Adaptive Virtual Reality Shopping Malls

George Lepouras
University of Peloponnese, Greece

Costas Vassilakis
University of Peloponnese, Greece

INTRODUCTION

Firms and organizations are increasingly exploiting electronic channels to reach their customers and create new business opportunities. To this end, electronic shops have been developed, either offering products from a single firm or encompassing multiple individual electronic stores, comprising thus electronic shopping malls. Besides development activities, electronic shopping has attracted the attention of researchers, who have studied various perspectives, including user attitude, critical success factors, security, technical aspects, and so forth (e.g., Fang & Salvendy, 2003; Wang, Makaroff, & Edwards, 2003).

Two main concerns for e-commerce are personalization and enhancement of user experience. Personalization addresses the ability to offer content tailored to the preferences of each user (Anupam, Hull, & Kumar, 2001) or user group (Wang et al., 2003). Preferences may be explicitly declared by the user, or derived by the system through inspecting user interaction; if the system dynamically reacts to changes of visitor behavior, it is termed as *adaptive*. Personalization allows customers to focus on the items they are interested in, and enables electronic shops to make targeted suggestions and send promotions to customers (Lekakos & Giaglis, 2005).

Enhancement of user experience is another major issue in e-commerce, given that 2D images and texts on the screen are not sufficient to provide information on product aspects such as physical dimensions, textures, and manipulation feedback (Park & Woohun, 2004). Major e-commerce categories that could benefit from giving a more accurate and/or complete view of the products include real estate brokers who could present detailed models of properties, furniture stores that could allow their customers to view how certain pieces would fit in the target place (Hughes, Brusilovsky, & Lewis, 2002), and clothing shops that could provide a virtual fitting room with customizable avatars (Compucloz Corporation, 2003). Multimedia presentations can also be used as a means for "information acceleration" for promoting "really new" products (Urban et al., 1997). Enhancement of user experience may finally compensate for the loss of the pleasure associated with a visit to a shopping mall (Laskaridis, Vassilakis, Lepouras, & Rouvas, 2001).

Nowadays, the technological potential of Internet systems provides adequate means for building online multimedia applications that can help e-commerce sites attract e-shoppers. Applications can be built to adapt to the user's profile and provide the user with a suitable set of information in the most efficient way. Virtual reality (VR) technologies are also now mature enough to be used for the wide public, offering vivid and highly interactive environments, allowing users to view synthetic worlds within which they can visualize and manipulate artifacts. This article aims to specify a system that exploits capabilities offered by adaptation and VR technologies to offer e-shoppers personalized and enhanced experiences, while addressing challenges related to the cost, complexity, and effort of building and maintaining such a system.

BACKGROUND

E-commerce sites nowadays expose variable degrees of sophistication, functionality, and complexity. Most e-commerce sites offer lists of available products, usually organized in categories. For each product, a brief description, the price, and possibly an image are made available to e-customers; more information items may be included depending on the e-commerce domain (e.g., customer reviews for books and music). A basic e-commerce site offers the same content to all its visitors.

The first step towards offering services tailored to the user needs is the categorization of users into groups and serving each group with specifically selected content (e.g., Arlitt, Krishnamurthy, & Rolia, 2001). Personalization provides a finer granularity for tailored content delivery, because content formulation is based on the preferences and behavior of individual users, rather than aggregate data from user groups. Preferences may be declared through *static profiling* (Datta, Dutta, VanderMeer, Ramamritham, & Navathe, 2001) where users declare their preferences through profile definition pages; dynamic

profiles extend their static counterparts by incorporating information collected from user activities during the interaction sessions.

On the other hand, 3D objects and VR can greatly enhance user experience within an electronic shop. Since 3D environments are inherently more complex as compared to 2D interfaces, the issue of navigation within such an environment is important. Chittaro and Coppola (2000) discuss the use of animated products as a navigation aid for e-commerce. Hughes et al. (2002) examine the integration of ideal viewing parameters with navigation, to assist the navigation procedure. Park and Woohun (2004) present a prototype augmented reality system, enabling users to "put and feel a product" in order to find the match in the real environment.

Although adaptation and VR technologies seem promising for e-commerce, their adoption is currently hindered due to a number of challenges, mainly related to the technologies themselves. The first major challenge is *content creation*: for each item in the VR-mall, the respective representations have to be created. The virtual space for the mall must also be designed, and stands and shelves on which items will be placed must be inserted. Finally, interaction methods for each item need to be designed. These may vary from item to item depending on the type of digital representations (e.g., 3D models may be rotated; videos may be played, paused, and continued; photographs may be only viewed), and the nature and semantics of the item (e.g., for a 3D model of a camera, interaction may be provided to illustrate change of lenses, while a 3D model of a vase can be only rotated). This is a cumbersome, time consuming, and costly process (Lepouras, Charitos, Vassilakis, Charissi, & Halatsi, 2001).

A second major challenge is the overall system complexity, stemming from the diversity of its components, structures, and interactions (European Center for Virtual Reality, 2004). The system must include provisions for user profile modeling (both static and dynamic parts), selection of the items that best fit the current user profile, dynamic creation of virtual worlds (VR-worlds) in which the selected items must be placed, coupled with proper interaction methods.

A final challenge is the overall size of the VR-mall description. VR-worlds tend to be of large size, and thus their download time can be considerable. Constructing thus a single world representing the whole VR-mall will result in long waiting times, which may lead users to navigate away from the VR-mall. A more prominent approach would be the formulation of smaller VR-worlds, each one containing a subset of the VR-mall merchandise. These worlds may be interconnected using gates, teleports, or any other suitable means (when a user reaches an interconnection item, they are transferred to another VR-world constructed and downloaded at that time; thus waiting times are broken down into small portions). The proposed architecture adopts this approach, which additionally provides the opportunity to populate each VR-world with the merchandise that best fits the user interests, as this can be determined by the user activities observed so far. The details of this process are analyzed in the next section.

THE VR-MALL ARCHITECTURE

The proposed architecture provides a generic framework for building an adaptive VR-mall, undertaking the tasks related to user profiling and monitoring, selection of the items best suited to the user profile, association of the relevant interaction methods, and dynamic formulation of the VR-worlds. In this sense, the tasks that need to be performed by the VR-mall maintainers are limited to the provision of the content—that is, the digital representations of the items merchandised through the VR-mall. The proposed architecture is depicted in Figure 1.

Defining the VR-Mall Content

In the proposed system, creation and maintenance of the adaptive VR-mall is undertaken by two stakeholder groups, namely content creators and domain experts, who perform their tasks using specially crafted *content management tools*. Content creators provide the digital forms of the VR-mall merchandise in the appropriate form (pictures, 3D models, sounds, videos, etc.). Content creators additionally design the space elements that are used within the VR-mall, including rooms, halls, corridors, shelves, display cases, and stands. Space elements generally contain *merchandise placeholders*, which are replaced by appropriate merchandise items or navigation aids when an instance of the VR-mall is created. For example, shelves may contain placeholders indicating where products will be placed, whereas a placeholder within a corridor may be replaced by a sign listing the merchandise categories along the corridor. All resources can be provided in multiple *levels of detail*. High levels of detail are used for e-shoppers with broadband connections and when e-shoppers explicitly request highly detailed images of items; low levels of detail are used to reduce download times, because the size of the digital representation in low levels of detail is significantly smaller.

To enable the selection of the most suitable items for each user, the adaptive VR-mall system needs to possess certain information regarding each item, such as the item category (e.g., furniture, electric appliance, holiday pack), target age group, shopping season, and so forth. This information is provided in the form of *property-value*