Ontology Based Information Distribution in the Pervasive Display Environment

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Abstract— **Displays providing different information at many different locations are exponentially increasing. Under this pervasive display environment, users may be provided with customized information in real-time at each point of interest (POI). However what type of information to be provided is not easy to define. In this paper, architecture for information distribution based on the "environment ontology" is proposed. Display system embedded with the environment ontology relates the location with available services/information with the user profile. We implemented information push and pull system SAS (Shopping Agent Service) integrated with environment ontology to support human decision in the process of purchasing a product within a shopping mall. SAS demonstrates how the information is distributed harnessing ontology and user profile at each different location.**

Keywords-ontology; environment ontology; recommendation; pervasive display; shopping agent service

I. INTRODUCTION

Displays as an access channel of information has come to the pervasive level where anyone can access any types of information anywhere. Rapid and wide range deployment of displays led to a pervasive display environment where different types of information can be accessed at many different locations. They are embedded in the bus, in the building and even along the streets. Displays in the form of a digital signage or kiosk screens push information to the anonymous people in the form of an advertisement without user intentions. They are designed to show only the information programmed into the display. For example, displays in the shopping mall are used to inform the customers about new arrivals or benefits provided through promotion. They are placed in a highly accessible location and target anonymous people. However the user activity and intentions are not considered. There are tremendous amount of information accessible to the users but what and where the certain information to be provided is not easy to define.

Two main issues to tackle in such environment are the service matchmaking and social adaptation for service evolution. Service matchmaking consists of service provider, the user and a matchmaking engine. Such system requires the services available and user information. We applied ontology based matchmaking algorithm to connect the available service or information in a certain location with the user. The complex physical world information and relations are defined into the environment ontology for information filtering according to the user's location.

The physical world and its relating information change over time with the social demographics and their preferences[1]. The relevance and importance of information shift to one another. Therefore the social adaptation and learning algorithm is defined and applied in our architecture weighting the popularity from the users' interaction history to catch the dynamic change for social recommendation. Ontology based matchmaking engine is refined through the learning process.

In chapter two discusses related works on location based services and personal recommendation systems relating ontology. In chapter three and four architecture to realize personalized information distribution in the pervasive display environment is proposed with an implementation. Chapter five concludes with its limitations and future work.

II. RELATED WORKS

The goal of this work is to propose a novel architecture harnessing environment ontology to provide a personalized location based service. The target user for our system is the consumer in the process of purchasing a product within a pervasive display environment. There are related works in the decision support system based on the web and personalized recommendation system, also services in the pervasive display/computing environment (e.g. location based service, context aware service, personalized service).

Cho et al.[2] and Kim et al.[3] implemented personalized recommendation system based on web usage mining, product taxonomy, association rule mining, and decision tree induction. Target customer or active customer was determined and the preferences were mined through the product affinity and previous shopping behavior. Yu et al.[4] proposed a recommendation system using location-based ontology. He described a LBS knowledge base inference platform reflecting each user's current location and available time of users. The users participated in building the knowledge base using mobile devices and user condition and user profile information were applied in the inference system to recommend customized information to the other users [4].

In the research of pervasive display/computing environment and its services, Rui José [5] stated Pervasive

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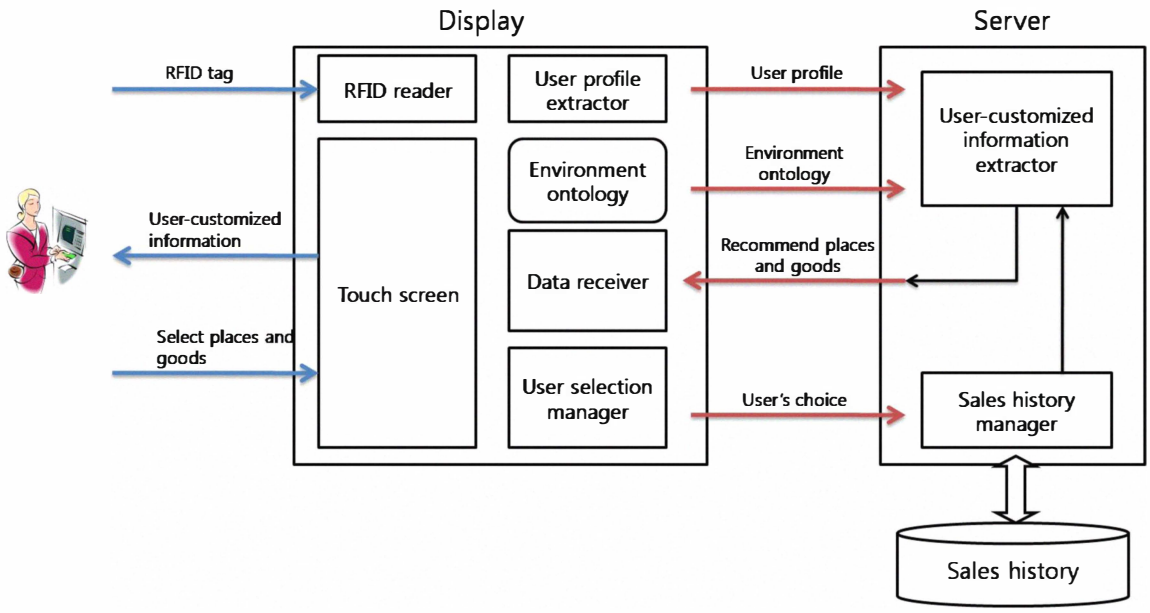

Figure 1. Hardware and system architecture.

Display System(PDS) is not controlled by a single user and the main difference between Distributed Displays Environment(DDE) is that it is a public displays as a multi-purpose system. He proposed a Situation Framework for PDF usage model and its handling. Mitchell and Races[6] studied the user attention in the pervasive display environment. Ranganathan et al.[7] used ontology to describe GAIA[8]'s different kinds of entities and their properties. Ontology was also used to define a standard description of the location, activities, weather information and other context-aware applications.

Based on the previous studies, we propose a ontology based environment description and information distribution and recommendation combining the user profile to support the user's decision at different POIs.

III. SYSTEM ARCHITECHTURE

In order for displays to show the user-customized information, the system refers to the environment ontology that models the location of POIs together with its demographics. A set of POIs with demographics and a set of displays are considered into the environment factors. Specifically, the POI is a particular location where a product is available. The demographics describes the types of people shopping (including both eye shopping and actual purchase made) associated with the POI at the location. The system shows information about a POI that sell the product user wants to buy. In addition, information about related POIs is also shown together in the display that sells related products. The relatedness is mined from a product ontology that models hierarchy of products with some properties about products.

Given environment ontology and user's profile, the system extracts a subset of places and goods by traversing the ontology according to the profile. Since in the pervasive display environment the displays are exposed to a various people who are interested in goods sold at that place, the traverse path is adjusted as data on purchase and visit is accumulated.

Figure 1 depicts the hardware and system architecture. Display is equipped with a RFID reader and touch screen interface. When user with a RFID tag approaches the display, the RFID reader reads data stored in the RFID tag and extracts user profile. It then sends the user profile and environment ontology to the server. The user-customized information extractor requests the sales history manager to send information associated with the user profile. For example, a list of goods that can attract the user profile can be extracted. Considering the goods list, it traverses the environment ontology to extract user-customized information. The list of popular goods can be changed according to the user's choice. The sales history manager updates the list whenever the user's choice is received.

A. Hardware Settings

Users carry a RFID tag which the user's profile is stored. The display is equipped with a RFID receiver so that it can read user's profile whenever user approaches the display within a distance he can interact with the display. The display renders texts and images on the screen and offers a touch-screen interface just like a conventional kiosk does. By allowing users to select a place and goods they prefer shown on the screen, the display can collect information about preferences of users visiting the place. By this interaction, additional information is transferred to the server, either selection of places or products. It combines the decision with the previous user profile and environment ontology and returns customized information on the screen.

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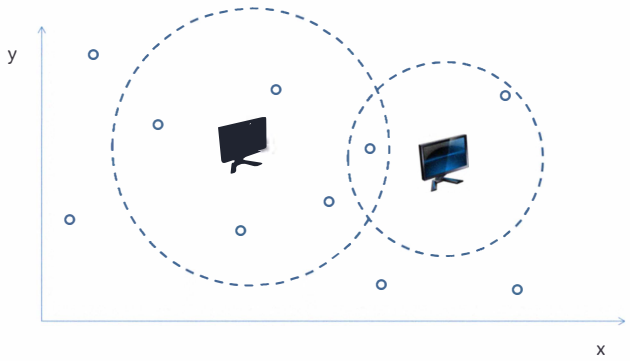

Figure 2. An illustrative example of environment where two displays are associated with some POIs.

B. *Environment Ontology*

Environment ontology describes POIs with demographics and the location of displays. The POI is a specific location where a certain product is available. To simplify, the location or the POI is mapped into two dimensional space of x and y axis. The environment can be viewed as a map where a set of POIs and a set of displays are distributed. See Figure 2, there are two displays and ten POIs in an environment.

Figure 3 depicts the environment ontology. It consists of three classes: POI, display and demographics. POI class has location information and relations with other classes. We assume that there is one representative product which is available in a POI. The product is from the other ontology called product ontology. The product ontology models product hierarchy and properties of the product. It is used for finding related products of a given product. For example, we know that iPhone is a related product of BlackBerry with respect to a product hierarchy. Both of them belong to the same parent class of SmartPhone.

According to the available product, each POI has demographics which provide information about the group of peoples who buy the product in that location. The groups of people can be viewed as an averaged attributes of peoples. In our case, sex and average age were clustered to reveal the typical products sold at the POI. The clustered groups of people are associated with the POI dynamically to show the trend of product sales for more reliable recommendation.

Each display is associated with regional POIs, meaning each display shows information based on the location, considering user activity radius. The display class has location property in order to provide information users near it. Which POIs to be assigned to the displays depends on target domain. In this paper, to simplify, we select nearest POIs within a certain radius (the radius may vary according to the scale of the area the pervasive displays are installed).

Figure 4 depict an example scenario in an environment in which there are one user and two displays. Assume that the system knows from user's RFID tag that he is 26 years old and wants to buy a digital camera. The system then suggests the target POI to which user should go. From the product ontology, we can infer related product is camera bag for a digital camera, because people often carry digital camera with the bag for protection when they go to outside to take a picture. In the display that user sees for the first time in this environment, there are three of remarkable POIs. Since he wants to buy a digital camera, information about cosmetic are not likely to capture his eyes. Rather, information about camera bag can do, with respect to the inferences from the product ontology. Of the two POIs that sell camera bag, we can select one out of them, because we know that he is 26 years old. Therefore the first display shows information about the route to the target POI and information about the POI that sell camera bag. In the second display, he is given only the route information because there are no related POIs that are associated with the display.

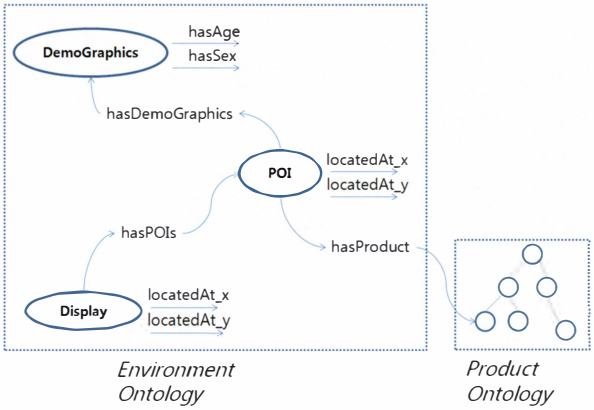

Figure 3. Environment Ontology.

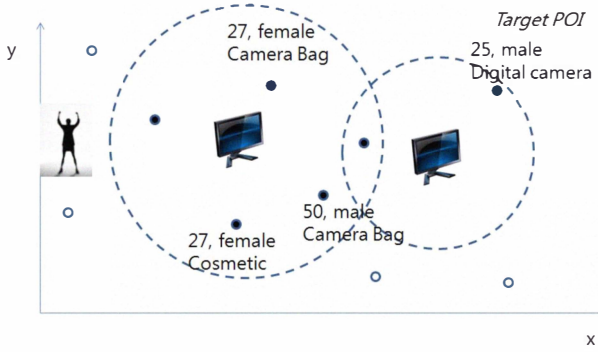

Figure 4. User wants to buy a digital camera. On the way to the target POI, the user will pass by two display. The display renders related information of the POIs to the user.

C. *Privacy Management*

There exists privacy issue of collecting user profile of age and sex at each POIs. The importance of privacy management has escalated ever since the web or a system which demands user information in order to provide a user customized information or services.

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In our system, user profile stored in the RFID is required, for both personalized recommendation and its refinement. Also, it relates to the environment ontology for further services. The user profile only contains age and sex. It does not require user name or affiliation. It only collects the demographics with frequency of product search or purchase made at a certain location. Therefore privacy mining is very shallow. Moreover, the users are notified beforehand that use of the profile may provide personalized benefits, which they all agreed on.

There always exists a trade-off between user data and user customized service. These two factors are in inverse proportion to each other. Therefore it depends on the user to make a decision to provide his personal information for personalized information or services.

IV. IMPLEMENTATION

We have applied and implemented the environment ontology based recommendation and information distribution system, SAS (Shopping Agent Service). It is specially designed under the scenario of the user wanting to purchase a certain product in the digital camera domain within a shopping mall environment. It covers the whole process from the user entering a shopping mall to the purchase point, SAS providing and recommending goods and customized information for the user. SAS was demonstrated with three displays assuming it is placed at three different points of interests. The architecture and the specifics of our SAS are described below.

A. System Environment

SAS consists of a touch panel and a RFID reader each embedded with the display; and a main server to compute and render information based on the interaction between the display and the user.

In this system, three displays were used according to the scenario to be placed at three different POIs. Each display represents a certain location embedded with its environment ontology. Single environment ontology was designed and specific location was configured with the installation.

The information mainly relies on its location similar to the advertisement signs we see every day. It targets anonymous people passing by the display. However once a user approaches with a RFID card, the system recognizes the user's age, sex, and registered job information if any, filters out non-relevant contents and distributes only the information relating his profile. This is a typical user customized advertisement or an information providing service. It differs from the usual advertisement in the way that the user not only is pushed with anonymous information but able to pull additional information in need. This pull process in SAS logs the data for ontology weighting in a way of social machine learning.

B. Shopping Agent Service

The male in the twenties enters the shopping mall and approaches the first display near the main gate. The first display provides overall information of the department store and informs which floor the digital camera is sold. By environment ontology inference, the relation between the current location and target location (6th floor where digital camera is sold) is analyzed and informs the user to take the escalator due to the traffic in the elevator. When he arrives at the 6th floor, nearby display informs more specific information of each stores in the current floor (second display). The big category of digital camera within the ontology – DSLR, high-end, and compact digital camera is in the recommendation list with the stores.

Ontology and information hierarchy descends as the user moves toward the store selling target product. Arriving at the store, the third display informs the user of the target product and its related products based on the product ontology. Also related accessories of digital camera with its location is inferred and listed in the information panel for recommendation.

Once the user selects the final recommended product, the information route from the main gate to the store the user purchased the product is weighted for recommendation. Finally, the demographics of preferences in each location accumulate and the next user with similar preference and profile may get a socially refined recommendation results through the weighted environment ontology.

The display does not necessarily use the user's RFID, but once the demographics of the surrounding people and their activities are weighted, the product (or the POI) most likely interests people are displayed. This is a public advertisement mode, which will be further developed with camera and infra-red sensors for more personalized service integrated with the environment ontology

Figure 5. SAS system implemented with three displays providing a user interactive environment for information push/pull service.

V. CONCLUSION AND FUTURE WORK

In this work, architecture for information distribution based on the environment ontology was proposed. It was integrated into the SAS system to test its functionality and user experience. The environment ontology successfully distributed information according to each different location considering the user profile. The activity of selecting a location or a place and moving on to the next location was logged for user demographics and sales history analysis for social machine learning. It refined the recommendation data weighting the ontology map and ontology route. The user

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data was not much collected for a quantitative analysis, which will be done in the next phase of the research for refined algorithm of information recommendation based on the profile. SAS expects to extend its ontology toward other domain of location and products.

The system is optimized for the users with a RFID, in order to receive a clear keyword for personal information. Ontology provides flexibility to our system, especially for the computer to understand what the human wants, vice versa. We are working on wider range of ontology, relating not only with age and sex, but also movement and context of the surrounding of the display to provide context-aware customized information through camera and infra-red module.

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