagram misses many of the interesting interactions between people enacting the *Developer* role. It also misses the richness of interaction between the *Ambassador* and his 50 or so contacts external to the project. The *Ambassador*, like Allen's gatekeeper [Allen1977], handles most of the external project technical interfaces.

Parallelism can be seen throughout. Design might start before system engineering. Requirements continue to change and accumulate after coding has started, and sometimes after performance verification.

9.3 *The Pasteur Analysis Of The Process*

Figure 2: Adjacency Diagram (Natural FORCE- BASED Placement)

I analyzed the interview data using the Pasteur organizational analysis tools [CainCoplien1993]. Figure 2 shows the adjacency diagram, or force-based communication network diagram, for the development organization. The graph has two communication "hubs" at the *Developer* and *Ambassador* roles, respectively. We generate coupling metrics from the same model used to build the adjacency diagram. Coupling per role is 41%, about at the median but far above the mode and mean for all processes we have studied. It is about half the value of 89% for QPW.

There is an amazingly even distribution of work across the project. The *Mad Artichoke*, *Ambassador*, *Manager*, and *Service Development* roles all share the same degree of coupling to the process as a whole. *Hacker*, *Domain Experts*, *Service Management*, *Product Management* and *Performance Verification* are slightly less coupled. As we have found in most organizations, the *Developer* role is more tightly coupled to the process as a whole than any other single role.

It is rare that we find an organization with an architect, and rarer still that the architect occupies a central position. In this network platform development, the *Mad Artichoke* (architect) role is more coupled to the process as a whole than any role except *Developer*, which links *every* role in the communications model (This, again, is reminiscent of QPW.) Much of the communication burden that normally falls on the developer's shoulders is taken on by *Ambassador*, which is a secondary hub in the organization structure. This role fits Allen's description of the "gatekeeper" role exactly: again, reminiscent of QPW.

The centrality of the architect is reminiscent of QPW. In QPW, Quality Assurance was more central than we find in this organization.

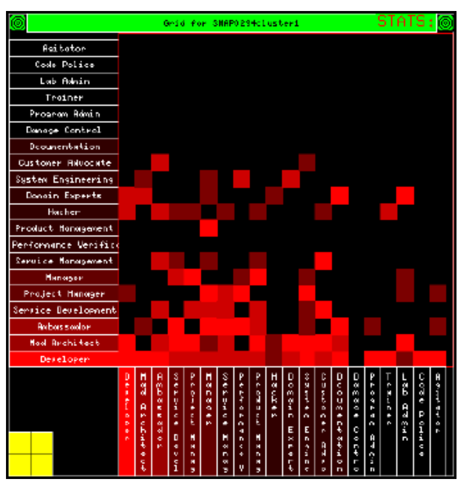


Figure 3: Interaction Grid

Figure 3 shows the interaction grid for the project. The picture is curiously asymmetric. The large blank space at the top occurs because roles outside the process are not approached to do work; they supply work, constraints, and input to the project. That anomaly aside, communication patterns are distributed evenly across the organization. Such an even spread of connectivity is rare in the processes we have studied, but it *was* a characteristic of the Borland QPW organization.

9.4 The Human Side

The process and culture have a richly human side. This shows up in how the group talks about itself, as well as in its organization and process. I explore three aspects of the human issue here. how people issues are integrated into the process, the anthropomorphizing of code, and management practices.

9.4.1 Engineering people issues into the process

The “high touch” flourish in this “high tech” environment became clear from the outset [Naisbitt1984]. People invented outrageous role names to describe themselves: *Mad Artichoke* for the architect; *Agitator; Code Police, Damage Control.*

The “person-ality” of the project goes deeper. Consider the perceived responsibilities of role *Agitator*:

- Keep team from getting too comfortable
- Trigger discussions
- Say things nobody wants to say

“Say things nobody wants to say”? Many conservative development organization cultures are loaded with “unmentionables” that plague progress by cutting off painful avenues of progress with taboos. In this organization, everything is open to criticism by anyone. As Steve Bauman (then a director at Bell Laboratories) once said, it is not “warm and fuzzy”; it is “open and productive.” This behavior can be found in patterns like WISE FOOL (4.2.21) and PUBLIC CHARACTER (4.2.17). The *Damage Control* role has the following responsibility: “Repair inter-organizational and inter-personal damage”.

The first-level manager plays a less authoritarian role in the process than in a typical corporate development setting. Most of his role is to provide support and to track project status, but "twisting arms" of people outside the team is also among his responsibilities. He sees his job as ensuring that the team has the best people possible, that they have the resources and time necessary to do a good job, and that outside interference and roadblocks are kept out of the developers' way. He also fills the *Damage Control* role.

9.4.2 Code Ownership and Programming Anthropomorphism

The project has strong code ownership that transcends release cycles. Everybody knows what everybody else is working on. Nobody changes anyone else's code, except in an emergency. If one programmer finds a bug in another's code, the person finding the bug asks the owner to make the change.

Code ownership creates an interesting project mentality that is difficult to codify, but which might be summed up in a wry comment from one developer: "We don't use ECMS or Sablime, [source management tools] so we need code ownership." Code ownership makes job responsibilities visible in the culture, rather than burying them in a tool.

Code ownership goes so deep that the project has anthropomorphized their software. Software anthropomorphizing is something taught in some analysis techniques, including the popular CRC technique for object-oriented analysis, [Beck1991] but this project takes this to an unparalleled extreme. During scenario walk-throughs, you don't hear them saying, "the X module sends this message to the Y module," but rather, "A message comes in from Dara and goes over to Roman" or something analogous. "Now, Peter kills Pat" describes a signal sent between processes. One can go by the lab at night, and hear a programmer scream "Oh, Peter! Why did you do this?" as "Peter's" code reaches out and creates some system atrocity that makes the tester's life difficult. The code is strongly identified with the individual owning it.

Responsibility is a deep underlying value in this project. Ownership exists for its own sake, but if you own something, and you make a change, you have responsibility for it. Code ownership and the associated culture raise everybody's awareness, expectation, and assurance that such responsibility will be carried forward. It seems more powerful than having a tool to track down a change to an accountable individual: there is a mind-set that transcends the need or such version management tools in a small project. This makes site support and FOA activities easier: when a problem is found in the field, it is usually clear who needs to be brought in to fix it.

Will the project need version management as it grows? Possibly, but the market is constrained enough that multi-featurism may not become a serious problem. If they can coordinate releases for all sites (the market is believed able to bear 11 systems) then versioning may never be needed.

9.4.3 Growing a Garden

After the group session, I stopped by to debrief the department head on my findings. She briefly described her management philosophy, which she likened to gardening. Her main job, however, is to "keep the pests away." That, she said, is what a good project manager should do as well. Curiously enough, the role we ended up calling "project manager," we were initially going to call "smoke screen," because it distanced the development community from surrounding organizations.

On the way out, I ran into a manager from another project who in an unrelated context talked about "controlling the people who sit in the bleachers and throw rocks." Insulation appears to be an important and successful management strategy in our culture.

9.4.4 Rewarding Excellence

Traditional rewards like money and promotions are in short supply—but that doesn't constrain the intrinsic motivators which can be equally direct and even more effective. People *enjoy* their work here. Their talents are appreciated and the people are respected as individuals. The people are *trusted*: they are given much latitude, much responsibility, and are trusted to talk directly to customers. The issue of trust was also central to the Borland QPW team.

Their department head had this to say:

> [M]uch of the reward is intangible...not something I as a manager give, but something I allow them to achieve. I give lots of personal attention to them mostly and try to create a fun, creative environment with challenging assignments. I try to personalize the whole set of interactions so that everyone thinks they are doing this to better ourselves and better our chances of getting more challenging, fun, creative work.

This approach is reminiscent of the "getting one's ticket punched" concept described in *Soul of a New Machine*, [Kidder1981] a mentality common to Silicon Valley companies as well. The close coupling between influential management (in this case, a widely respected department head) and their reports is also reminiscent of the Borland environment.

9.5 The Small Team Spirit

As was true for Borland's QPW, this product is developed by a small team. Small teams can achieve results that would be impossible in a traditional organization. It makes anthropomorphism feasible. It gives everyone a feeling of connectedness. It smooths communication, and in fact enables communication dynamics that may lie at the heart of concurrent engineering.

"I think I'm going to need this soon," Bryan yells down the hall to Dave about a module with changes that must be coordinated with Bryan's fixes. It's mid-morning, and he knows that before the morning is over, he'll need Dave's module so he can test his own work out. Dave knows that unless he stops what *he's* doing and turns to the module Bryan asked for, that Bryan will become blocked. Dave drops what he's doing and moves to finish up the work he needs to do to support Bryan. At about 2:00, Dave yells down the hall, "Here it is." Bryan is now in shape to test after only a short delay, and Dave goes back to what he's doing, without ever having been idle.

An exceptional instance? No: interrupt mode is the modus operandi of the whole group, in the interest of minimizing wait states. It is the Interrupts Unjam Blocking (4.1.25) pattern. Wait states can add substantially to product interval. The micro-parallelism of this process alleviates much of the blocking one finds in large projects. Just as in processor scheduling, interrupts reduce the latency to service a request. If the context-switch overhead is low enough, an interrupt-driven development's throughput will be about the same as for any other approach. It takes close-knit communications to make it work.

How do these communications take place? I asked if they held periodic team meetings. "Not if we can help it," was the reply. Team members have a small number of small three- or four-person meetings during the day. Yelling up and down the hallway is *de rigueur.* It is unlike Borland, where much more of the dialogue seems to have taken place at a round table under the banner of architecture. But the underlying principle—close-knit communication—is the same.

This approach leads to an unconventional view of time and schedule. Most software development projects are *monochronic societies*: They believe time adds up algebraically. This organization seems to be more *polychronic*: with parallelism and task shuffling, time becomes fluid and can be manipulated. The interrupt-driven nature can be somewhat nerve-racking, and carrying on in parallel with people outside the team (e.g., in front-end and back-end processes) can be uncomfortable. But the resulting productivity gains are high.

9.6 Process Improvement Opportunities

Code ownership can be maintained in the long term only if there is a solid high-level architecture with clear, explicit interfaces. This project should work to make their architecture more explicit, and to better formalize the interfaces. This will become increasingly important as development moves from initial product formulation to ongoing evolution.

Right now, there is no clearly identified role in this project to conduct arms-length black-box testing for faults. They are aware of this problem and are addressing it.

Bell Laboratories modular building construction may not be the most conducive to the team interactions that seem to nourish this team. Alternative architectures and room configurations might support the necessary interworking while maintaining the sense of "space" and privacy that has long been a valued aspect of the Bell Labs culture.

9.7 Thoughts And Conclusions

On a person-for-person basis, this organization is one of the most productive organizations we've studied. Such high productivity usually comes not only from good development and management practices, but from a high commitment of time and energy from its developers. Such behavior should be encouraged through the reward system, and by recognition, as it was at Borland.

The small team dynamics of this organization have been the dominant factor in its prodigious success: The high degree of parallelism, the interrupt-driven development, and the use of concurrent engineering, are all related to the team size. Other similarities to Borland QPW include the high degree of trust between members of the project; the tight coupling with respected and influential management; the centrality of the architecture function; tight code ownership and software anthropomorphism; and the even distribution of communication across all roles in the organization. These latter factors characterize a *true* team. Such distinguishing characteristics of organization and process should be carefully considered as key factors that differentiate highly productive organizations from most contemporary software development efforts, and the mature practices they use.

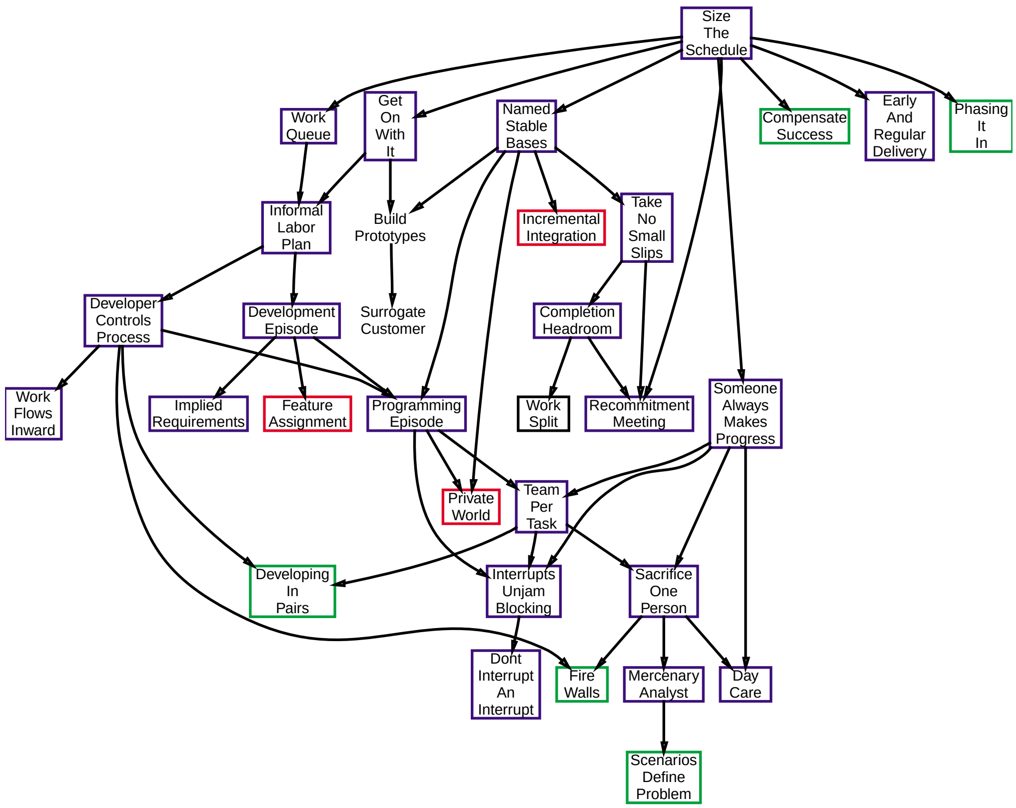
PART V. Appendices

CHAPTER 10 Summary Patlets

A *patlet* is a short summary of the problem and solution for a pattern. Patlets are often used as an aid to discovering patterns to solve a particular problem at hand. Here, we use the patlets as a way for you to find patterns you are looking for.

10.1 Project Management Patlets

These patlets point to patterns for initial organizational design. You can find the patterns in the section PROJECT MANAGEMENT PATTERN LANGUAGE (4.1).



Community Of Trust (4.1.1):

If you are building any human organization, *Then:* you must have a foundation of trust and respect for effective communication at levels deep enough to sustain growth.

Size The Schedule (4.1.2):

If the schedule is too long, developers become complacent; *but* if it is too short, they become overtaxed. *Therefore:* reward meeting the schedule, and keep two sets of books.

Get On With It (4.1.3):

If you are starting a project and have enough information to get started on parts of it, *Then:* don't wait until you have a complete schedule before starting to do parts of the project

Named Stable Bases (4.1.4):

If you want to balance stability with progress, *Then:* have a hierarchy of named stable bases that people can work against.

INCREMENTAL INTEGRATION (4.1.5):

If you want developers to be able to test changes before publishing them, *Then:* allow developers to build the entire product code independently to allow testing with the very latest base (not the latest Named Stable Base).

PRIVATE WORLD (4.1.6):

If you want to isolate developers from the effects of changes, *Then:* allow developers to have private work spaces containing the entire build environment.

BUILD PROTOTYPES (4.1.7):

If early acquired requirements are difficult to validate without testing, *Then:* build a prototype, whose purpose is to understand requirements.

TAKE NO SMALL SLIPS (4.1.9):

If you are getting behind schedule and need additional time resources, *Then:* take one large planned slip instead of allowing yourself to nickel and dime yourself to death with small, unanticipated slips.

COMPLETION HEADROOM (4.1.10):

If work is progressing against a set of hard dates, *Then:* make sure there is COMPLETION HEADROOM (4.1.10) between the completion dates of the largest task and the hard delivery dates.

WORK SPLIT (4.1.11):

If people too close to the problem are escalating their problems, either as a “pork barrel” issue or as something well-intentioned, *Then:* split work into an urgent and deferred component, with less than half of development work in the urgent half.

RECOMMITMENT MEETING (4.1.12):

If: the schedule can’t be met with simple adjustments to the work queue and staffing, *Then:* assemble developers and interested managers to recommit to a new strategy based on doing the minimal amount of work to reach a satisfactory conclusion

WORK QUEUE (4.1.13):

If deliverables are ill-defined, you need to allow time to do everything. *Therefore:* produce a schedule with less output than you have input. Use the list of IMPLIED REQUIREMENTS (4.1.16) (really just names) as a starting point and order them into a likely implementation order favoring the more urgent or higher priority items.

Informal Labor Plan (4.1.14):

If developers need to do the most important thing now, *Then:* let developers negotiate among themselves or “just figure out the right thing to do” as regards short term plans, instead of master planning.

Development Episode (4.1.15):

If we overemphasize individual contributor skills, work suffers.

Therefore: approach all development as a group activity as if no one had anything else to do.

Implied Requirements (4.1.16):

If you need a way to nail down the functionality that needs to be covered, *Then:* make a list of functional areas and domains instead of breaking it down into traditional requirements.

Developer Controls Process (4.1.17):

If you need to orchestrate the activities of a given location or feature, *Then:* put the Developer role in control of the succession of activities.

Work Flows Inward (4.1.18):

If you want information to flow to the producing roles in an organization, *Then:* put the developer at the center and see that information flows *toward* the center, not *from* the center.

Programming Episode (4.1.19):

If you need to split up work across time, *Then:* do the work in discrete episodes with mind share to commit to concrete deliverables.

Someone Always Makes Progress (4.1.20):

If Distractions constantly interrupt your team’s progress, *Then:* whatever happens, ensure someone keeps moving toward your primary goal.

Team Per Task (4.1.21):

If a big diversion hits your team, *Then:* let a sub-team handle the diversion, the main team keeps going.

Sacrifice One Person (4.1.22):

If a smaller diversion hits your team, *Then:* assign just one person to it until it gets handled.

Day Care (4.1.23):

If your experts are spending all their time mentoring novices, *Then:* put one expert in charge of all the novices, let the others develop the system.

MERCENARY ANALYST (4.1.24):

If you want to keep documentation from being a critical path roadblock for developers, *Then:* hire a MERCENARY ANALYST.

INTERRUPTS UNJAM BLOCKING (4.1.25):

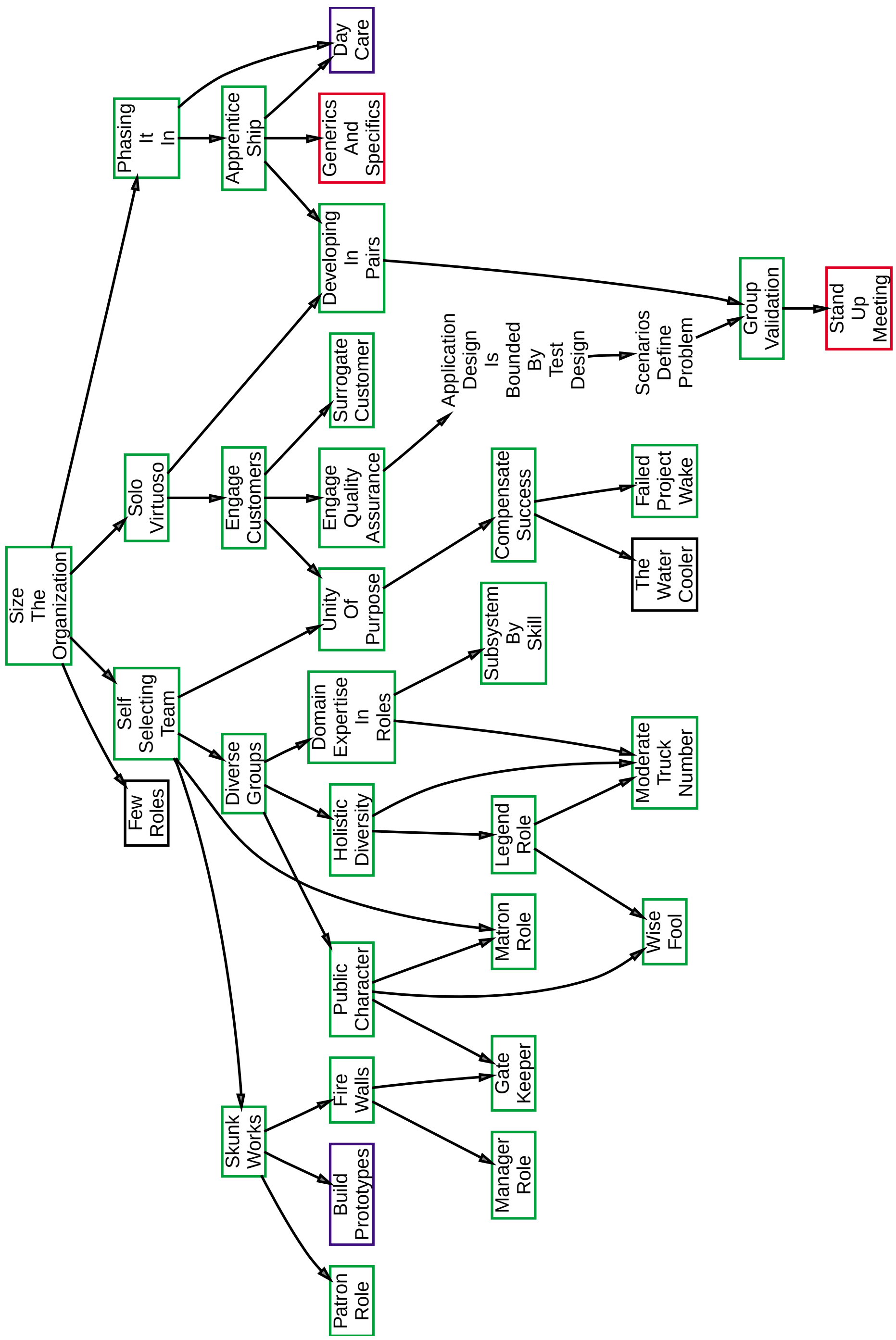
If you need to schedule urgent development activities according to some reasonable priority scheme, *Then:* use an interrupt scheme to keep individual problems from blocking the entire project.

DON'T INTERRUPT AN INTERRUPT (4.1.26):

If you're in the middle of handling an interrupt to keep the project from getting stuck, and a new urgent need arises, *Then:* continue handling the current issue before moving on to the new one.

10.2 Piecemeal Growth Patlets

These patlets summarize patterns for the growth of an organization once it is up and running. You can find the patterns in the section PIECEMEAL GROWTH PATTERN LANGUAGE (4.2).


Size The Organization
Phasing It In
Solo Virtuoso
Self Selecting Team
Few Roles
Apprentice Ship
Engage Customers
Diverse Groups
Skunk Works
Day Care
Generics And Specifics
Developing In Pairs
Surrogate Customer
Engage Quality Assurance
Unity Of Purpose
Domain Expertise In Roles
Holistic Diversity
Public Character
Fire Walls
Build Prototypes
Patron Role
Application Design Is Bounded By Test Design
Compensate Success
Subsystem By Skill
Legend Role
Matron Role
Gate Keeper
Manager Role
Scenarios Define Problem
Failed Project Wake
The Water Cooler
Moderate Truck Number
Wise Fool
Group Validation
Stand Up Meeting

Size The Organization (4.2.2):

If an organization is too large, communications break down, and *if* it is too small, it can't achieve its goals or easily overcome the difficulties of adding more people. *Therefore:* start projects with a critical mass of about 10 people.

Phasing It In (4.2.3):

If you can't always get the experts you need, *Then:* grow new experts from new hires.

Apprenticeship (4.2.4):

If you have difficulty retaining expertise, *Then:* grow expertise internally from existing employees or even new hires.

Solo Virtuoso (4.2.5):

If a project is intellectually small, then overstaffing it is a waste of time and money. *Therefore:* staff small projects with Solo Virtuosos.

Engage Customers (4.2.6):

If you want to manage an incremental process that accommodates customer input, and if you want the customer to feel loved, *Then:* engage customers after Quality Assurance and project management are prepared to serve them.

Surrogate Customer (4.2.7):

If you need answers from your customer, but no customer is available to answer your questions, *Then:* create a surrogate customer role in your organization to play advocate for the customer.

Scenarios Define Problem (4.2.8):

If you want a good characterization of customer needs, *Then:* use scenarios to define the problem.

Fire Walls (4.2.9):

If you want to keep your developers from being interrupted by extraneous influences and special interest groups, *Then:* impose a Fire Wall, such as a manager, who "keeps the pests away."

Gate Keeper (4.2.10):

If you need to keep from being inbred, *Then:* use a Gate Keeper (4.2.10) role to tie together development with other projects, with research, and the outside world.

Self Selecting Team (4.2.11):

If you appoint people to a team, it doesn't come together as a team. But people with outside interests and who wish to joint a team make the best team members. *Therefore:* teams should be largely self-selecting with limited screening on the basis of track record and outside interests.

Unity Of Purpose (4.2.12):

If a team is beginning to work together, *Then:* make sure all members agree on the purpose of the team.

Team Pride (4.2.13):

If a team needs to perform above and beyond the call of duty, *Then:* instill a well-grounded sense of elitism in its members.

Skunk Works (4.2.14):

If a project innovates too much, then it increases its risk; yet there is a place for innovation. *Therefore:* give innovation an organizational space and time.

Patron Role (4.2.15):

If you need to insulate Developers so Developer Controls Process (4.1.17) and provide some organizational inertia at the strategic level, *Then:* identify a patron to whom the project has access, who can champion the cause of the project.

Diverse Groups (4.2.16):

If everyone has similar views, you have a good team, *but* too much normalization leaves important problem areas unaddressed. *Therefore:* assemble a diverse team, based on different experiences, cultures, and genders.

Public Character (4.2.17):

If you need a catalyst to bring people together, *Then:* recognize some roles as Public Characters.

Matron Role (4.2.18):

If your team needs ongoing care and feeding, *Then:* include a Matron in the team who will naturally take care of social needs of the team.

Holistic Diversity (4.2.19):

If Development of a subsystem needs many skills, but people specialize, *Then:* create a single team from multiple specialties.

Legend Role (4.2.20):

If a key person will leave the organization soon, *Then:* train a key replacement, and have them assume a role named after the key person.

Wise Fool (4.2.21):

If critical issues do not get aired easily, *Then:* nurture a Wise Fool to say the things nobody else dares say.

Domain Expertise In Roles (4.2.22):

If you need to staff all roles, it's difficult to determine how to match people to roles to optimize communication. *Therefore:* match people to roles based on domain expertise, and emphasize that people play those roles in the organization.

Subsystem By Skill (4.2.23):

If you need to organize subsystems for the long haul, *Then:* divide them up by skills.

Moderate Truck Number (4.2.24):

If you can't eliminate having a single point of failure in allocating expertise to roles, *Then:* spread expertise as far as possible, but not more so.

Compensate Success (4.2.25):

If enterprises are to succeed, they must reward the behaviors that portend for success; but, these behaviors are varied, and success is difficult to measure. *Therefore:* establish a spectrum of reward mechanisms that reward both teams and individuals.

Failed Project Wake (4.2.26):

If people have put their hearts and souls into a project, only to have it canceled, *Then:* celebrate its demise; hold a "wake" for it.

Developing In Pairs (4.2.28):

If you want to improve the effectiveness of individual developers, *Then:* have people develop in pairs.

Engage Quality Assurance (4.2.29):

If developers can't be counted on to test beyond what they already anticipate what might go wrong, *Then:* engage Quality Assurance as an important function.

Application Design Is Bounded By Test Design (4.2.30):

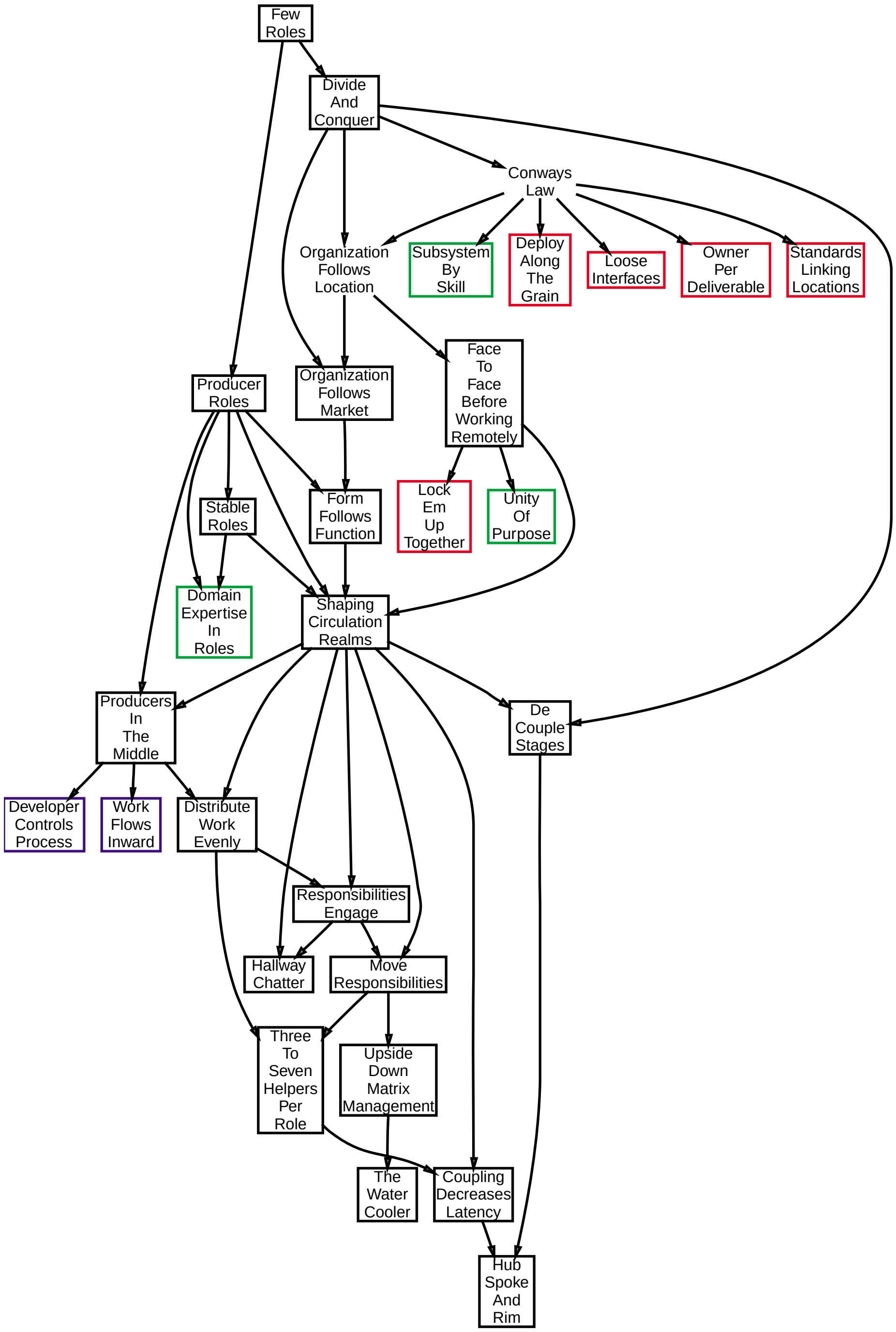
If you want to organize the interworking between test developers and software developers, *Then:* organize the process so Application Design Is Bounded By Test Design.

Group Validation (4.2.32):

If you want to avoid being blindsided in quality assurance, *Then:* Engage Customers (4.2.6) and Developing In Pairs (4.2.28) and others to validate the system.

10.3 Organizational Style Patlets

Good design lends a sense of style to anything we build. Each great organization has its own style. These patterns shape the “style” of an organization. Different organizational styles fit different needs, so these patterns provide a good foundation for tailoring an organization to your business and market. The patterns can be found in the section ORGANIZATIONAL STYLE PATTERN LANGUAGE (5.1).



Few Roles
Divide And Conquer
Conways Law
Organization Follows Location
Subsystem By Skill
Deploy Along The Grain
Loose Interfaces
Owner Per Deliverable
Standards Linking Locations
Producer Roles
Organization Follows Market
Face To Face Before Working Remotely
Stable Roles
Form Follows Function
Lock Em Up Together
Unity Of Purpose
Domain Expertise In Roles
Shaping Circulation Realms
Producers In The Middle
De Couple Stages
Developer Controls Process
Work Flows Inward
Distribute Work Evenly
Responsibilities Engage
Hallway Chatter
Move Responsibilities
Three To Seven Helpers Per Role
Upside Down Matrix Management
The Water Cooler
Coupling Decreases Latency
Hub Spoke And Rim

Few Roles (5.1.2):

If your organization has high communication overhead and latency, *Then:* identify the roles in the organization, and keep the number of roles to sixteen or fewer.

Producer Roles (5.1.3):

If your organization has too many roles, but does not know which to eliminate, *Then:* identify roles as Producers, Supporters, or Deadbeats; eliminate the Deadbeats, and combine some of the Supporters.

Producers In The Middle (5.1.4):

If your developers are somewhat lost, *Then:* make sure the producer roles are at the center of all communication.

Stable Roles (5.1.5):

If you have to deal with project disruptions, *Then:* keep people in their primary roles, and deal with disruptions as temporary tasks.

Divide And Conquer (5.1.6):

If an organization is getting too large for communications to be effective any more, *Then:* try partitioning it along lines of mutual interest and coupling, forming a separate organization and process.

Conway's Law (5.1.7):

If organization structuring concerns are torn between geography, expertise, politics, and other factors, *Then:* align the primary organizational structuring with the structure of the business domains, the structure that will be reflected in the product architecture.

Organization Follows Location (5.1.8):

If you need to distribute work geographically, communications suffer, *but* you can limit the damage if work is partitionable. *Therefore:* organize work at locations so groups of people that work together are at the same location.

Organization Follows Market (5.1.9):

If there is no clear organizational accountability to a market, *Then:* make some organization accountable for the market to assure that the market's needs will be met.

Face To Face Before Working Remotely (5.1.10):

If a project is divided geographically, *Then:* begin the project with a meeting of everyone in a single place.

Form Follows Function (5.1.11):

If there is little specialization, and people don't know where to turn for answers to technical questions, *Then:* Create domains of expertise called *roles* that cluster around artifacts or specialization.

Shaping Circulation Realms (5.1.12):

If you need mechanisms to facilitate the communication structures necessary for good group formation, *Then:* shape circulation realms.

Distribute Work Evenly (5.1.13):

If you want to optimize utilization of human resources, *Then:* alleviate hot spots of overload on specific groups and individuals in your organization by Distributing Work Evenly

Responsibilities Engage (5.1.14):

If central roles are overloaded but you don't want to take them out of the communication loop *Then:* intensify communication more among non-central roles to lighten the load on the central roles

Hallway Chatter (5.1.15):

If developers tend to huddle around the organizational core or supporting roles are inadequately engaged with each other, *Then:* rearrange responsibilities in a way that encourages less isolation and more interworking among roles and people.

Decouple Stages (5.1.16):

If stages are too interleaved for the good of some high-context development where phases can be separated to increase parallelism, *Then:* serialize process steps, with well-defined hand-offs between steps.

Hub Spoke And Rim (5.1.17):

If you want to Decouple Stages in a high-context development process, *Then:* orchestrate the process with a hub role, and minimize coupling between other roles, in a hub-spoke-and-rim geometry.

Move Responsibilities (5.1.18):

If you want to change coupling between roles (particularly if you want to decouple roles), *Then:* move responsibilities from one role to another.

Upside Down Matrix Management (5.1.19):

If the right skills and resources don't seem to be applied to a particular aspect of the work, *Then:* go beyond corporate structures to leverage teams in other organizations (customer, partners, other internal organizations)

The Water Cooler (5.1.20):

If you need more communication between institutionalized organizations, *Then:* leave space for everyday human activities at the workplace that can provide more complete and informal communication

Three To Seven Helpers Per Role (5.1.21):

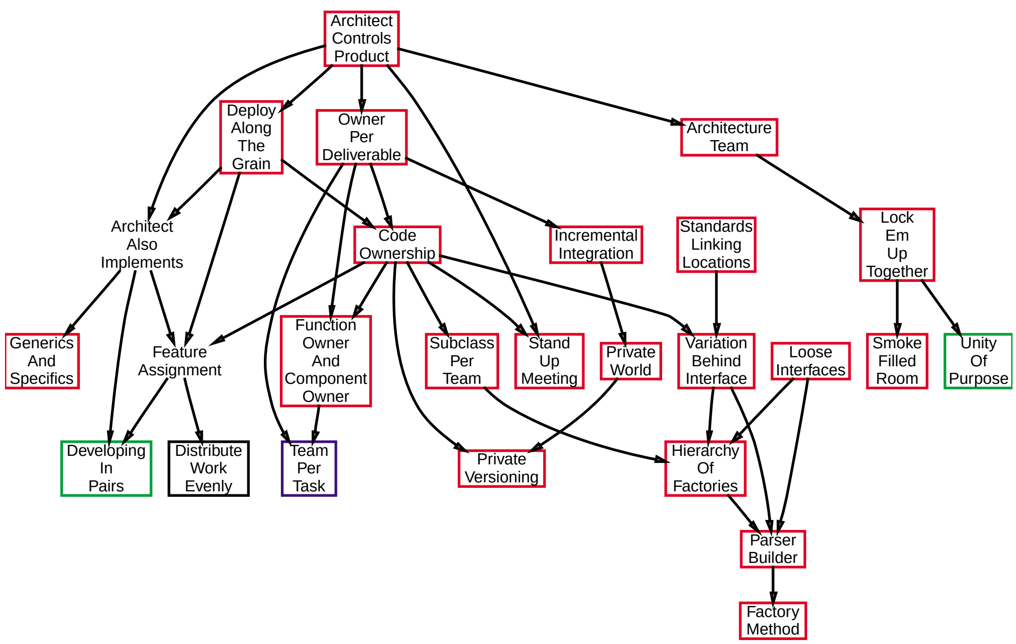
If you want to even out communication, *Then:* at least try to limit communication to Three To Seven Helpers Per Role, and to pull up the outliers to the same level of engagement.

Coupling Decreases Latency (5.1.22):

If you need a high throughput development process, *Then:* increase coupling between roles to decrease latency.

10.4 People And Code Patlets

People and code are the two most important components of a software development organization. Customers wouldn't exist without code to sell to them, and code wouldn't exist without people. People write code, and the structure of code in turn affects how people organize. These patlets point to patterns that help an organization align the people and code structures properly. The patterns themselves can be found in the section People And Code Pattern Language (5.2).



Architect Controls Product (5.2.3):

If a project has a long life, *Then:* use the architect to carry the vision forward and serve as the long-term keeper of architectural style.

ARCHITECTURE TEAM (5.2.4):

If you are building a system too large or complex to be thoroughly understood by a single individual, *Then* build a team that has both the responsibility and the power to create the architecture.

LOCK 'EM UP TOGETHER (5.2.5):

If your team is struggling to come up with an architecture, *Then:* isolate them physically for several days where they can work uninterrupted.

SMOKE FILLED ROOM (5.2.6):

If you need to make a decision quickly and there are reasons to exclude others, *Then:* make the decision covertly so that the rationale remains private, though the decision will be publicized.

STAND UP MEETING (5.2.7):

If there are pockets of misinformation or people out of the loop: *Then:* hold short daily meetings to socialize emerging developments.

DEPLOY ALONG THE GRAIN (5.2.8):

If reuse is suffering from fragmentation of responsibilities for an artifact, *Then:* give people dedicated, long term responsibility for a management piece of the system.

ARCHITECT ALSO IMPLEMENTS (5.2.10):

If an architect is on an ivory tower, they are out of touch; yet someone needs to take the big and long view and reconcile it with practice. *Therefore:* the architect is materially involved in day-to-day implementation.

GENERICS AND SPECIFICS (5.2.11):

If you have many new people, *Then:* put the experienced people on generic parts of the work, and give specific assignments to the new people.

STANDARDS LINKING LOCATIONS (5.2.12):

If you have geographically separated development, *Then:* use standards to link together parts of the architecture that cross geographic boundaries.

CODE OWNERSHIP (5.2.13):

If you need responsibility for code and want to build on DOMAIN EXPERTISE IN ROLES (4.2.22), *Then:* give various individuals responsibility for the overall quality of the code.

FEATURE ASSIGNMENT (5.2.14):

If you are trying to partition work in a large project, *Then:* make assignments of features to people.

VARIATION BEHIND INTERFACE (5.2.15):

If more than one person is developing software, then changes affect not only the code, but people as well. *Therefore:* create interfaces around predicted points of variation.

PRIVATE VERSIONING (5.2.16):

If you want to enable incremental changes without publishing them, *Then:* set up a mechanism for developers to version code without checking it in to a public repository.

LOOSE INTERFACES (5.2.17):

If you need to develop systems rapidly in an environment where communication is less than optimal, *Then:* limit the number of explicit, static, interfaces. Use loose interfaces like callbacks.

SUBCLASS PER TEAM (5.2.18):

If subsystem teams have different Design points, *Then:* where two subsystems collide in one class, assign them to different layers of the class hierarchy.

HIERARCHY OF FACTORIES (5.2.19):

If you have a creational system which creates different products specified by different groups, *Then:* set up factories in a hierarchical arrangement, where each knows about 1 level below only.

PARSER BUILDER (5.2.20):

If you need you create objects based on type information in an input stream, *Then:* use a parser builder which reads type information from the stream and builds the appropriate objects based on this information.

10.5 Patlets From Other Pattern Languages

This book has been a team effort, incorporating pattern material from many sources including works by Alistair Cockburn, Ward Cunningham, Steve Berczuk, and others. Sometimes we have included other patterns almost intact, and in other cases we have updated or edited the patterns to fit into the format or the context of the pattern languages in this book. For example, many of Alistair Cockburn's patterns have essentially the same content here as in their original publication, but have been radically reformatted from their original form for the sake of consistency.

Some patterns, while still relevant to the topic of organizational structure, didn't quite fit in the pattern languages here. That might be because they describe process instead of structure, or because they are idioms sensitive to particular situations, or because they are off-topic, or because they are proto-patterns awaiting broad substantiation. But we still refer to some of those patterns and we commend them to you as great reading.

Here, we provide patlets for those patterns to which we refer, but which didn't make it into the book. Because these are often quotes from others, they do not follow the patlet style we used in our own patlets. Some of the patlets come verbatim from Linda Rising's *Pattern Almanac* [Rising2000]—which is a great source of other organizational pattern reference material.

10.5.1 Arranging The Furniture

Your established team is entering a transition period where members are replaced by newcomers who must quickly come to grips with large and complex software modules. People are territorial and need to mark their intellectual territory to establish a feeling of ownership. Newcomers should move in by cosmetically arranging code. This must be a background, incremental task and should not be used as an excuse to trash the backyard. Verbatim from [Rising2000], p. 27. From [Taylor1999], pp. 632-635. Referenced in CODE OWNERSHIP (5.2.13).

10.5.2 Ad- Hoc Corrections

It's difficult to keep documents up to date. Keep a master hard copy of the design accessible to the entire team. Anyone who updates the design must make corrections in the margin, delete sections that no longer apply, or write a description of the change. Ultimately, one team member should update on-line copies to reflect the corrections. (Verbatim from [Rising2000], p. 119.) From [Weir1998]. Referenced in MERCENARY ANALYST (4.1.24).

10.5.3 All At Once

If your downstream implementation teams are ready to get started even though requirements aren't ready, *Then* let them go ahead and make progress based on their instinct and information at hand. [Cockburn2003] Referenced in GET ON WITH IT (4.1.3).

10.5.4 Architecture Definition Team

You don't want the architecture to become convoluted, so create a small team of resonating minds charged with the job of defining the initial architecture. [Meszaros1997] Referenced in ARCHITECTURE TEAM (5.2.4).

10.5.5 Balanced Team

Using teams of similar, like-minded individuals to develop use cases can result in a set of limited, narrowly ranged use cases that do not satisfy everyone's needs. *Therefore*: Staff the team with people from different specialties to champion the interests of the stakeholders in the development process. Make sure the team contains both developers *and* end users. From [Bramble2002], p. 39. Referenced in DIVERSE GROUPS (4.2.16).

10.5.6 Business Process Model

If you need to understand requirements and business needs beyond the use cases, Then:

> Understand first the network of agents and commitments that make up the business. Specify the conversations that take place at an appropriate level of abstraction, so that they are stereotypes for actual stories. Get people to tell these stories. Ensure that you produce both 'before' and 'after' business process models. Eliminate conversations that do not correspond to business objectives (or discover the missed objective). Ensure every objective is supported by a conversation.

The solution is verbatim from [Graham2003], p. 59. Referenced in WORK SPLIT (4.1.11).

10.5.7 Clear The Fog

You don't know the issues well enough to put together a sound plan, so deliver something. This will tell you the real issues. (Verbatim from [Rising2000], p. 168.) From [Cockburn1998]. Referenced in BUILD PROTOTYPES (4.1.7) and in the patlet MICROCOSM (10.5.18), below.

10.5.8 Creator- Reviewer

People make mistakes. It's difficult to see problems and errors in your own work. When one or two designers are producing a design, there is a strong likelihood of undetected errors. Have each designer produce a draft or a complete design. Each of one or more reviewers receives a copy and provides feedback. (Verbatim from [Rising2000], p. 119.) From [Weir1998]. Referenced in GROUP VALIDATION (4.2.32).

10.5.9 Demo Prep

This pattern language is a "preparation for customer demonstrations" ([Rising2000], p. 48). The pattern language comprises seven patterns named ELEMENT IDENTIFICATION, CATALYTIC SCENARIOS, MUTABLE CODE, PROTOTYPING LANGUAGES, LIGHTWEIGHT USER INTERFACES, JUDICIOUS FIREWORKS, and ARCHIVE SCENARIOS. From [Coram1996]. Referenced in BUILD PROTOTYPES (4.1.7) and SCENARIOS DEFINE PROBLEM (4.2.8).

10.5.10 Designers Are Our Friends

How should testers work with designers? Build rapport with designers. Approach designers with the attitude that the system has problems that require cooperation to resolve. Designers and testers have a common goal. Use GET INVOLVED EARLY (10.5.13) and DOCUMENT THE PROBLEM. (Verbatim from [Rising2000], p. 126.) From [Delano1998]. Referenced in ENGAGE QUALITY ASSURANCE (4.2.29) and in the patlet GET INVOLVED EARLY (10.5.13), below.

10.5.11 Early And Regular Delivery

You don't know what problems you will encounter during development, so deliver something early. Discover what you don't know you don't know. Deliver regularly and improve each time. CLEAR THE FOG

(10.5.7) is the general expression of this strategy. (Verbatim from [Rising2000], p. 168.) From [Cockburn1998]. Referenced in BUILD PROTOTYPES (4.1.7), SIZE THE SCHEDULE (4.1.2), LOOSE INTERFACES (5.2.17), and in the full text of CLEAR THE FOG (10.5.7), which is abstracted above.

10.5.12 Establish The Business Objectives

People tend to over-emphasize Use Cases as the final authority on requirements at the expense of other considerations and particularly of business needs. Therefore:

> Hold a workshop involving as many stakeholders as possible. Make sure that potential users are represented by marketing personnel or the results of focus groups, surveys, etc. Find a good facilitator. Agree a mission statement. Find measures for each objective. Agree a numerical rank ordering of the priorities.

The solution is verbatim from [Graham2003], p. 54. Referenced in WORK SPLIT (4.1.11).

10.5.13 Get Involved Early

You're a system tester working on a large software project. To maximize support from the design community, establish a working relationship with the designers early in the project, for example, learn the system and the features along with the designers or attend reviews of requirements and design documentation. Invite designers to reviews or test plans. Use DESIGNERS ARE OUR FRIENDS (10.5.10). Don't wait until you need to interact with a designer; by that time it's too late. Trust must be built over time. (Verbatim from [Rising2000], p. 126.) From [Delano1998]. Referenced in DESIGNERS ARE OUR FRIENDS (10.5.10), above, and in ENGAGE QUALITY ASSURANCE (4.2.29).

10.5.14 Gradual Stiffening

> The requirements and use cases may evolve during the lifetime of the project. How do you respond to such developments? Should you adhere strictly to the original plan? If not, what is fixed and what should be allowed to vary?

Therefore:

A web site development project should start with loose design but clear business objectives, defined use cases and types and a sound project plan. Allow the site structure to stiffen the design only as the site unfolds and only completely towards the end of the project.

The entire patlet is abstracted verbatim from [Graham2003], p. 77. Referenced in WORK SPLIT (4.1.11).

10.5.15 Guru Does All

A newly formed team is given a project with a tight schedule, uncertain requirements, uneven distribution of skills, and new technologies. Let the most skilled and knowledgeable developer drive the design and implement the critical pieces. (Verbatim from [Rising2000], p. 130.) From [Olson1998a], pages 153-154. Referenced in ARCHITECT ALSO IMPLEMENTS (5.2.10).

10.5.16 Market Walk-through

When PRODUCT INITIATIVE (10.5.22) has been followed, hold a walk-through of program and product concepts with both the development and business sides of an organization. When this pattern has been followed, use IMPLIED REQUIREMENTS (4.1.16). (Verbatim from [Rising2000], p. 52.) From [Cunningham1996], p. 375. Referenced in IMPLIED REQUIREMENTS (4.1.16) and in PRODUCT INITIATIVE (10.5.22), below.

10.5.17 Master- Journeyman

You need to partition the design work for a large system. There must be a chief architect or small team to provide design integrity. Yet in a large development project, it might be possible for this core team to do all the design work. The core team should provide an overview of the system architecture and divide the system into independent components. Journeymen architects then design the components and act as chief architects for the components. (Verbatim from [Rising2000], p. 118.) From [Weir1998]. Referenced in ARCHITECTURE TEAM (5.2.4).

10.5.18 Micro Cosm

You have to create a plan but have never done this sort of project, so run an 8- to 12-week instrumented pilot to get productivity and throughput data for your plan. CLEAR THE FOG (10.5.7) is the general expression of this strategy. (Verbatim from [Rising2000], p. 168.) From [Cockburn1998]. Referenced in BUILD PROTOTYPES (4.1.7).

10.5.19 Owner Per Deliverable

Be sure every deliverable has one and only one owner. This is a general strategy with specializations: DAY CARE (4.1.23), FUNCTION OWNER AND COMPONENT OWNER, and TEAM PER TASK (4.1.21). (Adapted from [Rising2000], p. 169.) From ([Cockburn1998], p. 220-221). Widely referenced in many patterns, but key to CODE OWNERSHIP (5.2.13), FUNCTION OWNER AND COMPONENT OWNER, SUBCLASS PER TEAM (5.2.18), and TEAM PER TASK (4.1.21).

10.5.20 Participating Audience

You cannot satisfy stakeholders' needs without their input and feedback. *Therefore:* Actively involve your customers and internal stakeholders in the use case development process when possible. From [Bramble2002], p. 35. Referenced in ENGAGE CUSTOMERS (4.2.6).

10.5.21 Peace Maker

A peacemaker is a placeholder in an organization who tries to calm and hold things together until a leader can be found or a reorganization is complete. The peacemaker should be someone who is well liked but who is not necessarily technically proficient. Usually this individual has many years with the company, knows the political ropes, and can buy time for a team as well as the team's management. Usually PEACE MAKER (10.5.21) follows SACRIFICIAL LAMB and precedes CULT OF PERSONALITY or GURU DOES ALL (10.5.15). (Verbatim from [Rising2000], p. 131.) From [Olson1998a], p. 168. Referenced in MATRON ROLE (4.2.18). In this book, SACRIFICE ONE PERSON (4.1.22) is an alias for SACRIFICIAL LAMB.

10.5.22 Product Initiative

When a wish list of features and functions is created for a product, clearly define an initiative for product improvement and be sure everyone understands the initiative. When this pattern has been followed, use MARKET WALK-THROUGH (10.5.16). (Verbatim from [Rising2000], p. 52.) From [Cunningham1996], pp. 374-375. Referenced in IMPLIED REQUIREMENTS (4.1.16) and in MARKET WALK-THROUGH (10.5.16), above.

10.5.23 Proto Types

To avoid the risk of commiting to production decisions prematurely and the problems of long-term maintainability of code, work with customers to initially build LO FIDELITY PROTOTYPES using paper widgets, drawings, paper stickies, and index cards. If the skill and tools are present, build HIGH FIDELITY PROTOTYPES. From ([Whitenack1995], p. 288). Referenced in BUILD PROTOTYPES (4.1.7).

10.5.24 Query Objects

You're using REPORT OBJECTS and need to create queries for reports at run-time. Create objects that represent queries. Define operations on these objects and a method to return query results. (Verbatim from [Rising2000], p. 41.) From [BrantYoder1999]. Historically from [BrownWhitenack1999]. Referenced by PARSER BUILDER (5.2.20).

10.5.25 Shared Clear Vision

The lack of a clear vision about a system can lead to indecision and contrary opinions among the stakeholders and can quickly paralyze the project. *Therefore:* Prepare a statement of purpose for the system that clearly describes the objectives of the system and supports the mission of the organization. Freely distribute it to everyone involved in the project. From [Bramble2002], p. 80. Referenced in UNITY OF PURPOSE (4.2.12).

10.5.26 Shearing Layers

Software systems cannot stand still, but different components change at different rates. Factor the system so that components that change at similar rates are together. (Verbatim from [Rising2000], p. 21.) From [Foote2000]. Referenced by VARIATION BEHIND INTERFACE (5.2.15).

10.5.27 Small Writing Team

Using too many people to write a use case is inefficient, and the compromise made to align the many different points of view may result in a less than satisfactory system. *Therefore*: Restrict the number of people refining any one work product to just two or three people. From [Bramble2002], p. 31. Referenced in SIZE THE ORGANIZATION (4.2.2).

10.5.28 Skill Mix

When team membership is likely to change, separate subsystems by staff skill requirements. This allows specialists to work in their area of expertise and enables successors to see the results of these special abilities in isolation. (Verbatim from [Rising2000], p. 135.) From [Cockburn1996]. Referenced by CONWAY'S LAW (5.1.7) and DEPLOY ALONG THE GRAIN (5.2.8).

10.5.29 Work Allocation

Work is not always assigned to right place, done at the right time and assigned to correct people. Go beyond the historical, organizational, financial or political barriers and allocate work to produce the most effective outcome. Unpublished; see [Beedle2000]. Referenced in UPSIDE DOWN MATRIX MANAGEMENT (5.1.19).

CHAPTER 11 *Bibliography*

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Solo Virtuoso (4.2.5): Photograph by Russell Lee, 1940, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF34-036598- D.

Engage Customers (4.2.6): Photograph by Russell Lee, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34-033032- D.

Surrogate Customer (4.2.7): Photograph by John Collier, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34-081569- E.

Scenarios Define Problem (4.2.8): Photograph by Jack Delano, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3-001663- D.

FIRE WALLS (4.2.9): Photograph by Jack Delano, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USW3-000320- D.

GATE KEEPER (4.2.10): Photograph by Russell Lee, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF34-034339- D.

SELF SELECTING TEAM (4.2.11): Photograph 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-010189 .

TEAM PRIDE (4.2.13): Photograph by Russell Lee, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF34- 072474-D.

SKUNK WORKS (4.2.14): Photograph by John Vachon, 1940, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF33- 001945-M2.

PATRON ROLE (4.2.15): Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-009365.

DIVERSE GROUPS (4.2.16): Photograph by Howard Lieberman, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-004480.

PUBLIC CHARACTER (4.2.17): Photograph by Roger Smith, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 031897-C.

MATRON ROLE (4.2.18): Photograph by John Collier, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF34- 081012-E.

HOLISTIC DIVERSITY (4.2.19): Photograph by Russell Lee, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3-003770- D.

LEGEND ROLE (4.2.20): Library of Congress, Prints & Photographs Division, LC- USZ62-103759.

WISE FOOL (4.2.21): Photograph by Russell Lee, 1937, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF34- 010273-E.

DOMAIN EXPERTISE IN ROLES (4.2.22): Photograph by Howard R. Hollem, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-007049.

SUBSYSTEM BY SKILL (4.2.23): Photograph by Alfred T. Palmer, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3-055143- C.

MODERATE TRUCK NUMBER (4.2.24): Photograph by John Vachon, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 018497-D.

COMPENSATE SUCCESS (4.2.25): Photograph by Russell Lee, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 072226-D.

FAILED PROJECT WAKE (4.2.26): Photograph by Russell Lee, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 038817-D.

DEVELOPING IN PAIRS (4.2.28): Photograph by Arthur Rothstein, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 022054-D.

ENGAGE QUALITY ASSURANCE (4.2.29): Photograph by Lee Russell, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 034109-D.

APPLICATION DESIGN IS BOUNDED BY TEST DESIGN (4.2.30): Photograph by William M. Rittase, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-005139.

GROUP VALIDATION (4.2.32): Photograph by Marion Post Wolcott, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 057706-D.

FEW ROLES (5.1.2): Photograph by Jack Delano, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 000678-D.

PRODUCER ROLES (5.1.3): Photograph by Arthur S. Siegal, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3-009444- C.

PRODUCERS IN THE MIDDLE (5.1.4): Photograph by Alfred T. Palmer, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-010081.

STABLE ROLES (5.1.5): Photograph by Marion Post Wolcott, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 051788-D.

DIVIDE AND CONQUER (5.1.6): Photograph by Russell Lee, 1940, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 012796-M1.

Conway's Law (5.1.7): Library of Congress, Prints & Photographs Division, LC- USZ62-77389.

Organization Follows Location (5.1.8): Photograph by Marion Post Wolcott, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 058783-D.

Organization Follows Market (5.1.9): Photograph by Russell Lee, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 013047-M3.

Face To Face Before Working Remotely (5.1.10): Library of Congress, Prints & Photographs Division, LC- USW33- 023716-C.

Divide And Conquer (5.1.6): Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW33- 015705-C.

Shaping Circulation Realms (5.1.12): Photograph by Ben Shahn, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 006275-M5 .

Distribute Work Evenly (5.1.13): Photograph by Russell Lee, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 039855-D.

Hallway Chatter (5.1.15): Photograph by Russell Lee, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33-011743- M2.

Decouple Stages (5.1.16): Photograph by Jack Delano, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 019552-E.

Hub Spoke And Rim (5.1.17): Photograph by Howard R. Hollem, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-004435.

Move Responsibilities (5.1.18): Library of Congress, Prints & Photographs Division, Edward S. Curtis Collection, LC- USZ62-117709.

Upside Down Matrix Management (5.1.19): Library of Congress, Prints & Photographs Division, Gottscho- Schleisner Collection, LC-USZC2-4505.

The Water Cooler (5.1.20): Photograph by John Collier, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 015264-C.

Work Split (4.1.11): Photograph by Russell Lee, 1937, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USF34- 030069-D.

COUPLING DECREASES LATENCY (5.1.22): Photograph by Arthur Rothstien, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 027252-D.

ARCHITECT CONTROLS PRODUCT (5.2.3): Library of Congress, Prints & Photographs Division, Theodor Horydczak Collection, LC- H814- T-1849-031- A. **Double check photo. It appears that it is in public domain, but there are restrictions in this collection.**

ARCHITECTURE TEAM (5.2.4): Photograph by Theodor Jung, 1940, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34-002702- C.

LOCK 'EM UP TOGETHER (5.2.5): Photograph by John Vachon, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 025304-D.

SMOKE FILLED ROOM (5.2.6): Library of Congress, Prints & Photographs Division, Detroit Publishing Company Collection, LC- D4-62045.

STAND UP MEETING (5.2.7): Photograph by Walker Lewis, 1944, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3-055963- D.

DEPLOY ALONG THE GRAIN (5.2.8): Photograph by Marjory Collins, 1943, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USW3- 003097-D.

ARCHITECT ALSO IMPLEMENTS (5.2.10): Photograph by Russell Lee, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 072428-D.

GENERICS AND SPECIFICS (5.2.11): Photograph by Russell Lee, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 012474-M2.

STANDARDS LINKING LOCATIONS (5.2.12): Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF345- 007754-ZA .

CODE OWNERSHIP (5.2.13): Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 014122-D.

FEATURE ASSIGNMENT (5.2.14): Photograph by Russell Lee, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 012033-M4.

VARIATION BEHIND INTERFACE (5.2.15): Photograph by Carl Mydans, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 000650-D.

PRIVATE VERSIONING (5.2.16): Photograph by Russell Lee, 1937, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 011316-M5.

LOOSE INTERFACES (5.2.17): Photograph by Russell Lee, 1939, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF33- 012300-M1.

SUBCLASS PER TEAM (5.2.18): Photograph by Alfred T. Palmer, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USE6- D-007624.

HIERARCHY OF FACTORIES (5.2.19): Photograph by Arthur Rothstein, 1937, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 026129-D.

HIERARCHY OF FACTORIES (5.2.19): Photograph by John Vachon, 1941, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC- USF34- 063633-D.

PARSER BUILDER (5.2.20): Photograph by Jack Delano, 1942, Library of Congress, Prints & Photographs Division, FSA / OWI Collection, LC-USW3- 004283-D.

CHAPTER 13 *Parking Lot*

NBH - 10/17/03: As far as I can tell, everything is done except:

Reference to be verified in Size The Schedule (4.1.2)

(My note: Check the book; if we can't, we can refer to a talk I heard by Tom De Marco in 1984.)

Here are things we need to remember, either in the Book Outline or the book itself. Add to this list as needed.

Important: Context Audit

Need stars on patterns.

Short Stories and Anecdotes

These are not full case studies, but rather short stories that might end up as sidebars or fillers (maybe transitions) between patterns, or something like that.

1. Story of group therapy debugging (for Group Validation (4.2.32) or maybe Developing In Pairs (4.2.28))
2. Crisis-oriented organization (see Crisis Management)
3. Group that came together to for a week to hammer out architecture. (Lock 'em Up Together (5.2.5))
4. The Simon Role (Legend Role (4.2.20))
5. Personal experience (NBH) — what it's like to develop in pairs.

Other Stuff We Shouldn't Forget

1. Schmismogenesis (done — see The Open Closed Principle Of Teams (6.1.4))
2. Symmetry (old Aesthetic Pattern)
3. Say something about Crisis Management (done: see Stability And Crisis Management (6.1.3))
4. Review Patterns To Be Catalogued and Neils Orphan List
5. Reference to be verified in Size The Schedule (4.1.2)

Gratuitous reference to Master Planning And The Theory Of Constraints (6.2.4) [fixed — JOC 2002/8/29]

These are things we need to remember...