A Future for System Engineering Tools

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Purpose and Scope

- To talk about system engineering tools and the the state of their use
- To describe some problems that inhibit development and uptake of tools
- To describe an alternative future for tools and system engineers using free and open-source software (FOSS)
- To illustrate the potential of this future with a system engineering modeling toolkit built with FOSS components
- To find out what you think and how we might work together

Speaker Calibration

- I'm a working system engineer
- This is a presentation of fact and opinion
- These are my personal opinions and not those of my employer
- I'm not predicting the future; I'm advocating a course of action
  - I believe that there are strong forces that favor this approach, but nothing is certain
- I might be wrong
  - This is known to be survivable
- I might be a little provocative to keep it interesting

Terminology

- By *system engineering* I mean essentially the process described by INCOSE or Buede
  - Building complementary hierarchical views of a complex system under design
    - Physical, Functional, Operational, others
  - Capturing these views in formal documentation
- By *system engineering tool* I mean anything that you use to execute that process
  - Restricted for today to information technology, as the product of system engineering is information
  - With special attention to tools marketed specifically for system engineering

Varying Tool “Strengths”

- Simple drawing tools
  - Examples: Power Point, Visio
  - Help you express yourself clearly
  - Good for making things look exactly right
  - Make you do too much of the work yourself
- Specialized text processing tools
  - Example: DOORS
  - Good for applying structure to documents
  - Too much focus on the document product; not enough on the complementary views in the model
  - The document mindset is hard to dislodge

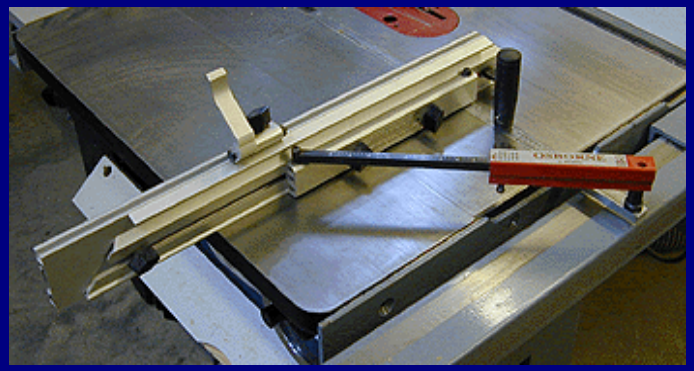
Varying Tool “Strengths”

- “Classical” system engineering tools
  - Examples: CORE, Cradle
  - Support full life cycle
  - Expensive
  - Annoying “security” measures
  - Cumbersome to integrate with other tools
- Software engineering/code generation tools
  - Examples: Rational/Rose, Rhapsody
  - Feature UML, which is Greek to most system engineers, but not necessarily bad
  - Expensive

What's Wrong?

- Imagine being a framing carpenter in this world:
  - The customer provides all hand tools
  - Each house uses a different set of tools
  - Learning one doesn't mean you know the others
  - Jigs you make for one tool won't work for others
    - A jig is a special-purpose tool, often a tool for a tool
- This is a lot like our world:
  - The customer or employer chooses the tool
  - Changing projects or employers often means changing tools
  - Your personal bag of jigs isn't very portable
  - It's hard to accumulate expertise over many years

Example: Table Saw Miter Gauge



- Works with any table saw
  - Use standard interface
- Saves time and money
- Increases your skill
- Learn it once, use it forever

The Price Catch-22

- The market for system engineering tools is small compared to more general purpose tools (e.g., Visio)
- This, among other things, leads to relatively high prices (compare with $500 for Visio Professional, a highly capable tool in its domain)
- Which keeps the market small, which....
- When the tool is expensive, the vendors waste resources building security features instead of features you care about
  - These “features” get in the way of doing work

An Alternate Future

- Tools are “free” in the sense of being unencumbered
  - They're also low-cost *because* they're unencumbered
- Free system engineering tools create a *lingua franca* for SE the way the web has:
  - How many of you used the terms “home page”, “web site”, “link”, or “blog” before 1990?
- SE tools have a long lifetime
  - Tools become more powerful to meet user needs
  - Users become more powerful as their tools grow
- Is this some kind of Communist fantasy?

Free and Open Source Software

- There has been a significant movement in the software world since 1984 to create a complete software environment (kernel, utilities, applications) free of all proprietary claims
- This movement is *highly* politicized (in ways that do not concern us right now) and not entirely unified
  - The “Free” and “Open Source” camps don't agree
- This movement has produced some things you may have heard of
  - Linux, Perl, Netscape
- And lots of things you probably haven't

Other FOSS Products

- OpenOffice
  - Full-featured office automation suite
- GCC
  - High-performance compiler suite
- KDE, GNOME
  - Desktop environments and toolkits
- MySQL, PostgreSQL
  - Relational DBMS
- Mozilla suite
  - Web browser, email
- Python, Ruby
  - Object-oriented languages
- Apache
  - High-performance web server
- Sendmail, Postfix
  - Email transfer agents
- TeX, LaTeX
  - Typesetting

FOSS Success Stories

- RedHat (Linux vendor) posted 22% 12-mo profit margin ending Nov 2004
- Netcraft says Apache is by far the most popular web server on the Internet
- IBM has made major investments in Linux and open source business
  - And claims to have made it back already
- Amazon claims 25% savings switching to Linux
- MySQL AB has sold commercial support for a free product for more than five years
- Firefox is rapidly growing in popularity
  - Try it!

SourceForge

- SourceForge is one of the primary collaboration sites for open source development
- Some interesting statistics
  - More than 1,000,000 registered users
  - 700 new users added daily
  - 97,000 registered projects
  - 70 new projects added daily
  - 12 million page views daily
  - 1.2 million program downloads daily
- Clearly, something is happening here

What Do We Need For SE?

- Database management
- Data architecture
- Text browsing/editing
- Graphical browsing/editing
- Reasoning
- Simulation
- Document production
- Distributed computing framework
- Access control management
- Neutral import/export
- Application frameworks

FOSS Offerings

- Data management
  - MySQL: full-featured high-performance RDBMS
  - phpMyAdmin: web-based MySQL administration
  - PostgreSQL: robust object-relational DBMS
- Data architecture
  - Protégé ontology editor
- Text browsing/editing
  - Protégé knowledge base editor
- Graphical editing/browsing
  - Dia: Visio work-alike
  - ArgoUML: UML modeling tool suite

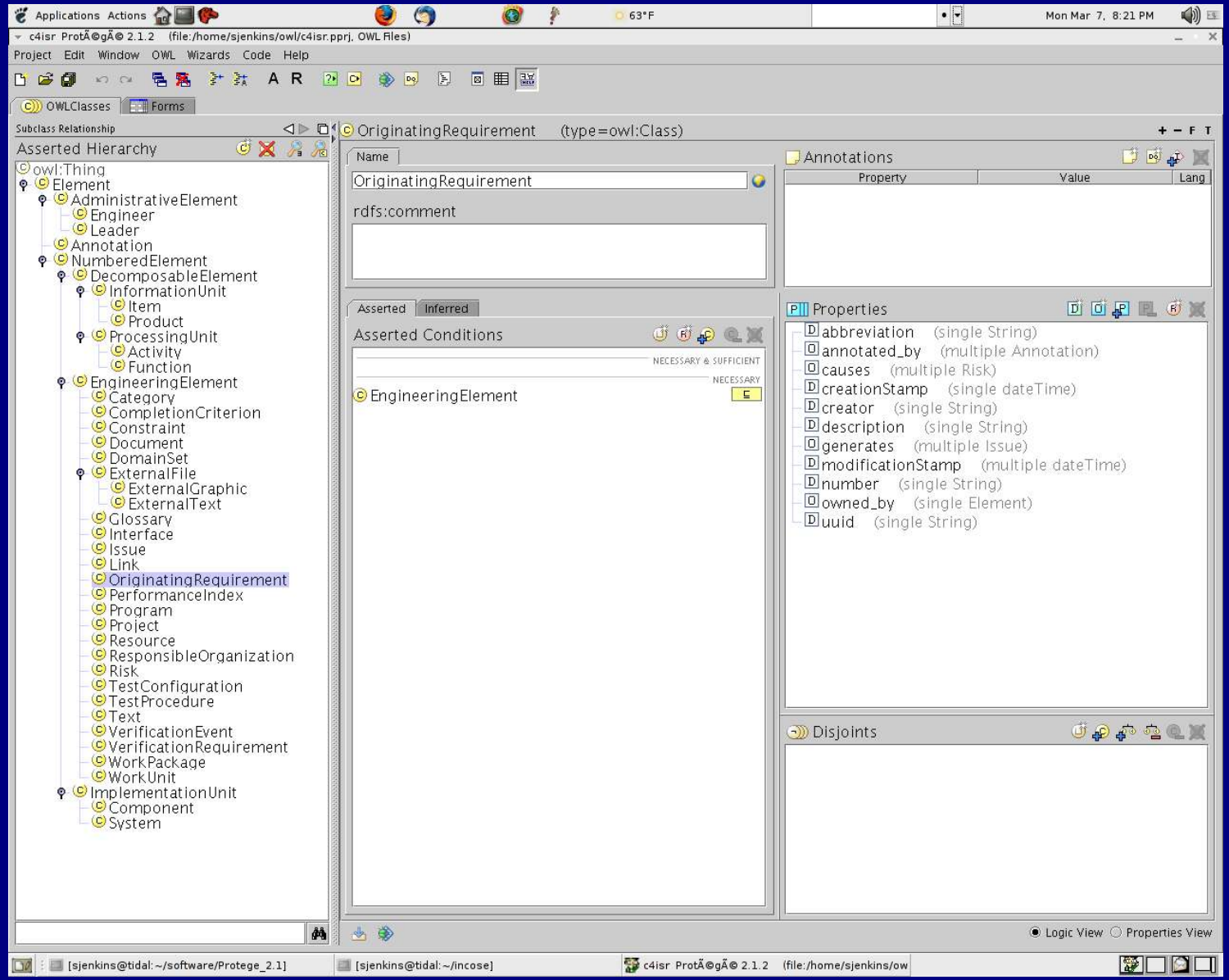
FOSS Offerings

- Reasoning
  - CLIPS: expert system tool
  - OpenCyc: knowledge base and reasoning engine
- Simulation
  - Ptolemy II: modeling and simulation framework
  - SimPack: discrete event simulation package
- Document Production
  - SGML/XML/DocBook: semantic markup for technical documentation
  - OpenJade: XML processor
  - TeX/LaTeX: typesetting
  - XML-based web publishing tools

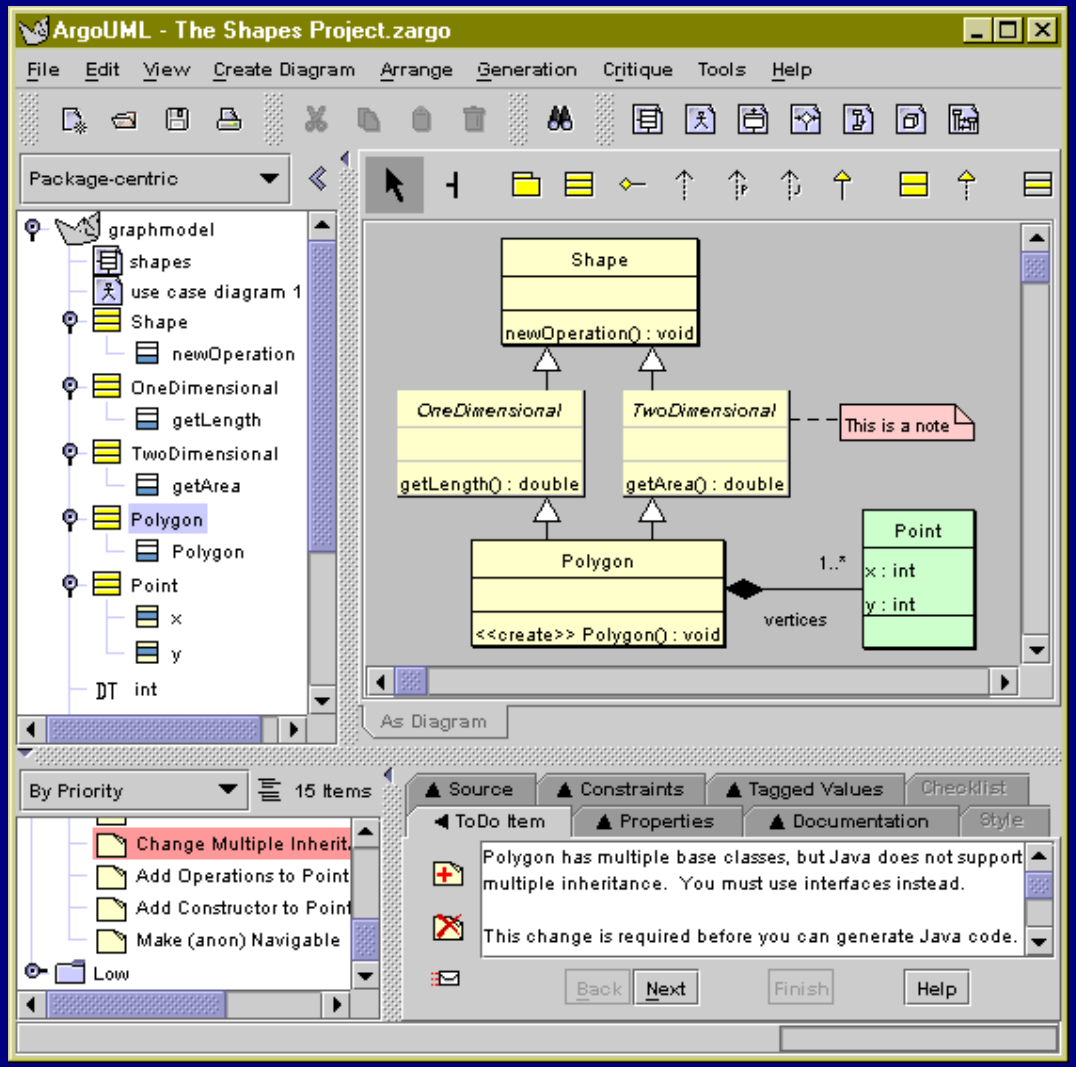
FOSS Offerings

- Distributed computing framework
  - Zope: Web application server
  - Rails: Web application framework
- Access control framework
  - OpenLDAP: online directory
  - GPG: public-key encryption toolkit
- Neutral exchange formats
  - SysML/XMI/STEP
- Application frameworks
  - Eclipse: universal development platform

Focus: Protégé Ontology Editor



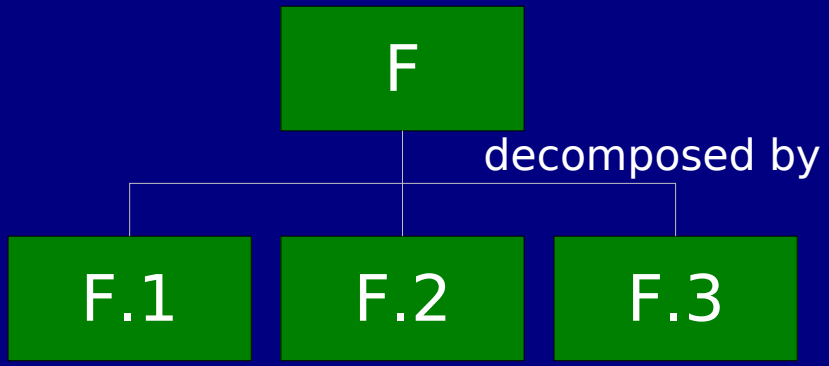
Focus: ArgoUML

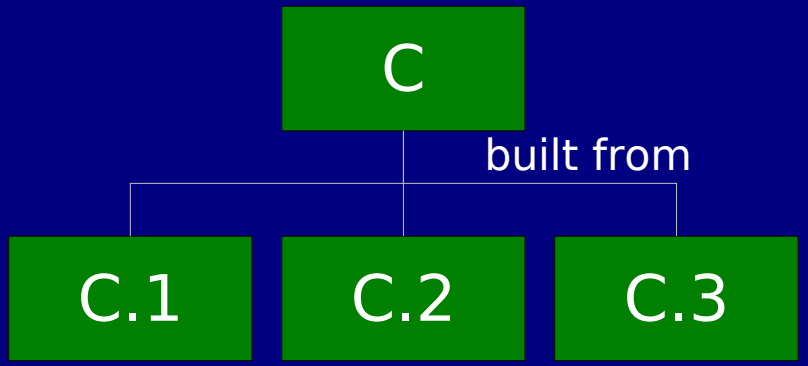


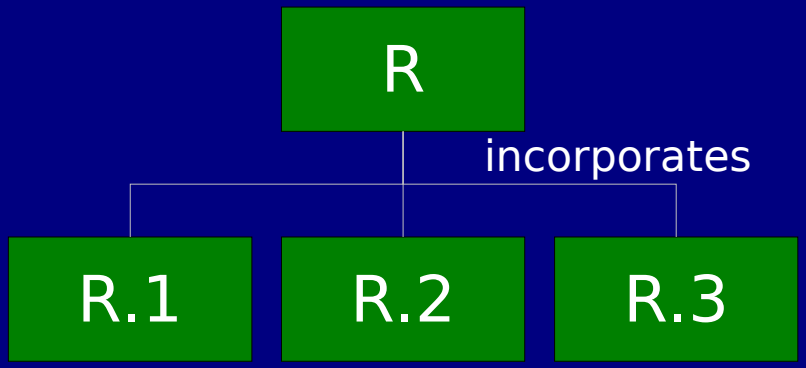
A Real Example

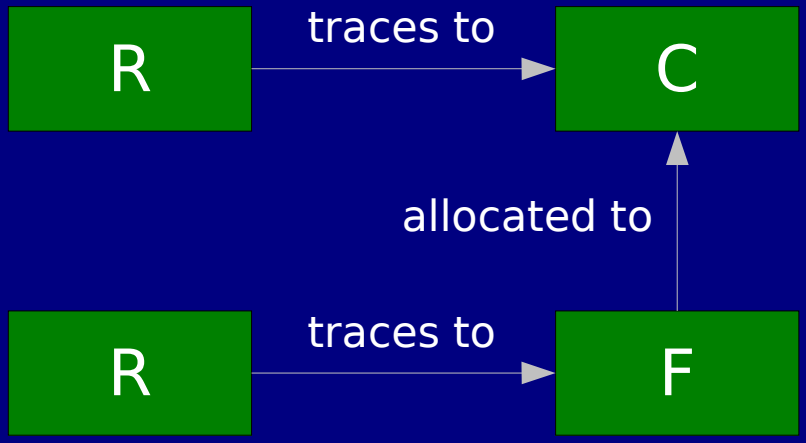
- Just to show what you can do with FOSS parts
- A system engineering model application
  - Database consisting of
    - Elements: Components, Functions, Requirements
    - Relationships: 'incorporates', 'traces to', 'allocated to', 'built from', 'decomposed by'
  - Document production system
    - Extracts elements from the database
    - Produces a MIL-STD-490-like document in DocBook format
    - DocBook file can be translated to HTML or high-quality PDF
  - No user interface yet (not my strength)

Simplified Model Schema









Size of the Test Model

- Components
  - 6 levels deep
  - Every component has 3 children except Level 6
  - Total of 364 components
- Functions
  - 3 functions allocated to each component
  - Function *n* allocated to child component is a child of function *n* allocated to parent
  - Total of 1092 functions

Structure of the Test Model

- Requirements
  - 5 non-functional requirements trace to each component
  - 2 functional requirements trace to each function
  - Requirements form a tree like Components and Functions
  - Total of 4004 requirements
- Total of 5460 elements
- Relationships
  - Total of 10555 pairwise relationships
- Stored in a MySQL database
- Populated by a driver script written in Ruby

Spec Document Generator

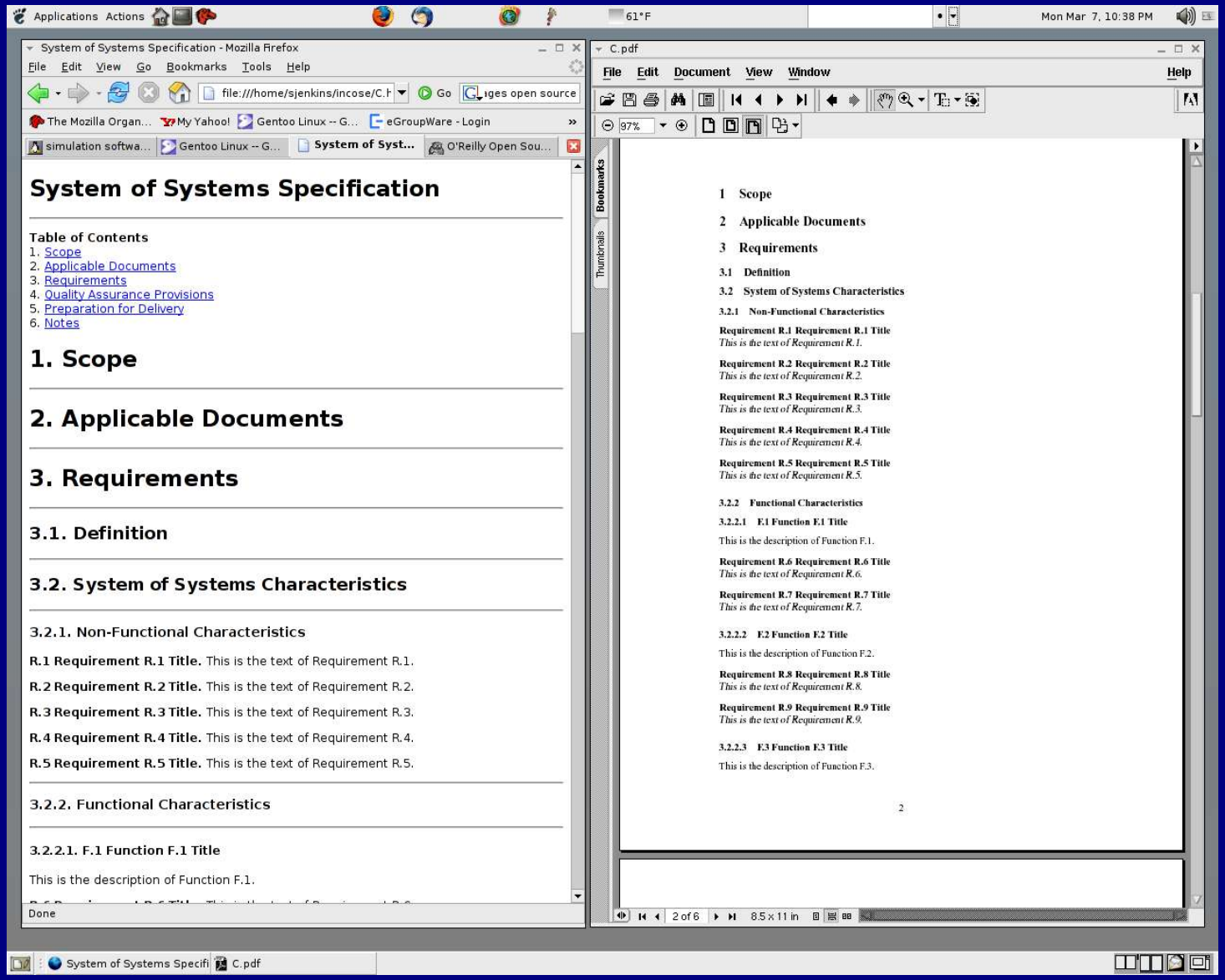
- Objective: for any of the 121 non-leaf-level components, print a specification document
  - In Section 3.2.1, print all non-functional requirements tracing to that component
  - In Section 3.2.2, print the description of each function allocated to that component, and print the functional requirements tracing to each
  - In Section 3.7, for each child component:
    - Print all non-functional requirements
    - For each allocated function, print all functional requirements
- Script produces DocBook (XML) output

Excerpt from the DocBook Output

- Markup shows structure and content, not presentation
- Presentation is added by back-end processing

```
<section role='subsubsection'>
<title role='subsubsection'>Non-Functional Characteristics</title>
<simpara role='empty'></simpara>
<formalpara role='requirement'>
<title role='requirement'>R.1 Requirement R.1 Title</title>
<para>
This is the text of Requirement R.1.
</para>
</formalpara>
<formalpara role='requirement'>
<title role='requirement'>R.2 Requirement R.2 Title</title>
<para>
This is the text of Requirement R.2.
</para>
</formalpara>
<formalpara role='requirement'>
<title role='requirement'>R.3 Requirement R.3 Title</title>
<para>
This is the text of Requirement R.3.
</para>
</formalpara>
<formalpara role='requirement'>
<title role='requirement'>R.4 Requirement R.4 Title</title>
<para>
This is the text of Requirement R.4.
</para>
```

After Output Processing



Example Summary

- All done on my home Linux system (1 GHz PIII)
- Model data stored in MySQL
- Application scripts and libraries written in Ruby
  - 519 lines of code total
  - A few hours work, mostly learning new tools
- Og object/relational mapping library used to access database from Ruby
- OpenJade used to translate DocBook to HTML
- Custom script used to drive LaTeX to produce PDF
- Time to extract data for any component and generate both outputs: about 10 seconds

What Does This Prove?

- One guy casually messing around on a <$1k computer with free software can make something that does real work and scales
- From this, I extrapolate that a handful of people working part-time for a year could produce a usable toolkit
  - Largely by writing interface code to glue existing software components together
  - For the most part, the programming is elementary
  - Some specialized knowledge is required for building user interfaces, etc.
- Should we do it?

Envelope Economics

- It is not unusual for a large company to spend $20k/yr on software maintenance for tools
  - Some spend a lot more
- Suppose 100 companies decided it's in their interest to invest .1 FTE annually on FOSS
  - Having a staff programmer write code and donating it to the tool suite
  - 10 FTEs is more than some tool vendors have
  - Arrangements like this are not unusual
    - Much FOSS code is written by salaried employees with the blessing of their employers

What About Tool Vendors?

- Our purpose is not to put them out of business
- But (personal opinion) $5k and up for a single-seat license is not sustainable
  - Not when operating systems are $200 or less
  - Not when powerful applications are $500 or less
- So how do people make money with FOSS?
  - Services and Consulting
    - Same way they do with commercial software
- System engineering is *hard*
  - People need help to do it
  - It's easier to sell them help if their CIO doesn't have to approve a large software procurement

Recipe for Consulting Success

- Write the definitive how-to book on SE
  - Not a textbook, but a *workbook*
  - Establish yourself as the expert in getting it done
- Include a CD in the back with the FOSS toolkit
- Give away copies of the book at INCOSE meetings
- Your sales pitch:
  - Take the book; it's yours
  - Take the tools; they're yours
  - Your data is always yours
  - Pay me for my skills, expertise, connections, judgment, knowledge, reputation, experience, ...

Role of Data Exchange Standards

- Data exchange standards are about interoperability and transparency of design
- They don't address (directly) what you can do with design data
  - Just how you move it around
- But data exchange standards are essential for code reuse of the kind we need
- A tool I develop is useful for you if (and only if)
  - The transformation is performs is useful
  - You can get your data in and out of it
- Parsers and emitters for standard formats should be some of the first code written

Possible Next Steps

- Drum up support
- Set up a collaboration site (e.g., SourceForge)
- Establish a not-for-profit foundation to manage development
  - Like Apache, Mozilla, OpenOffice
- Perform system engineering analysis of tool needs and requirements
- Issue Requests for Technology to see
  - Who has what
  - Who's willing to contribute
- Formulate a development roadmap
- Get to work!

What Do You Think?