DYNAMIC INFORMATION VISUALIZATION IN B2C E-COMMERCE

Mao Lin Huang and Bernard Doyle
Department of Computer Systems
Faculty of Information Technology
University of Technology, Sydney
PO Box 123 Broadway, NSW 2007 Australia

ABSTRACT

This paper describes the application of dynamic information visualization in the field of B2C e-Commerce. We discuss the traditional approaches for conducting B2C eCommerce as well as some recent applications of visualization techniques in the field. We then present the research work done by us. We discuss the development of a 2D interactive visual interface for navigating large online product catalogs. We introduce our framework for *Visual Online Shopping*. This is a common activity in on-line e-Commerce. We discuss the application of the *OFDAV* browser as a means to assist buyers in navigating large product information spaces dynamically with a sense of information space. This technique helps buyers to select appropriate products by mouse-clicks in the visualization. The prototype is written in *Java, JavaScript* and *PHP Script* that simulates the online shopping experience. They are applicable to any e-commerce online purchasing application.

1. INTRODUCTION

One of the major elements for online ecommerce is the online product catalog. It provides sellers with a content management system that stores, indexes, aggregates, normalizes, and distributes product information. It also provides potential buyers with an interactive interface that offers a multimedia representation of the product information as well as classification and navigation services.

Many research works have been done for both aspects of online product catalogs. For content management, a number of commercial products have been developed, such *as CardoNet, Interwoven* and *OnDisplay*, and are used by many e-commerce web sites [1]. For catalog interfaces, many methods supporting product search and navigation have been developed [2]. These product information navigation methods are sometimes referred to as *shopping metaphors*. The usability of several product selection mechanisms was studied in [3, 2]. Also, the impact of different shopping metaphors on the effectiveness of online stores in terms of click-through and conversion rates was analyzed in [4, 5].

While these product catalogs can effectively assist the seller/buyer in managing, searching and accessing product information through the WWW, they usually do not provide a 2D graphic user interface that gives buyers a sense of information "space" when he/she is exploring a large product hierarchy. Instead they only provide buyers with a series of textual lists placed in separate pages. Each list in a page shows only one level of the product hierarchy. The buyer has to click through many pages to move down/up the product hierarchy to find appropriate products he/she needs. Thus, the entire structure of the product hierarchy is split into many small pieces and it is very difficult for buyers to perceive the overall structure of the product hierarchy by reading these textual lists. In fact, the effectiveness of this navigation mechanism in terms of click-through and human cognition is lower.

In recent years, some techniques of information visualization have been introduced into this area. These techniques attempted to provide users with a 2D interaction space that could give users an overall view of product hierarchies for the navigation of product catalogs. A typical example of such techniques is *Hyperbolic Tree Browser* developed by *Inxight Co.* and *Xerox PARC* (see Figure 1).

HT Browser uses a focus+context viewing technique [6] based on hyperbolic geometry for visualizing and manipulating large hierarchies. It assigns more display space to a portion of the hierarchy where the user is currently focusing allowing the user to see more detail of this portion while still embedding it in the context of the entire hierarchy. It lays out the hierarchy in a uniform way on a hyperbolic plane and maps this plane onto a display region. The chosen mapping provides a fisheye distortion that supports a smooth blending of focus and context. It also has effective procedures for manipulating the focus using pointer clicks, as interactive dragging, and smoothly animating transitions across such manipulations.

While this technique effectively deals with catalogs of moderately large size, it does not help where the product catalog is not completely known. The limitation of the HT model is that it is unable to handle dynamic or distributed product databases. There are a number of aspects to this problem. Firstly, a "real world" catalog of products will tend to be large. There may be tens of thousands or possibly hundreds s of thousands of products in the catalog. This will mean that the initial download time of the applet and the calculation time of the visualization are increased significantly as the entire catalog has to be downloaded and placed in its appropriate portion of the HT and the geometrical layout of visualization has to be calculated.

Further, this technique predefines the geometry and generates views that are extracted from the geometry layout. This means that changing views is a geometrical operation and not a logical operation. The user naturally thinks of the logical relations in the product hierarchies, not in terms of the synthesized geometry of the layout; thus logical navigation of product catalogs is limited by the predefinition of the layout.

In this paper, we discuss the use of dynamic graph visualization to address the above problems. We aim to develop high-quality catalog interfaces in terms of readability, understandability and comprehension by upgrading a broken 1D interactive space (a series of textual lists placed in many pages) to an integrated 2D interactive space (a overall navigational graph visualization). Furthermore, we used OFDAV browser [7] technique to address the "partially unknown" catalog problem allowing buyers to navigate large product catalogs dynamically.

This 2D visual structure of the product catalog addresses the product navigation problem and allows buyers to visually browse through the entire product catalog with a sense of "Information Space".

The OFDAV technique [7] can be used to explore a huge product hierarchy online (especially for exploring distributed product catalogs that are partially unknown). It can quickly track the subset of a huge product hierarchy based on the focus of the user, and provides buyers with a series of dynamic visual maps for guiding online shopping activities.

In OFDAV, the view of the user is focused on a small portion of a large product catalog at any point in time. This portion is defined by several focus graphical nodes and we use a force-directed algorithm to draw the hierarchy of this sub-catalog. We then allow the user to change focus nodes by selecting new nodes in the visualization. We use multiple animations to guide users between views and preserve their mental map. We also adopt a linear "history" for tracing the sub-catalogs that the user has visited. This assists in backtracking through the visualization.

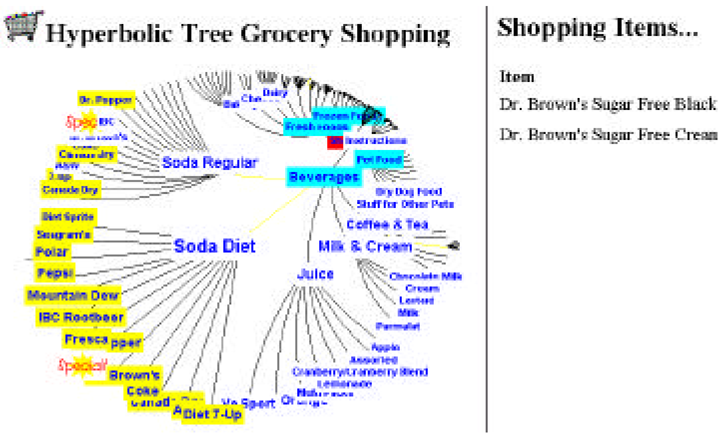

Figure 1. A HT Browser developed by Inxight Co. and Xerox PARC

2. THE FRAMEWORK OF VISUAL ONLINE SHOP

The proposed *Visual Online Shop* is made up of several components. These components and interconnections among them can be described in Figure 2; details are below:

- **Dynamic Visualization:**

  An navigational visual presentation that automatically displays a sequence of the subset of the product catalog following the buyer's orientation of navigation. It adapts several visualization techniques, such as *Image-Maps* and *OFDAV* – an on-line exploratory visualization technique that allow buyers to interactively navigate the large product hierarchy incrementally by swapping of views. It addresses the "small window" and "partially unknown" catalog problems.

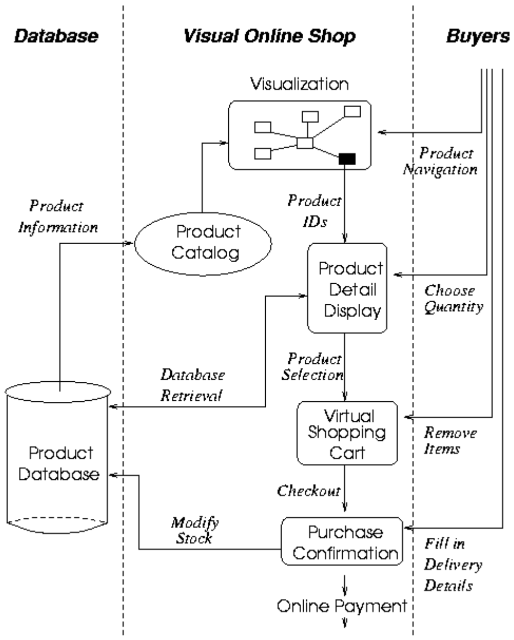

Figure 2. The framework of Visual Online Shop.

- **Product Database:**

  A relational database used to store product information, including all data fields and attributes associated with a particular product that are available for sale in the online shop. In our implementation, we used a *MySQL* database.
- **Product Catalog:**

  A content management system that assembles, indexes, aggregates and normalizes product information from the product databases, and quickly distributes the product information.
- **Product Detail Display**

  A web page generated on the server side by a scripting language (we use a PHP script in our implementation) It retrieves the appropriate product entry from the database table in corresponding to the mouse-click on a particular graphic node in the visualization. It then displays selected attributes of one or more products in the page. Each product displayed has an associated "Add" button and an associated "Quantity" text field. The "Quantity" field allows buyers to fill in the number of items they want to purchase, while the "Add" allows buyers to add the selected product to the virtual shopping cart.

- **Virtual Shopping Cart**

  The core element of the shopping-cart model of e-commerce could be written in one of a number of server-side scripts, such as *PHP, ASP* or *JSP*. This shopping cart is responsible for controlling the buyer selection of products and the checkout operation. It shows how many products are already chosen and the total value of the chosen products in the cart so far.

  Buyers can empty the shopping cart (i.e. clear all selections made so far) by clicking on a "Clear" button, and remove items from the shopping cart by clicking on the "Remove" button. Users can also complete their shopping session by clicking on a button labeled "Checkout".
- **Purchase Confirmation**

  The component displays a purchase form asking buyers to fill in their delivery details (including name, address, suburb, state, country and email address).

  All these fields must be completed for the order to go ahead. The user completes the transaction by clicking on a button labeled "Purchase". The details of the order are sent via email to the email address given on the form. It then retrieves the product database, re-calculates the product stock and modifies the in-stock field of those relevant product entries.
- **Online Payments**

  In this project, online payment is not a research focus. Therefore, we are not going to discuss it in further detail. There are many existing online payment systems are available, and the implementation for each one is different. In this framework, we use a *dummy* function that can be replaced with an interface to a chosen online payment system.

3. DYNAMIC VISUALIZATION OF PRODUCT CATALOGS

OFDAV Browser [7] is a 2D interactive graph visualization written in Java. It can be used to incrementally visualize a subset of the entire category hierarchy (visualization) of products by updating the visualization online. Exploration of the entire category hierarchy proceeds by changing viewing frames. The transformation between two viewing frames is done smoothly through two types of animation: *Layout animation* and *Fade animation*. This greatly reduces the extra cognitive effort spent by buyers in re-forming the mental map of the picture after each transition.

OFDAV Browser has two working modes "Navigation" and "Select". Under the "Navigation" mode, you may explore the other parts of the category hierarchy (visualization) by selecting new focus nodes in viewing frames.

Under the "Select" mode, however, you can activate a *PHP* script appearing in the top right hand frame of the page by clicking on a graphical node (representing a product) at the lowest level of the hierarchy. The *PHP* script will then retrieve the appropriate product entry from the *MySQL* product table and display selected attributes of the product.

- **OFDAV Visualization**

Graph Information visualization concerns viewing relational data where the underlying data model is a graph. Most existing information visualization techniques have problems presenting very large data (such as product hierarchies) with millions or perhaps billions of nodes. The major problems can be summarized as following:

- Static visualization techniques predefine or pre-compute the layout. In many cases, the whole huge graph is not known. The online product catalog is updated automatically from time to time. So it may be impossible to pre-compute the layout of the whole visual structure.
- Pre-computation of the overall geometrical structure (global context) of a huge graph (with, perhaps, billions of nodes) is very computationally expensive. Many graph layout algorithms have super-linear time complexity, and in practice are too slow for interactive graphics if the number of nodes is larger than a few hundred.
- Pre-computation of the layout itself poses another problem. Since views are extracted from a predefined layout, changing views is a geometrical operation, not a logical operation. The user naturally thinks in terms of the logical relations in the application domain, not in terms of the synthesized geometry of the layout; thus logical navigation of the product catalog through the entire visualization by using static techniques is difficult.

Online Force-Directed Animated Visualization (OFDAV) [7] is a new Graph Visualization technique introduced in 1998 that addresses the above problems. It uses an exploratory model of visualization allowing users to navigate huge graphs that are partially unknown, see Figure 3.

This technique provides a major departure from traditional visualization methods. It does not predefine the geometry for whole graph at once; instead it incrementally calculates and maintains a small local visualization (part of the global context) on-line, corresponding to a change of the user's focus. This feature enables the user to logically explore a huge graph without requiring the whole graph to be known.

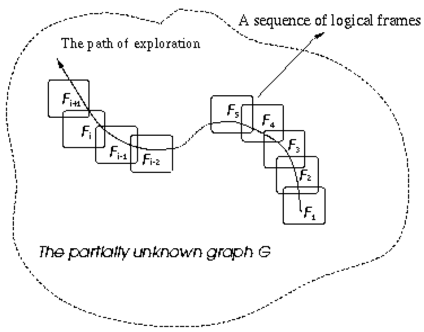

Figure 3. Online Visualization Model.

In *OFDAV*, the user's view is focused on a small sub-graph of a huge graph *G* at any point in time. The visualization of this sub-graph is called a *logical viewing frame* and is defined by its *focus* nodes. Conceptually, the focus nodes form a first-in-first-out queue with user's highest interest focus. The viewing frame is updated smoothly following the changes of the user's interest focus. The user can change focus by selecting another node in the viewing frame, but we do not anticipate the user's selection. However, we do assume that the user can always discover the neighborhood of the focus node.

It uses a *force-directed* graph drawing algorithm [7,8] to draw the sub-graph of *G* and the logical neighborhood around this sub-graph. The logical neighborhood of the focus nodes gives users a clear idea of where they are in the product hierarchy and helps them to decide where they should go next in a large information space. It uses multiple animations to guide the user between views, reduce the cognitive effort and preserve the mental map of views. It adopts a graphical *history* tail that contains a sequence of previous focus nodes. It traces the sub-graphs that the user has visited. This assists in backtracking through the large product hierarchy.

- **An Example**

To illustrate how the system works to navigate the large product hierarchy, a simple example session is presented here. Suppose that we are required to use an *OFDAV* Browser to explore a very large product hierarchy that presents the product information of an e-Market.

The system first displays an initial viewing frame showing the top three levels of the product hierarchy at the beginning of the navigation (see Figure 4). It then updates the frame on-line as the buyer moves the focus by clicking on a succession of new focus nodes. We see that nodes of the initial frame are within 2 hops from the root node "A" that are presenting top level categories and sub-categories of the products available in the e-Market.

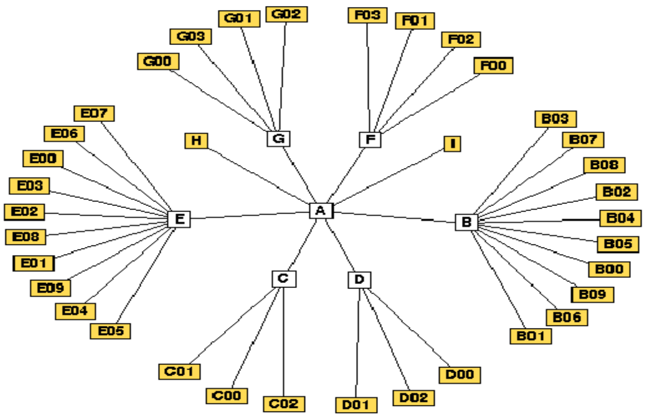

Figure 4. An initial viewing frame showing the top three levels of the product hierarchy that is drawn by a modified spring algorithm.

Figures 5 shows the incremental change to the next viewing frame when the buyer selects the node labeled "F01". We see that the node "F01" becomes a new focus node added into the focus queue; its immediate neighborhood appears into the frame and the old focus node "B" is deleted from the focus queue and its neighborhood disappears from the current frame.

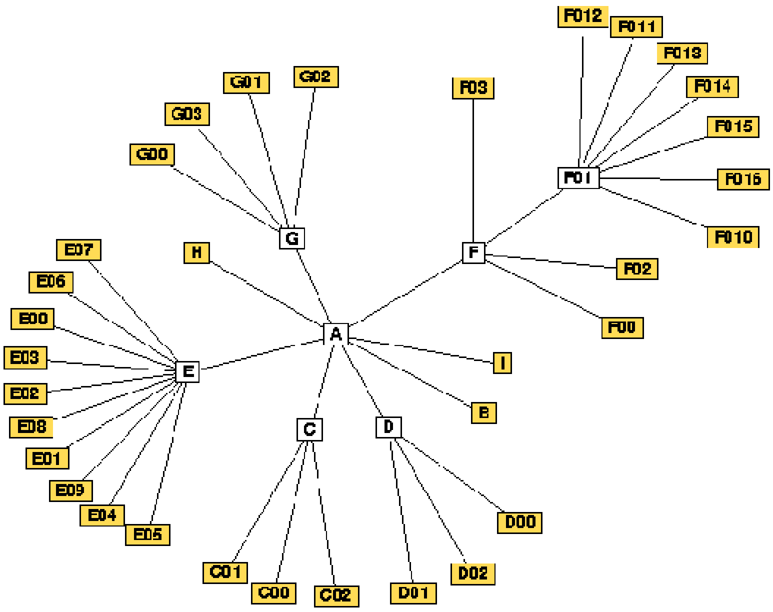

Figure 5. Navigating the product hierarchy on-line by changing the focus node to "F01".

Figure 6 shows one frame further on after the buyer has selected the node ``F012''. We see some new nodes appearing and three old nodes disappearing.

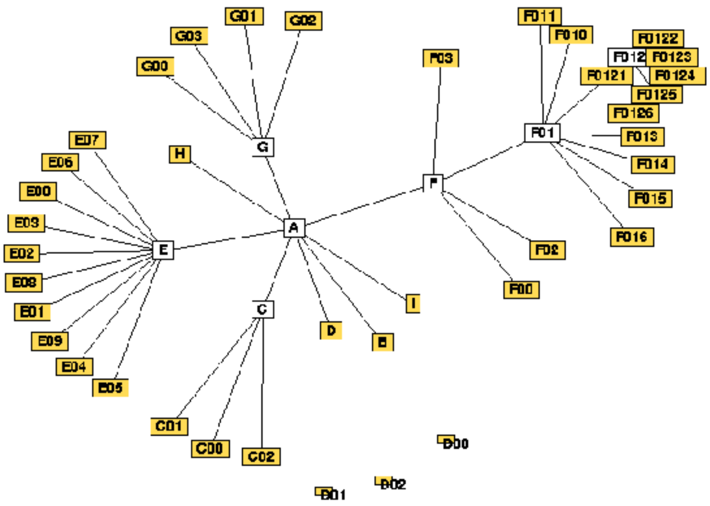

Figure 6. An example of nodes appearing and disappearing. We use fade animation to implement the addition and the deletion of nodes.

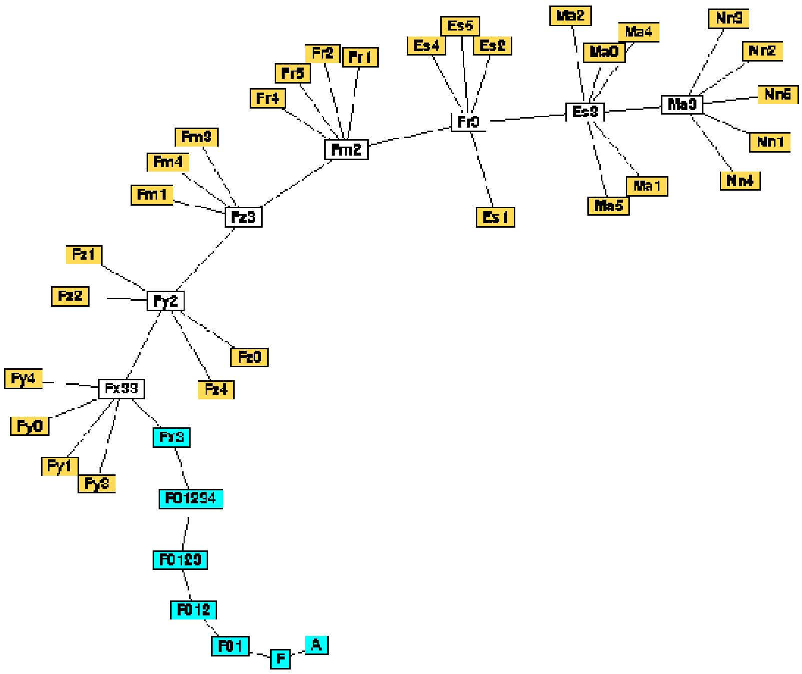

Figure 7. An example of viewing history nodes that indicate the location of where you are in a large product hierarchy.

Figure 7 shows the visualization ten frames further into the buyer's exploration of the product catalog. Notice the history tail consisting of the previous focus nodes labeled ``A", ``F", ``F01", ``F012", ``F0123", ``F01234"and ``Fx3".

4. CONCLUSIONS

In this paper, we presented a new framework for the visualization of online product catalogs that provide an integrated 2D interactive space allowing buyers to visually navigate the product hierarchies with a sense of information space.

The traditional presentation of product catalogs provides buyers only a series of textual lists placed in several separate pages for navigation. The cost of this is an increase in the buyer's cognitive effort spent in learning the overall structure of product hierarchies during the navigation. This navigation mechanism also requires a high rate of click-through for the navigation, as the navigational structure of the product category was implicitly presented in many separate pages. The parent-child relationships in the product hierarchies were presented by embedded hyperlinks that the navigator cannot see directly.

Some alternative techniques that have been proposed attempt to provide users with a 2D interaction space that gives users an overall view of the product hierarchies for the navigation of product catalogs. A typical example of such techniques is the *Hyperbolic Tree Browser*. While these techniques effectively deal with catalogs of moderately large size, they do not help where the product catalog (such as a dynamic or a distributed catalog) is not completely known. Further, this technique predefines the geometry and generates views that are extracted of geometry layout. This means that changing views is a geometrical operation and not a logical operation. The user naturally thinks of the logical relations in the product hierarchies, not in terms of the synthesized geometry of the layout; thus logical navigation of product catalogs is limited by the predefinition of the layout.

In this paper, we proposed the use of *OFDAV* graph visualization to address the above problems. The *OFDAV* technique [7] can be used to explore a huge product hierarchy online (especially for exploring distributed product catalogs that are partially unknown). It can quickly track the subset of the huge product hierarchy based on the focus of the user, and provides buyers with a series of dynamic visual maps for guiding the online shopping activities.

However, this is just a beginning and there are a lot of research works required in the future. We will conduct a usability study on this topic soon. We are also interested in investigating other visualization methods that could be more appropriate to be applied in the fields of e-commerce and B2B e-business. This will happen in the near future.

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