Information Design Journal 10(3), 221–228

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Applications of isometric projection for visualizing web sites

Keywords: web sites, isometric projection, information architecture

This essay describes the application of diagrams that use the form of isometric projections to visualize the contents of a web site. We begin by characterizing the data that makes up a site: documents, computer programs (applications), and the links that connect them. We describe a way of visualizing web sites in diagrammatic form for the teams that plan, build, and maintain the site. We propose that isometric projection has several strengths for presenting this kind of information. The advantages of an isometric over a 2-D (flat) diagram are described. We also note several weaknesses that must be accounted for when using this technique. We then describe the visual language we have developed for this kind of diagram. In conclusion, we present the case for hand-built, rather than automatic, methods for creating these kind of visualizations.

The data

It is fair to say that interaction with web sites has become a major part of the experience of computing throughout the world. Before beginning our discussion of why and how we visualize them in diagrammatic form, a brief definition of what we mean by a 'web site' is in order.

A web site is a group of documents and computer programs (applications) accessed by a web browser. Using a common access protocol, HTTP (hypertext transfer protocol), the web browser program can request documents and applications from any participating web server program on the public Internet. The content of these documents, and the common interface to these programs, is HTML (hypertext markup language), a simple text markup language that has been modified and extended several times since its introduction in 1989. An HTML document can make reference to or otherwise include many kinds of non-textual digital data, such as graphics, audio, video, and animations. It can also contain instructions to programs, such as email applications, search engines and database applications, which in turn can generate new HTML documents.

The hypertext link is a fundamental element of the HTML language, which allows navigational instructions to be embedded in just about any element on a document, commonly referred to as a web page. This allows the creator of a web site to link any document to any other document located on any web server on the Internet. These hypertext links have no type, classification, or structure other than uni-directional point-to-point navigation. As such, a hypertext has no inherent topology. While a web site may have a presumed point from which the exploration starts, the home page, there is no explicit information in the link data itself that provides any instruction as to the organization of the linked documents.

One general characteristic of a web site is navigation through user choice. Unlike a print publication, which contains an explicit sequence in the order of the bound pages, the web site is a hypertext, a non-sequential collection of documents. However, the control and management of a user's path through the web site is a major goal of web site design. By 'control and management' we mean that one of the designer's goals is to enable and support the user in their exploration of the site. The web site is a virtual space to be navigated. In this sense, it is analogous to any man-made physical environment. The creator of the building or landscape presents a person who enters it with a system of directions enabling informed choice about paths to be taken. As we can say about interaction with any man-made environment, a user's sense of choice seeks a perceived structure to provide direction. There are items to be located, anticipated interactions to be encouraged and supported, and information that will best be understood when presented in specific contexts.

The purpose of visualization

As users of a web site, we need to comprehend the space we are presented with. As creators of a web site, we need to plan and build a site to suit a specific set of usage goals. Both the user and the creator are presented with the task of visualizing this space. In this essay we will focus entirely on the use of visualization to support web site planning, analysis and creation. The kinds of visualizations we describe below were created to communicate information architecture concepts to clients.

In our experience, the intuitive nature of isometric diagrams makes them a perfect tool for bringing together people involved in the planning stages of complex web sites. Such groups may consist of persons with different professional backgrounds representing various levels of technical knowledge. Discussion about these diagrams becomes a crucial part of consensus building in the decision-making process.

Web sites can be represented as hierarchies of documents arranged in a tree structure. Strictly speaking, a hypertext is not a hierarchy, as many pages (nodes) can be reached by multiple navigation paths. However, in the planning and design of a web site all navigation paths are not equal. Starting from the home page, there is generally a group of pages that present the main topics or sections of the content. These 'level 1' pages are linked to sub-sections or related documents. By using this directed graph approach, the network of links can be placed into a tree topology. Most web sites can be represented as a 3- to 5-level tree.

Many of the early hypertext systems that preceded the World Wide Web, such as Xerox Notecards, used this technique to represent an overview of a specific hypertext network (see Utting and Yankelovich 1989 for a survey of early hypertext visualization techniques). Another example of hierarchy in visualization is the NetObjects products (www.netobjects.com), a commercial web authoring tool which assigns 'levels' to pages as they are created and builds a tree graph for the author.

The most common problems with this approach are utilization of space and the representation of links that do not adhere to the tree topology. The space problem is simple to explain. A flat representation of the tree becomes wide (or long) very quickly. This makes the overview difficult to grasp in a single view. The application of magnification on sections of the tree in combination with a reduced view of the entire structure can and has been used. The hyperbolic tree, developed at Xerox PARC and applied commercially by the InXight Star Tree (www.inxight.com), addresses the space problem by growing and shrinking portions of the tree through user interaction (see Lamping, Rao & Pirolli 1995 for a discussion of the geometry used for this visualization). While these techniques are useful, the loss of visual context and the absence of appropriate detail do not satisfy the need for a single comprehensible view. In our experience, the client needs a single overview of the entire structure to grasp the 'shape' of the web site.

We refer to the organizing or structuring of a web site as the information architecture. Our own practice of visualizing or 'mapping' web sites largely grew from the need to communicate the structural ideas behind our proposals for organizing or re-organizing web sites for clients. Often the first task in a project was to help the client 'see' what already existed on the site, or to visualize the structural implications of a set of requirements. Through repeated practice we found that the best method to critique existing architecture and to introduce new information architecture concepts was to create a visual overview of the content and interactions of the elements of the web site.

These visualizations were artifacts from a larger dialog with the clients, to discover and describe the best organization for the web site content. We found that the introduction of a third dimension to represent depth in the tree structure made the representations easier to understand. We all have the common experience of ourselves in a three-dimensional world. While not everyone can fluently draw three-dimensional representations on the two-dimensional space of a page or computer screen, we all can understand them. This experience gives a special quality to three-dimensional representations of information. When applied correctly, the introduction of depth makes the information easier to grasp by appealing to our intuitive understanding of space.

Application of isometric projection

In our information architecture practice, the first stages usually involve discussions with management and marketing professionals. This audience needs to have a sense of the overall shape and major components of the web site. We have found the isometric projection well suited to this task. The visualization works best as a large printed diagram, large enough to contain the necessary detail and organized to provide at a glance information about high-level structure. In this sense, it functions much like a city map or museum floor plan, providing the viewer with a sense of the organization in a single view while providing detail on specific locations. The same diagram can be presented in PDF format on the computer screen. However, the lower resolution of the screen, even at 1024 pixels wide, does not support the visual experience as well as a printed page. The requirement to magnify the view in order to read specific details introduces the same loss of visual context mentioned above in our discussion of large tree structures.

The application of isometric projection to represent a web site grew from several models. The technique is commonly used for architectural drawings. By representing a building on an isometric grid, the drawing can present details in the foreground and background on a uniform plane, aligned to the parallel lines of the grid. This avoids the reduction of background elements dictated by the geometry of a vanishing point perspective view. The same technique has been applied for mapping cities. A classical example of this is the Turgot map of 18th century Paris, an engraving produced in twenty sections. This map uses a raised point of view and isometric projection to represent all the building structures of the city as well as the major streets and geographical features. A portion of this map, along with a 20th century orthogonal map of Manhattan, are reproduced in Tufte 1990 in his discussion of Micro/Macro Readings. The full map is reproduced in Rouleau 1989.

Using this technique to visualize a web site brings with it two useful associations. First, the web site is seen as a space with depth. The site 'begins' at the lower left of the drawing, with the suggestion that the user will move 'into' the site by following links between adjacent pages, moving towards the upper right. In this way, the third dimension also reflects the element of time measured in number of 'clicks' needed to reach each level. Second, the Z dimension can be used to imply navigational connection without requiring additional visual symbols, such as lines or arrows. The illusion of depth carries with it the implication of connection between elements that are behind each other on the plane. In addition, the isometric projection allows us to introduce depth while still representing the foreground and background elements at the same size. This is critical for presenting detail in a uniform way throughout the visualization. In contrast to orthogonal three-dimensional representations used in architectural drawings that give preference to one plane over the other two, isometric projections allows for equal visibility of both vertical and horizontal planes, making it possible to include equally legible labels on every element of the diagram.

Along with these advantages comes a distinct disadvantage. Both the horizontal and vertical plane of the projection are skewed from the surface of the page. While contemporary drawing programs make it easy to align type to any surface on this grid, the fact that the type is skewed makes it more difficult to read. As a result of this problem, we have often used the isometric projection in combination with flat inserts containing large text blocks or representations of computer screens. In this way, better legibility can be combined with an economic use of space in the diagram.

In the terminology of Jacques Bertin's matrix theory of graphics, these diagrams could be considered reorderable networks with fixed topology (Bertin 2001) They are optimized for presenting comprehensive patterns of high level structures, with elements sorted on a depth axis according to their position in a hierarchy, while the value of the marks represented by color, size, vertical position, etc., carries secondary information. Portions of the floor of the grid can be bounded to signify grouping. This floor, or carpet, can be moved to positions above the base plane. The vertical position can then be used to signify other aspects of the information. Care must be taken to respect the alignment of elements to the grid and connection of lines between elements, to maintain the visual logic of the composition. When this is done, the relationship of the various elements are understood by the reader largely through intuition, without reference to an explanation key.

Elements of an isometric map

The basic elements of the isometric map can be described in these eight examples.

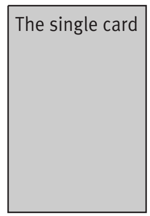

Figure 1. The element representing a web page is a rectangle, or card. This element can have text, color, or symbol applied to signify information about the page.

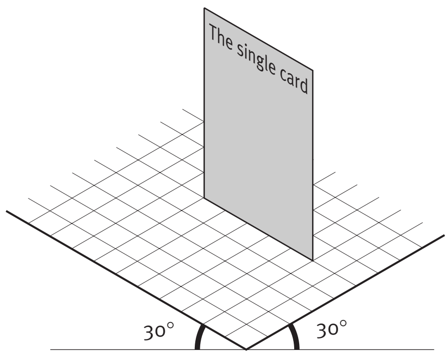

Figure 2. The card is aligned to an isometric grid, set at 30-degree angles to the surface plane.

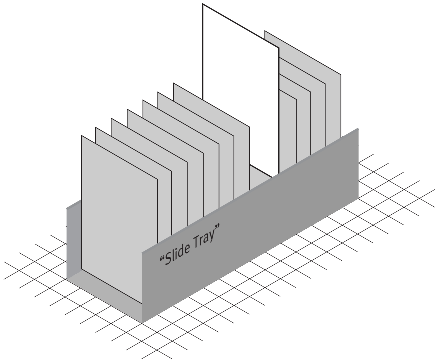

Figure 3. Cards can be grouped into slide trays, with individual cards raised from the tray to expose additional surface. This technique can be used to signify groups of pages stored in databases, or otherwise similar in value. The raised page can carry further information on the exposed surface that by implication is applied to the group. In some cases it can be used to highlight an individual example and/or illustrate a process.

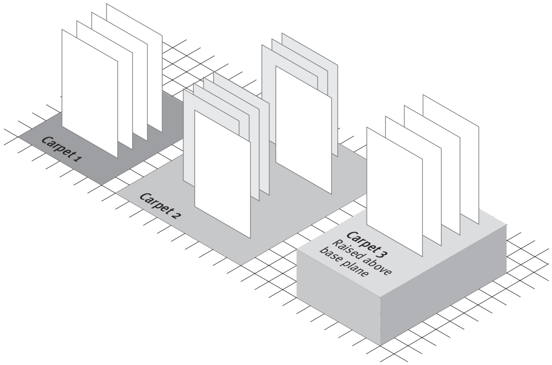

Figure 5. Cards in this orientation can be further grouped by adding carpets on or aligned with the base plane. This carpet can carry grouping information in the form of colors and text labels. The carpet can also be raised above the base plane to indicate separation of groups, such as distinctions introduced by access control models.

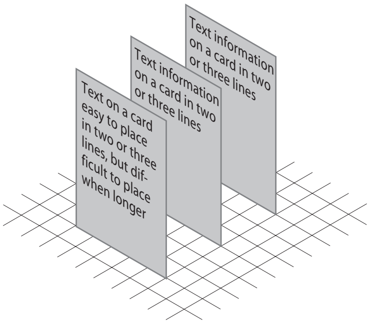

Figure 4. Cards can also be placed behind one another, at varying distances, to indicate structural groups with specific content variations. For example, pages within a section of a site can be illustrated in this fashion, with specific content for each page applied to the individual cards. Increasing the placement distance provides more exposed surface for presenting information about the individual page.

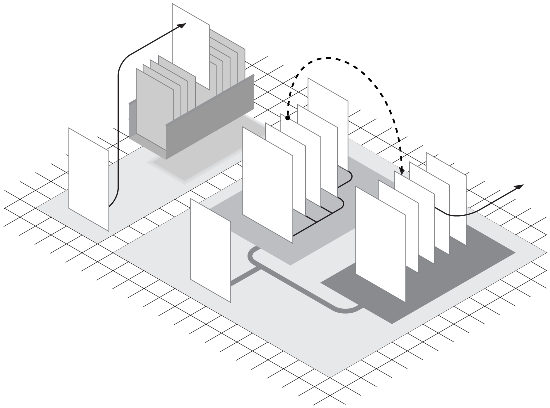

Figure 6. Lines connecting cards and carpets can be introduced in several positions. The diagram can represent main navigational paths by adding a minimum number of lines on the base plane. Lines can also be added to other positions representing pathways in a specific process (the solid line on the left), the flow of information between pages (the dotted arc), or links that lead out of the web site to other pages on the Internet (the solid line on the right).

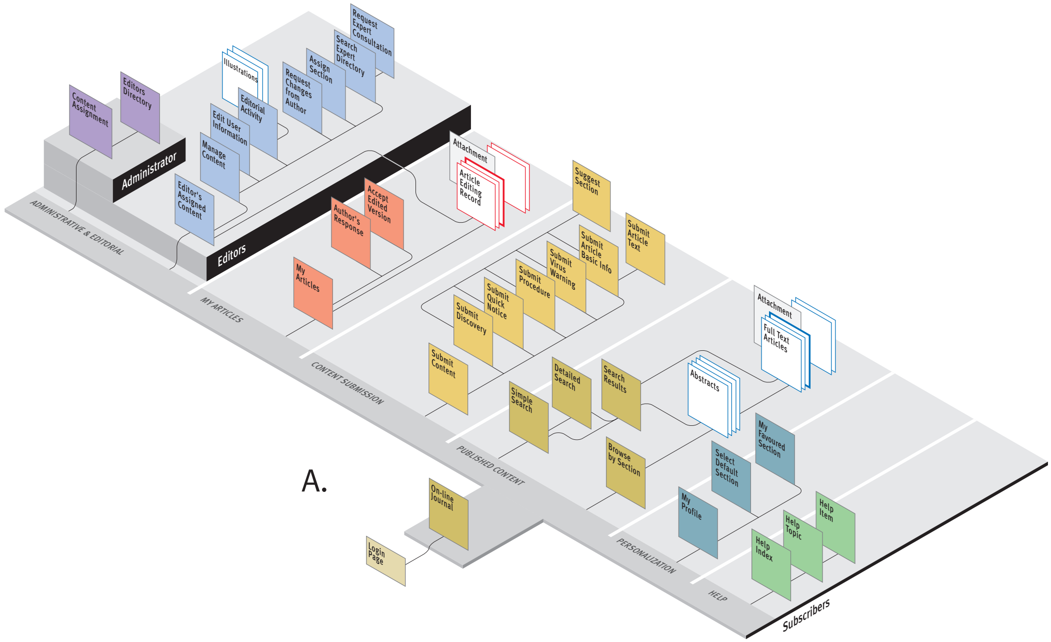

Figure 7. These elements can be combined to visualize and explain both structure and process in a web site. **Plate A** shows a web site for an Online Journal application. (The color version can be found at: http://www.benjamins.com/idj.) The site has a six-part structure, illustrated by separations in the carpet with text labels at the head (lower left) of each carpet. In addition, the section on the upper left is subdivided between Administrators and Editors, indicated by a difference in color (violet and blue) and in the height of the carpets. The cards representing pages are further distinguished by seven color fills or white fill with colored borders. These sections would be reflected in the global navigation requirements for each page, to be implemented in the final page designs.

The access model has three parts, illustrated by three raised planes. The Login Page is the only 'public' section of the web site. The user area of the site is raised slightly above the base plane, to illustrate that an account and password is required to navigate beyond the Login Page, presented at the start of the site on the lower left. Two further 'levels' of pages are shown for Journal Editors and Administrators, which are accessible only to special accounts. The lines connecting the cards on the carpets illustrate main navigational pathways within each section.

The click-depth of the site, that is the number of links that must be followed to reach a specific page, can be understood by reading the diagram from front (lower left) to back (upper right). In this case, access to the main page in each of the sections is two clicks deep, while the depth of specific pages in the sections vary according to the selection made on the third click.

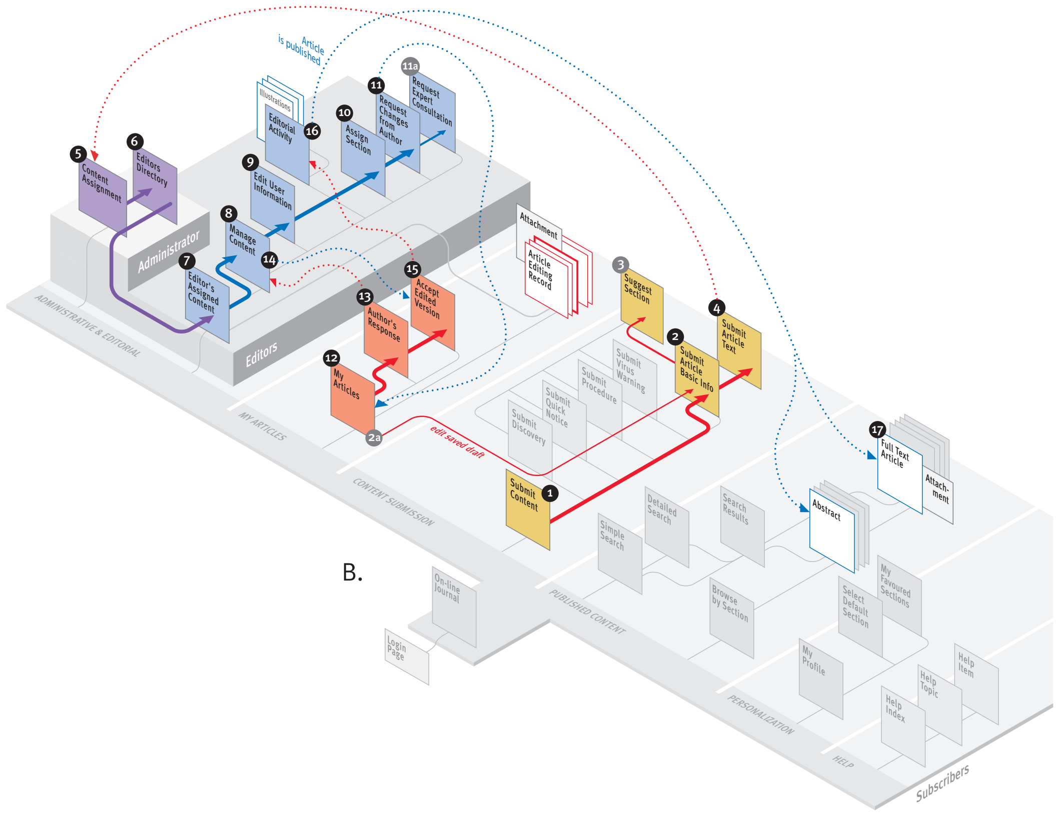

Figure 8. Plate B shows the application of the same diagram to illustrate a specific process — the submission of articles by users and their review by the editors and administrators. (The color version can be found at: http://www.benjamins.com/idj.) Pages not involved in the process are grayed-out, to focus attention of specific parts of the site. Numbers are applied to the pages, to be explained in a narrative or key. An article is submitted by the user (1–4), evaluated and assigned to an editor by an administrator (5–6), responded to by the editor (7–11a), accepted by the editor with the user's cooperation (12–14). The final text is accepted or rejected by the user (15), and finally published by the editor to the general publication area (16–17). The two kinds of actions are shown with two kinds of raised lines. The solid lines indicate the sequence of steps followed by the users, editors, and administrators, while dotted arcs show the flow of information that results from their actions. Two colors are used for the lines, to distinguish actions and information initiated by users (red) and by editors and administrators (blue). Text labels can also be applied adjacent to the lines, to support the explanation.

The case for hand-built maps

We are often asked what software we use to create these maps. The answer, Adobe Illustrator, is always disappointing to the people who ask. We would like to believe that a computer program could automatically map a web site, or the plans for a web site, and relieve us from the task of organizing and arranging hundreds of elements in a diagram. In this age of ubiquitous computing, it seems counter-intuitive to do this kind of work 'by hand' even when that hand is largely aided by a powerful, though generic, computer graphic program.

It is possible to programmatically generate isometric maps of portions of any web site from the document and link data. We created such a program, MAPA, which is described in Durand and Kahn 1998. This program was intended to be a navigation tool for users of large web sites. The experience presented two basic problems. First, the representation was too generic. While structure can be induced from the link data, the intended grouping and thematic association of pages cannot. As a result, the map presented a structural view of the web site that was too 'pure' to be useful. Second, the map always presented the actual data in a uniform manner. In fact, we rarely want to see literally everything a web site contains, unless we are a system administrator.

In fact, the main purpose of visualizing a web site is to highlight selected aspects of the data for a specific audience. The task of designing a computer program that would first capture all possible values and relationships and then allow the designer to selectively hide, reveal, highlight, and combine these values is enormous. At the same time, we can accomplish this enormous computing task by doing the same operation in the brain of a skilled information designer. This allows us to use our human intelligence for one of its most suitable tasks – resolving the ambiguity of a client's intentions, identifying and highlighting the discrepancies between intention and execution, and presenting the results in a form that will stimulate and support discussion. The computing power of a program such as Illustrator can be applied to the rendering process, without constraining or interfering with the creative process.

Web sites are inherently less static than printed publications or buildings. Books can be revised and buildings can be renovated and modified, but both are not daily or monthly occurrences. Web sites change frequently as information is easily added or removed. Many web sites are 'dynamic' in the sense that their pages are created programmatically through a combination of user interaction and database content. Therefore a 'static' representation of a web site, such as the hand-made visualizations we describe here, would seem to be inappropriate. Such visualizations do not change automatically along with the web site they describe.

We recognize this problem, but feel quite strongly that this technique is appropriate and extremely useful for several reasons. First, the purpose of these visualizations is communication. Communication occurs when the appropriate level of detail is presented to the audience. This communication is often tied to a specific moment in time, such as the planning stage for a new web site or the analysis of the site at the moment when it is to be revised. Secondly, while these time-slices may represent only a single point in a continuum, a clear representation of that single point is more important than a complex representation of the time-series recorded in megabytes of web log data. The same web site can be visualized at different stages in its development. An example of this, maps of the Nature web site from 1998 and 1999, are reproduced in Kahn and Lenk 2001. A comparison of the two diagrams help to reinforce an understanding of the changes that occurred during that period. Thirdly, while many web sites are populated by dynamic data, the structure of these sites remain the same as the content changes. Maintaining a stable structure is important for usability. While we all enjoy occasional changes in the arrangement of our office or home, few of us would enjoy returning to a completely new arrangement each day. A major e-commerce site, such as Amazon.com, is a good example of this combination of stable structure filled with ever-changing content. A diagram of this site from 1999 is also reproduced in Kahn and Lenk 2001 using a slightly different technique.

While web sites share many basic features, the significant details are often unique, both to the site and to the communication situation with the specific client. We have found that the technique described here can be used repeatedly, largely because it is flexible enough to express the many unique details of different web sites. Such techniques can be used for sites regardless of size. While creating a single overview of a web site containing many thousand documents may seem impractical, it can be done in 'real world' situations. We should always remember that a representation of the significant structure is more important for communication than reproduction of all individual details. Maps are a record of differences, not a reproduction of the territory. The target of the map is the most powerful selector, expander and arranger of the differences being communicated: the human mind.

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