A Graphical User Interface Integrating Features from Different Hypertext Domains

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Abstract. Integration of different hypertext domains is a relatively new concern to the hypertext community. This paper presents an integrative design of graphical user interfaces of hypermedia systems. This design embraces features from navigational, spatial, taxonomic, and workflow hypertexts. The result is a visual hypertext with a rich set of visual components and user interface mechanisms.

1 Introduction

One of the most important aspects that make hypertext popular is its intuitive appeal for users to browse information following explicitly indicated (visible) relationships or structures. Different flavors of hypertext are currently emerging with the goal of covering the specific needs of various application domains. Navigational, spatial, taxonomic, and workflow hypertexts are some examples. In the research community of open hypertext systems (OHS) much effort is being invested towards achieving interoperability between these hypertext domains. For instance, a component-based architecture has been developed to extend and utilize hypertext components from different hypertext domain in an open hypertext system [1]. In addition, a common data model has been developed for navigational, spatial, and taxonomic hypertexts [2]. Work has been already done mainly aiming at interpreting hypermedia belonging to one domain with the goal of visualizing it in some other [2]. However, how to integrate the user interface features found in these hypertext domains or how to meaningfully combine the look-and-feel of these flavors is still an open issue.

The rest of the paper is organized as follows: section 2 provides an introduction to different hypertext flavors of four well-known hypertext domains. Section 3 describes the motivation for the co-existence of the user interface features found in different hypertext domains. Section 4 presents an integrated design of a visual hypertext that embraces selected user interface features of different hypertext flavors. Section 5 discusses related work and the contribution of this work to the literature. Section 6 concludes the paper.

2 Hypertext Flavors

Following, we provide a brief description for each of the previously mentioned hypertext flavors. Emphasis is not placed on their underlying models, but on their look-and-feel, i.e. the visualization and navigation aspects that this paper tries to integrate:

- Set-based, *Taxonomic Hypertext [3]*: In this domain, relationships are indicated by nested, composition structures. Navigation in a taxonomy hypertext is to move up and down within its hierarchically nested structure (by closing or opening a composition structure at different levels).
- Layout-based *Spatial Hypertext [4]*: In this domain, relationship is indicated by spatial layout and visual characters of composition structures. Navigation within nested structures in spatial hypertext is similar to that of taxonomic hypertext. The difference lies in the fact that the graphical layout of the components at each level reveals the relationships between these components. For instance, related elements are placed near to each other or grouped in a composite. To navigate among components at the same level of a composition structure is to move from one component to the other mentally, based on the visual clues or to zoom or scroll in a content pane manually.
- Graph-based, *Navigational hypertext*: This is the classical hypertext model, which is based on nodes and links [5]. In navigational hypertext, relationships are indicated by embedded and/or explicit links. Nodes of navigational hypertext are normally presented as multimedia documents with embedded links (as in the case of web documents). Activating an embedded link has as a result the target node being displayed. Navigational hypertexts are also commonly presented as maps (i.e. as graphs of nodes and links). Opening a node in a map leads to the display of such node as in the previous case. When opening a node from a document or a map, the same or a new window can be used. Link representations (e.g. lines) in a map are often purely visual relationship indications.
- Automata-based, *Workflow Hypertext [6,7]*: Workflow hypertext is hypertext with application domain specific computational semantics. The computational behavior attached to nodes and links can support process enactment, for instance, to cause data or control to flow along the explicit workflow links. The control flow semantics can be used for process animation, which can serve as a mechanism for the implementation of guided tours.

3 Co-existence of Different Hypertext Flavors

In our experience of constructing holistic process centric enterprise models using hypermedia based visual languages, we have found the need for combining display mechanisms from the various hypertext domains into a single interface representation. For instance, while explicit link representations (e.g. as arrows) are good for expressing that an Actor has been assigned to a task, proximity is better to express that the Actor belongs to a given team. We use composition structures to express the way complex task are composed by simpler ones. However, we use proximity to indicate teams of Actors and explicit representation of links (arrows) to indicate dependencies between tasks. Figure 1 shows another example where the visual and layout based spatial hypertext and graph based navigational hypertext co-exist. In Figure 1, a list of pie chart images are placed together representing Market Segments. The Business Partner (as an image of shaking hands) and the Business Competitor (as an image of wrestling hands) are placed near to each other with images of the same background. Explicit links (represented as arrow lines) are used to indicate that some of the market segments are in the scope of the business partners and that others are in the scope of the business competitors. Here the navigational (semantic network map) metaphor is used together with the spatial and visual metaphors to enrich the expressiveness of spatial hypertext.

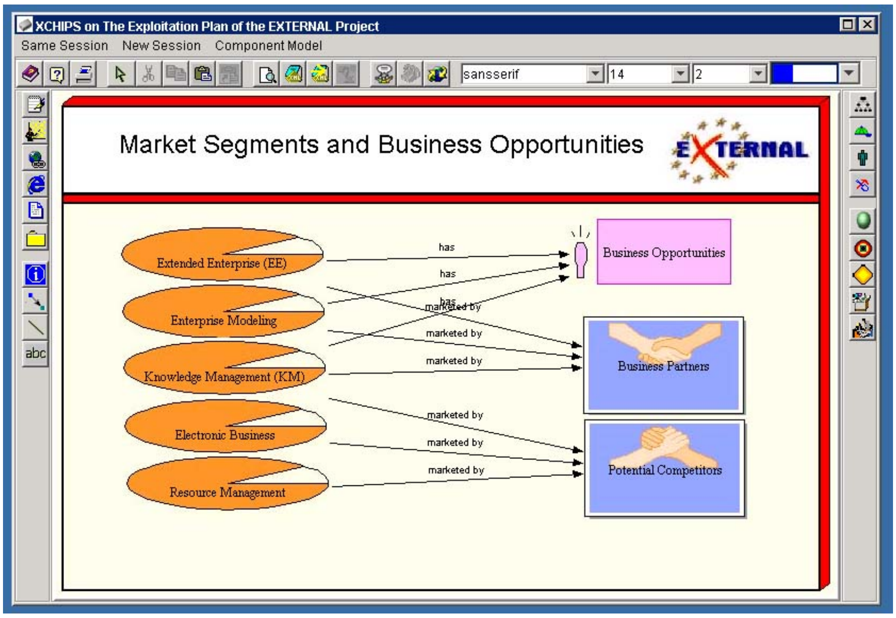

Figure 1. Co-existence of different hypertext flavors

Although we realize that not all combinations will make sense, we are motivated by the previous examples to look for an integrative model for the construction of the user interface of a hybrid hypertext. In this paper we discuss a group of hybrid features that, we believe, will lead us to such an integrative design.

4 An Integrative Interface Design for Visual Hypertext

The design we are presenting assumes that hypertext is presented in a graphical hypertext browser. A graphical representation of a hypertext is a view of its underlying model (instance). It is composed of the representations of the objects (nodes) and relationships (links, containment, and visual layout) in the model. For the remainder of this paper, the graphical element used to represent a node is called *node representation*. Likewise, the graphical element used to represent a link is called *link representation*. It is possible to have more that one representation for a node or link. In this case, all of them are kept consistently up-to-date with the model. The following subsections outline the key points in the model.

4.1 Graphic Elements, their Layout and Other Visual Properties

Building up on spatial hypermedia, nodes and links are represented by graphic elements. These elements can be moved and scaled. Some visual characteristics of graphic elements may relate to the attribute values of a node or a link. In this way, nodes are represented using shapes containing detailed information on type images, its content and attributes (see Figure 1). Lines in different styles are used as representations of explicit links between nodes (see Figure 1).

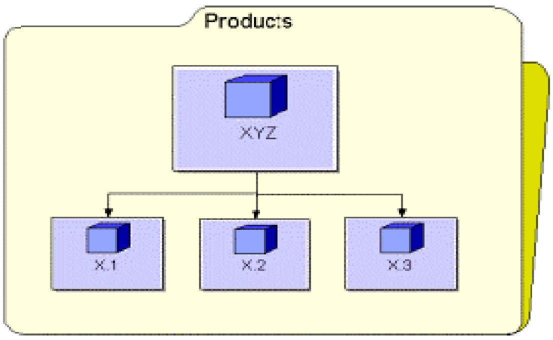

Figure 2. Node and link layout in a composite node

In addition to the explicit links, the layout (e.g. positions and visual properties) of the nodes can also indicate relationships. For instance, for a composite node presenting the structure of an organization, the contained representations of nodes and links can be laid out as an organization chart -- a top down hierarchical structure whose links are lines with rectangular corners (see Figure 2). A representation of a composite node can be provided with a layout manager to automatically layout its components. Visual properties related menu operations can be activated (on the visual component) for users to change the foreground and background colors or patterns, the label text, the size, the orientation, the shape, and the Z-ordering of the visual component. For manually handled free layout, positions, bounds and other visual properties should be persistently stored so as to assure a stable spatial and visual relationship representation.

4.2 Graphical Structure Unfolding in its Original Context

When a composite node is opened (for example through a double-click in the mouse button), its content is unfolded within the bounds and location of the composite node (see Figure 3 and Figure 4).

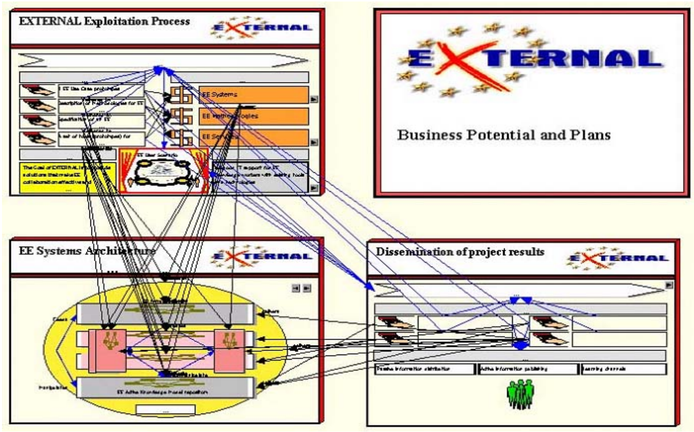

Figure 3. Node at upper right corner is closed

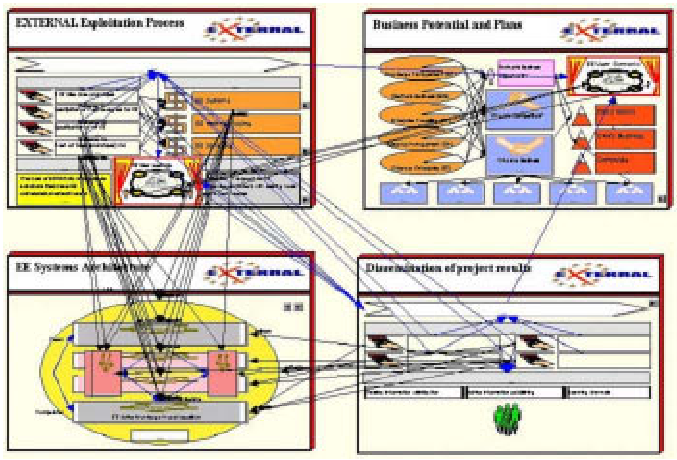

Figure 4. Node at upper right corner is opened in its original context

Opening a composite node may also make visible all the links connected from other nodes to its components (see Figure 4). The original bounds of the composite node are still visible (in light color or as surrounding outline) at the background to make moving and scaling possible. When the composite node is closed (for example through a menu operation), its graphical representation (for its closed view) will cover all its bounding area, and consequently hide (or fold) its internal structure (see Figure 3). If a user is only interested in having a local view of the composite structure, he or she can also open the composite node in a new window.

4.3 Spatial Navigation in Nested Structures and Along Explicit Links

Users can select and open (or close) multiple composite nodes in one operation. When many composite nodes are opened, users can zoom in/out the boundary of an unfolded composite node by clicking on any place within its bounds or its background (i.e. the bounds of its containing composite node) respectively. Clicking on the representation of a link leads the browser to scroll and zoom to the representation of the node at the other end of the link. This node then is displayed at the center of the window and parts of the bounds of its containing composite node can also be seen. The background elements provide users with information about the surrounding context and allow them to click and zoom out. Users can click and hold down the left/right mouse button to repeatedly zoom in/out. This navigation mechanism requires "browsing" to be independent from "editing" where mouse actions already have a special meaning. In editing mode, users can use menu operations or short cut keys for spatial navigation.

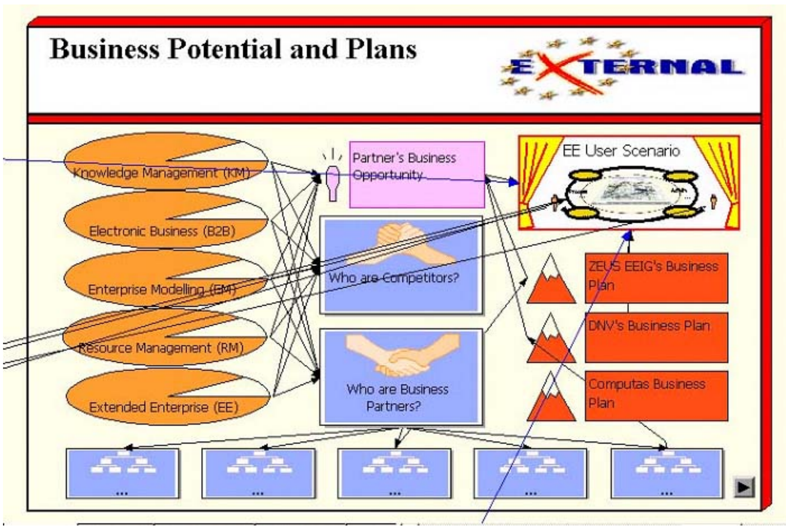

Figure 5. Spatial traversal along links

4.4 Filtered Views

The display of explicit links can be switched off to make a view less crowded and to allow users to navigate spatially in a graphical world (see Figure 5, which is a filtered view of the node at the upper right corner in Figure 4). Users can have a filtered view in which only selected types of explicit links are visible. They can also select a group of nodes to see its neighborhood (i.e. all the selected nodes and all the nodes that are connected to the selected nodes, again with/without all the explicit links between them displayed). Filtered views can be shown in separate tabbed panes in the graphical hypertext browser and users can switch between these views by selecting different tabs of the tabbed panes.

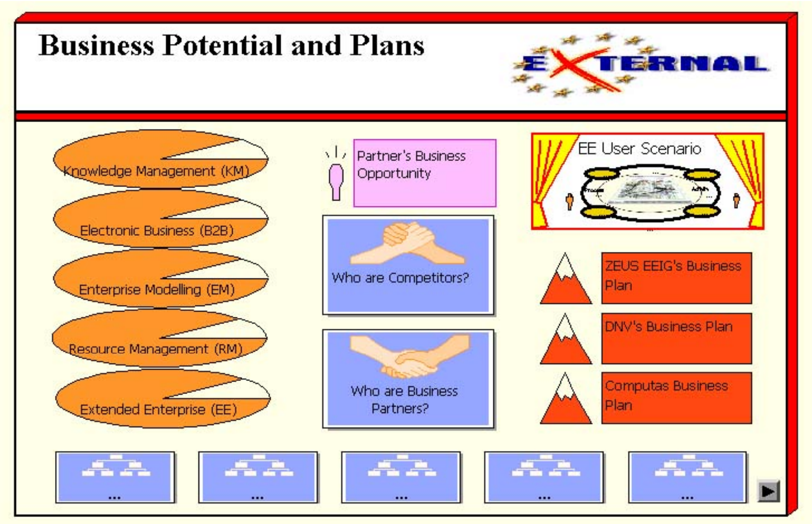

Figure 6. A filtered view of a composite node

Filtered views can also be use to filter-out spatial relations. That means that in a view where spatial relations have been left out, the proximity of some objects may not indicate that they are related. It must be noted that we are removing “implicit” relations, which cause an extra problem. Let’s say we decide to leave out only the spatial relation that express participation in a given team; we would be able to freely move all members of this team. However, for other teams, proximity would still imply participation. In this case it is necessary to make it clear that some relation has been filtered out while other stays (like in the case of explicit links). For instance, when moving a node representation, the positions of other representations of the node is kept unchanged in all its other views.

4.5 Spatial Tour Along Workflow Links

Process animation along workflow links can be used as a guided tour mechanism. Built on the spatial traversal feature described in §4.3, such a guided tour would resemble a spatial tour within and across composite structures. Support for process enactment can also be used for coordinating multimedia presentations (through triggering the audio/video applications by the task nodes containing or referencing the multimedia contents).

4.6 Views of Non-composite Nodes

Similar to composite nodes, non-composite nodes can also be visualized with a closed view and an opened view. The symbol of a closed view normally indicates the type of a node; while the opened view presents the content of the node (in its original bounds). Opening a non-composite node would display the information object contained in or referenced by the node in the same window in its original bounds, or in a separate window if the content is handled by an external application (e.g. MS Word).

5 Comparison and Contribution to the Literature

Interoperability and "cross fertilization" of different hypertext domains are relatively new concerns to the hypertext community [1, 2]. Work in [1] allows users to add and use structural services for different hypertext domains, e.g. one service for (clients in) one domain. Work in [2] defines a common hypertext data model of selected domains and develops different browsers to view the same model in different flavors (i.e. one service/model for multiple clients of different flavors). This paper specifies a graphical hypertext user interface for hypertexts with a mixture of navigational, spatial, taxonomic, and workflow hypertext flavors (i.e. one service/model or multiple services/models for clients of a hybrid flavor).

Many graphical hypermedia interfaces use small icons to represent nodes. This design uses full size, scalable graphics to represent nodes. This makes a graphical hypertext presentation a real picture of art. Pure spatial hypertext normally does not present explicit links (i.e. lines) for relationship. In this design, by adding explicit links and their layout to spatial hypertext, we have enriched its relationship expressiveness.

SuperBook [8] can fold/unfold sub-headings in the "table of content" part of an electronic book. Guide [9] can fold/unfold sub-headings plus their underlying content in their original context. This design allows a sub-graphical structure of a composite node or the content of a base node to be folded/unfolded in its original context (i.e. in its surroundings universe of nodes and links).

Spatial hypertext supports zoom-based navigation in a flat or nested structure [4]. By integrating explicit links, this design allows users to navigate (or zoom in) from one graphical component to the other by following the additional explicit links.

For people who want a pure spatial hypertext view, they can choose not to create explicit links, or to filter out such links for a tidy image of spatial hypertext. Unlike the filtered view mechanisms developed in each individual hypertext domains, in this design, it allows people to show a single hypertext flavor or a mixture of many flavors. It also allows people to create new persistent views of the underlying hypertext.

By incorporating process-related computational semantics to hypertext nodes and links, this design provides a guided tour mechanism for hypertext navigation or hypermedia presentation. Such a guide tour results in an automatic zooming-based traversal (i.e. a visual tour) in a spatial hypertext. Before activating such navigation, users can filter out the explicit links from display for a better spatial hypertext view. This kind feature is not possible in a pure spatial hypertext system.

Visual enterprise modeling tools (e.g. METIS [5] and System Architecture 2001 [10]) allow users to create and browse various diagrams of visual enterprise models. Such visual enterprise models resemble the visual hypertext this work wants to offer. Actually, the look-and-feel of the visual enterprise models in such visual enterprise modeling tools (especially the METIS system [5]) has inspired this work. However, most of such visual modeling tools are or have their root in diagramming or drawing tools, rather than hypermedia systems. They do not have all the integrated user interface features as described in this paper, since these features are made possible by their underlying hypermedia structures derived from various hypertext domains.

6 Conclusions

Integration of different hypertext domains is a relatively new concern to the hypertext community. This paper presents an integrative design of graphical hypertext user interfaces. This design embraces features from navigational, spatial, taxonomic, and workflow hypertexts. The multiple hypertext structures and their visual relationship indications (e.g., explicit links, nested structures, their graphical layout and visual clues such as position, size, color, shape, pattern and orientation) provide rich expressiveness of a *visual hypertext*. Consequently, the hypertext model underlying such a visual hypertext should be a generic structure based one that has structural constructs and properties for the variety of structures and relationship representations. The component-based system architecture [1] for structural computing has provided a basis for implementing clients using the user interface design presented in this paper. The structural services for the clients can be separated services for each of the hypertext domains or an integrated service based on an integrated data model of these hypertext domains.

Among the user interface mechanisms presented in this paper, the structure unfolding unifies the presentation of nested and flat graphical structures. The spatial traversal and the spatial tour along explicit links provide a new link traversal method in a visual hypertext space. This kind of user interface allows users to see a visual hypertext structure at various levels of granularity, from holistic to detailed. The design has been partly implemented in a cooperative hypermedia browser of the XCHIPS system [11] (see www.darmstadt.gmd.de/concert/xchips.html for details). Currently, we are using such visual hypertext to externalize and manage various knowledge models, such as process-centric, holistic enterprise models. We expect that the general availability of a shared visual enterprise model and the various ways to navigate in the visual hypertext space will cut training time and confusion of (virtual) enterprise partners and customers.

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