Semantics Aware RFID Middleware for Personalized Web Services to Retail Consumers

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Abstract. Retail giants have always been finding a way to reach consumers with more personalized and individualized services that are mutually beneficial. This is a third evolutionary stage of marketing after e-commerce and m-commerce and is popularly called as u-commerce (ubiquitous commerce). Currently personalized services are naive in nature, through email subscription, issuance of pamphlets and website advertisements etc. In this paper we propose ontology based RFID middleware that can be used in retail stores like Wal-Mart and Costco for a high quality consumer care by providing secured personalized services. We believe that RFID with Semantic web services is a beneficial combination for providing personalized services on par with u-commerce initiative. Our architecture is proposal is for a service oriented semantic aware RFID middleware responsible for providing semantic web application encompassing various services to the consumers on their entry to the retail store.

Keywords: RFID, Semantics, Ontology.

1 Introduction

Consumers visit their favorite retail store more often for variety of reasons such as looking for new deals and promotions, buying accessories for items they already bought from that store earlier, looking for new items of their choice or sometimes for returning unwanted items. We envision a rich shopping experience to the consumer such that when a consumer enters a store, his prior shopping records are retrieved and consumer's likes, dislikes and needs are understood. Based on this information, services like buying recommendations, suggesting promotional items of choice, reminders for items probably needed and rewards of his choice can be offered. We think that by doing so the retail shop will reap the benefits for enhanced consumer care and efficient inventory management. This enhanced care is addressed here as personalized services.

Currently personalized services are possible for online shoppers where consumers establish a one-to-one channel and feed in personal data. There is also a risk factor associated with this scheme as a lot of consumer's likes are confessed to obtain personalization. According to Sackmann et al [1], as the world is moving towards Highly Dynamic System (HDS) whose main goal is to provide personalized services

by communicating them to individuals in a one-to-one fashion, it is important to eliminate personalization risks by providing privacy mechanisms and minimize user inputs as much as possible. Hence we believe that RFID (Radio Frequency IDentification) based architecture is the most suitable candidate for the same.

While a consumer's entry to the retail store can be realized in many different ways (example: swiping card) in this article we visualize RFID epoch, where mobile phones /PDAs enabled with RFID technology can contain a retail store RFID tag. Roy Want [2] gives an excellent introduction to RFID concept. RFID technology enables radio frequency identification from a specific distance without the need for line of sight. The numeral growth of mobile users and the momentous potential of RFID technology together is a major conducive factor to perceive mobile based RFID solutions. RFID credit cards are gaining popularity and there have been proposals similar to the one described by GeethaPriya et al [3] to use RFID credit cards securely for online shopping is also available. We envisage similar possibility with retail card in the form of a RFID tag embedded on a mobile phone that can act as a retail and credit card usable within that retail store. It is evident from the reference mentioned by Weiping et al. [4], that Mobile RFID technology eases information gathering and is favorable in enhancing consumer's confidence along with improvement in the retailer's management level, competition ability and commerce profit.

In order to realize our architecture previous shopping history with respect to a consumer must be stored and relationships between different items must be internally stored and represented. While the former is a solved problem using various data mining techniques the latter is the challenging part. Relational databases can be used, but flexibility might not be guaranteed, as semantics are not captured there, and trials to capture semantics might result in increase of complexity.

Ontology can be defined as a set of concepts, definitions and relationships that can exist for an agent or a community of agents. It is strongly instrumental in capturing knowledge about some domain of interest. Ontology is now becoming a house hold name in the Semantic Web, wherein they are used to make the semantics of keywords and terms explicit, without any ambiguity. Ontology is being used in various domains, such as e-Banking, Information Retrieval systems, and Enterprises. Ontologies are represented using Web Ontology Language (OWL), which is feted to be a standard of semantic representation. OWL also boasts of the ability to represent complex semantic relationships.

As communities in large numbers are moving towards using ontology to improve their systems, various organizations have started the development of generic domain ontologies, which can be reused and altered depending on specific requirements. We are aligning our proposal with this movement and are thus proposing the use of ontology for the retail chain to provide personalized services to consumers automatically as they enter store. Our architecture makes use of a Retail Ontology that encompasses semantics of the retail domain, to provide personalized services to shoppers.

In this paper we propose a semantic aware service oriented RFID middleware architecture that is capable of constructing semantic associations between retail products. It is also capable of comprehending prior shopping behavior of the consumer who is identified using RFID tag. We envision a scenario wherein the retail store provides subscription cards that contain RFID tags. These cards can be inserted

into a consumer's mobile phone or PDA and are read at the entrance of the retail store by an RFID reader. The tag information can be detailed at the RFID middleware which hosts the semantic web service for providing personalization to consumers based on occurrence of events and their context.

The sample use case mentioned in this paragraph is the motivation for our proposal. A consumer enters a retail store. Assume the consolidated previous shopping history for this user is as shown below:

1) Items bought during previous month: Digital Camera, DVD player and Multi-Vitamin (box of 30)
2) Items bought previous year during this time: 1 year supply of contact lenses and Camping tent.

Assume the same consumer enters the retail store a month later. This time when he shops at the retail store he is likely to look at the following:

1) Memory stick and accessories for his Digital Camera, Another box of 30 Multi-vitamin, New DVD releases for his DVD player
2) He is due for an eye checkup and need to order another year's supply of contact lenses
3) Considering the environmental context, as it is a summer season the user might be interested in air conditioners and fans as he has no record of having bought those from that store.
4) He may probably not be looking for camping tent this summer as he had already bought one last year while he might still need some camping accessories.

If the likes of users can be predicted this way based on previous visits to the store, they can be provided with more useful and personalized advertisements. This is our vision.

The rest of the paper is organized as follows; In Section 2 we mention related work. In Section 3 explain a sample consumer workflow which includes the type of services we propose to provide to the consumer. Section 4 explains our architecture in detail. In Section 5 we explain the overall flow of events using functionality provided by our architecture. Section 6 concludes this article with possible future enhancements.

2 Related Work

A lot of work has been done in the area of personalized user services but most of them are for online shoppers or kiosk based at the retail store where consumer has to provide lots of inputs to get information. Recently, Ruta et al. [5] has presented a novel framework where Bluetooth and RFID cooperate to provide enhanced discovery process exploiting the semantics of resource descriptions available in a marketplace. This is very similar to our thought line except that our proposal does offline analysis of previous shopping behavior to predict current needs and does not require any consumer input at any time.

Gedenim, a French clothing retail chain specializing in jeans, has provided a loyalty card system to its consumers and interactive RFID-enabled kiosks that provide

personalized promotional information to cardholders [6]. The advertisement here is more simplistic as the range of products is limited, unlike our retail store where there is a wide range of products and consumer base, which brings out the need for a middleware with multiple databases and increased processing capabilities. Also the services are displayed in the Kiosk placed at the shop which could be physically inconvenient to access in a crowded store unlike our mobile based personalized services that reach the user directly. Semantics has also been a prime area of interest in the retail chain, but mostly for mining of logistical data. Stuart Madnick et al. [7] describes UCCNET, a B2B electronic trading platform, which makes use of context of data in its registry of items (called Global Registry) to improvise the supply chain system of retail stores. Rayid Ghani in [8] describes methods of unstructured data mining and natural language processing techniques to be used to obtain semantics of information from feedback forms in retail stores. Mirza Said [9] on the other hand, has focused on usage of semantics from data mined from the Web to enhance product databases. While this work is aligned to our proposal, the focus is more on Web and Text mining techniques rather than on using Semantics to provide services to consumers effectively.

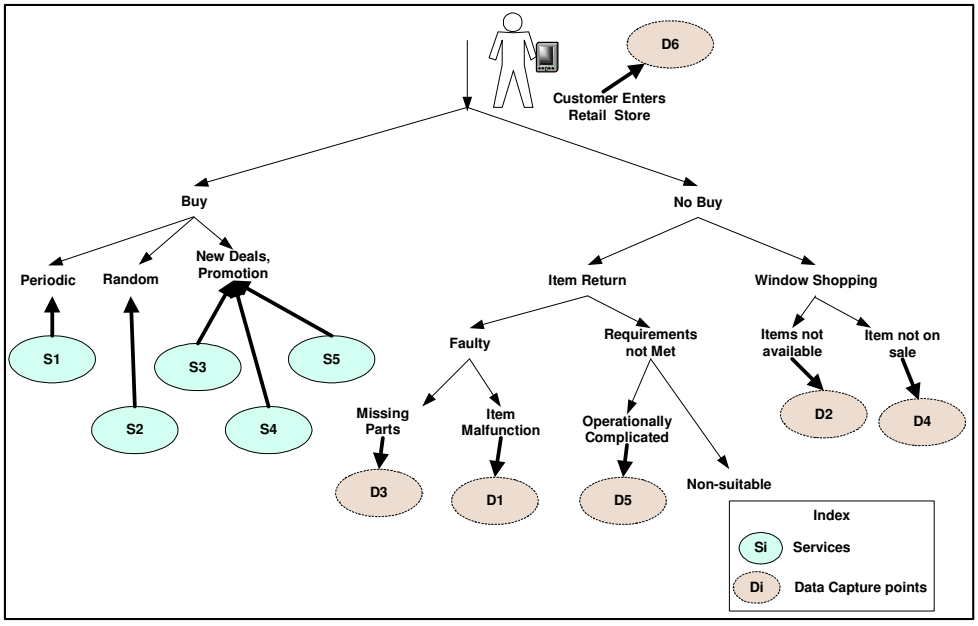

Fig. 1. Consumer Workflow inside a Retail Store

3 Consumer Workflow

The goal of our architectural proposal is to provide services that are useful to the consumer as he/she enters the store. Thus, in this section we will identify the possible types of services that are useful for any given consumer as he enters a store. We also identify the data capture points, i.e points from which events are captured and stored in database for offline and future analysis, as well as for faster and easier inventory management, ordering missing parts, fault management, etc

Table 1. Types of Services provided by our Architecture

Services/ Name	Type	Description	Analyze Past Events	Semantics Required
S1 (for periodic Buys) Reminder service	Personalized	Remind items required by the consumer	Yes	No
S2 Accessory Recommendation service	Personalized	Recommendations for accessories for consumer's previous purchases	Yes	Yes
S3 (Generalized) Sales and Promotional offer service	Generalized	General promotions throughout the store	No	No
S4 (Personalized) Sales and Promotional offer service	Personalized	Promotions of items of interest to the consumer	Yes	Yes
S5 Reward service	Personalized	Reward items of interest to consumer are presented	Yes	Yes

Table 2. Data Capture Points

Name	Description	Use
D1	Faulty items can be tracked when a consumer returns an item by capturing reason for return	Faster dispatching to supplier for fixing Parts re-ordering
D2	Unavailability of items. This can be sensed with advanced RFID-sensor network in the retail store. When a consumer returns without buying	Faster inventory update and ordering from suppliers
D3	This occurs when consumer returns an item for missing parts.	Faster ordering of missing parts from suppliers
D4	Items not on sale	Store it for future inclusion in promotional offers for that consumer
D5	Operationally complicated	Advertise simple to use similar products
D6	User Entry/User Exit	Trigger point for personalization and data storage

Table 1. shows the list of services which we think are necessary for personalized services, and hence will be offered by our architecture. Table 2. mentions some of the data capture points. Some data points are futuristic. For example D2, D4 require inputs from various sources such as sensors etc, and some intelligent analysis as well. Fig.1 indicates the workflow with services and data capture scenarios that are explained in Table 1. and Table 2.

4 Architecture

In this section we will describe the architectural requirements to realize our proposal. The entities that compose the end-to-end architecture can be classified as:

4.1 Consumer Subscription Card with RFID Tag

Retail stores generally issue subscription cards to their consumer cards as part of customer relations programme, etc. For example, whole sale giant in USA, COSTCO provides membership card to its consumers, who are supposed to present it at the store entrance. We envision that these plastic cards will be replaced by cards with RFID Tags, which can be inserted into consumer's mobile phone and can eventually be credit card usable within that store.

4.2 RFID Readers in the Store

In this architecture we assume an RFID reader is placed at the entrance of the retail store such that when a consumer enters the store, tag is read and current consumer information is provided to the RFID middleware. It also acts as a triggering point for composing and providing services. RFID readers can extend support with multiple features like, alerting expired cards, invalid cards etc. In future we propose to enhance the functionality of the reader with pre-processing abilities to minimize processing load on the middleware.

4.3 Semantics Aware RFID Middleware at the Backend

Semantic-aware RFID middleware forms the crux of the retail store's backend system. It is instrumental in transforming a retail store into consumer friendly, consumer centric and profitable retail store. Fig. 2 depicts a conceptual diagram of our semantic-aware RFID middleware. The Semantic-aware RFID Middleware consists of a retail service reservoir that provides semantic web services enabling consumers to shop with rich information on availability and offers such as sales, promotion, rewards etc. The middleware is incorporated with intelligence to carefully analyze the consumer likes, probable items required etc based on the consumer's shopping records. The logical components of our middleware can be identified as:

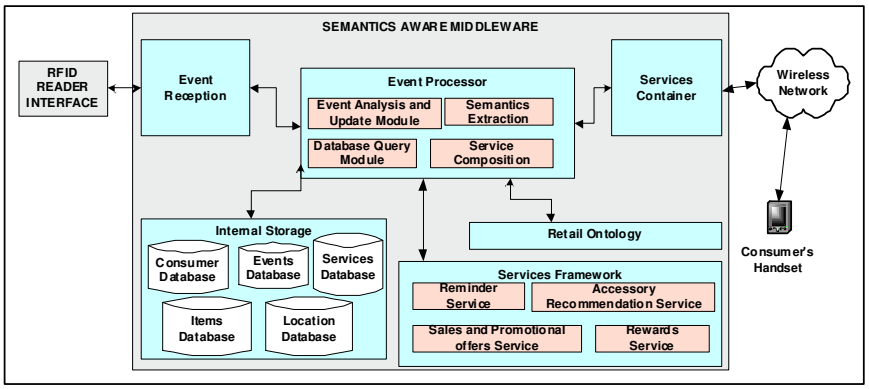

Fig. 2. Semantics Aware RFID Middleware Architecture

Event Processor. The event processor obtains events from RFID readers, sensors and other event publishing systems. It derives contextual information from these events and stores them appropriately in the Events database. We assume that proper data cleansing techniques and event filtering mechanisms are already in place so that only relevant events are processed by the Event Processor. An example is : The event could be with respect to a consumer searching for an item in an aisle, while the context could be current time, place, temperature etc. If events and contexts are captured, it may be further used for stock ordering.

Internal Storage. This layer is a repository of databases required for processing consumer information, consumer context and events, and other information related to the retail store itself. Fig. 2 identifies some of the databases appropriately. The consumer database is meant for storing consumer information. This may also store RFID Tag information against consumer's personal identification for retrieval /storage related information. The Event Database may store events and contextual information related to the consumer for offline analysis of shopping behavior. Items database may in turn contain items available in the store, recommended items for a consumer during his next visit etc. Location Database may provide location details of each item and is mainly for future extensions. The service database may contain all the services pertaining to a consumer.

Services Framework. Service Framework is our main focus that hosts semantic services offered by middleware. Various services can be offered and currently we have identified few of them in this paper. We will explain each of these services to emphasize their importance of being personalized. Table 1 explains these services briefly.

(a) *Reminder Service*. Reminder service is offered to consumers to remind items that they probably need. This will augment their memory for items required. In our architecture we propose to provide reminder service by offline

analysis of the previous shopping lists. For example, assume a consumer who bought a month supply of vitamins, when he visits the retail store 20-30 days later the reminder service will prompt the consumer with an alert that the vitamin supply would be over or about to be over.

(b) Accessory Recommendation Service. This service aims at recommending suitable accessories with respect to prior shopping list. A consumer who recently bought a new gaming device will also be interested in new games released and some famous ones.

(c) Sales and Promotional Offer Service. This service provides information regarding Sale of products that could be of interest to the consumer, and promotion of new products in categories of interest to the consumer. For example, if the consumer had bought some detergent previously, he can be given information on any sale or offers of existing detergent brands, or can be informed of new brands available. This service will, not only be beneficial for the consumer, but can also be a personalized advertising strategy for the product it self.

(d) *Rewards Program Service*. Often the retail stores come up with reward points and items available for redeeming them. If items on reward points can be chosen based on consumer's likes, it would be a win-win situation for both the retail store and the consumers. A frequent audio CD buyer can be rewarded with few audio CDs of his choice for reward points.

Retail Ontology. All the services mentioned in the previous section are made possible by Retail ontology that is created and stored in RFID middleware. Retail ontology represents retail domain, consisting of various categories of products and relationships between them. Retail ontology can be constructed with the help of retail semantics, a domain expert and Ontology languages such as OWL. We will construct non-exhaustive retail ontology for the purpose of implementation in our work. A snapshot of retail ontology is shown in Fig. 3 and Fig. 4 provides a close-up view of a part of the retail ontology, throwing light on semantic relationship between classes.Retail ontology can be broadly classified based on the product available as Apparel, Baby, Books, Electronics, Garden & Patio, Jewelry, Movies, Music, Pets, Sports, Toys and Video Games.

Services Container. Services Container is where the composed services are deployed, so that required information reaches the consumer.

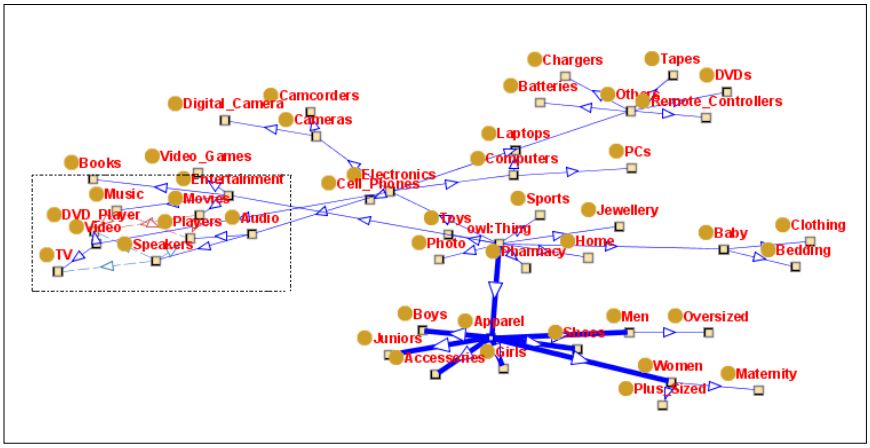

Fig. 3. Snapshot of Retail Ontology (developed using Protégé)

5 Overall Execution in Middleware

In this section we will explain the overall activity of the Semantics aware RFID middleware with respect to a consumer. The Semantics aware RFID middleware gets into action during the consumer's entry and exit. When a consumer exits the retail store, his shopping experiences are captured, analyzed and service computations are performed on them. The final list of services for the consumer and items associated with these services are computed and stored in the database. This is retrieved during the consumer's next visit.

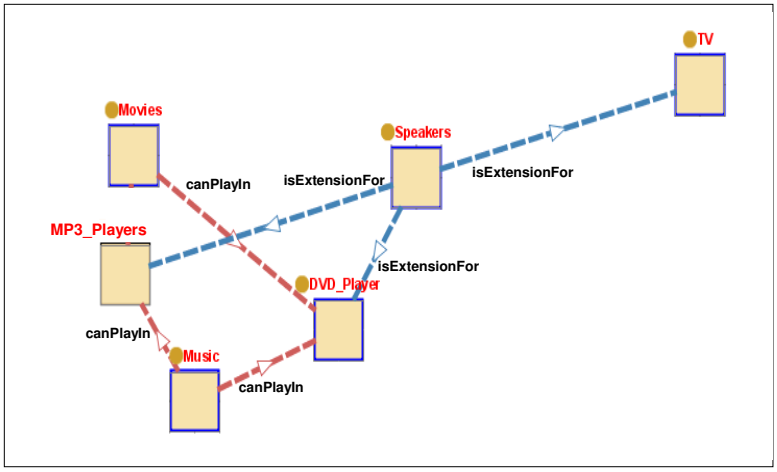

Fig. 4. Semantic Relationships between some classes in the Ontology

When a consumer buys a product, such as a month's supply of vitamins, the Event Processor captures this event and its context, such as the time and store location, apart from the user's details. This event is added to the Events database maintained by it. The items database is queried to extract the purchased item's (here, monthly supply of vitamins) semantics, such as its validity period, or periodicity in consuming etc. The services rendered for this item are selected. For example in this case, a month supply of daily vitamins means that the consumer must be reminded to buy another within next 30 days. So services identified for the consumer is Reminder Service. On the other hand the consumer is also eligible for Sales and Promotional offer service if there is a sale or if a new multi vitamin is out in the market. The consumer can be listed for these services related to the corresponding items.

When the same user enters the retail store again, the Event Processor captures this event from the entrance of the store. It immediately queries for the User's records to check for any services related to the consumer's current context. For example, if the user visits the next day again he need not be reminded about daily multi vitamins, but is eligible for vitamin reminder after twenty days or a month. Fig. 5 is a pictorial representation of the over all execution.

In short, the Event Processor performs the following steps for a given consumer:

1) Queries the User's database to obtain analyzed past events, such as the user's previous shopping list.
2) Performs a semantic matchmaking between the user's shopping list and the retail ontology to retrieve relevant items of interest for the user. Said in [10] suggests some effective ways of semantic matchmaking.

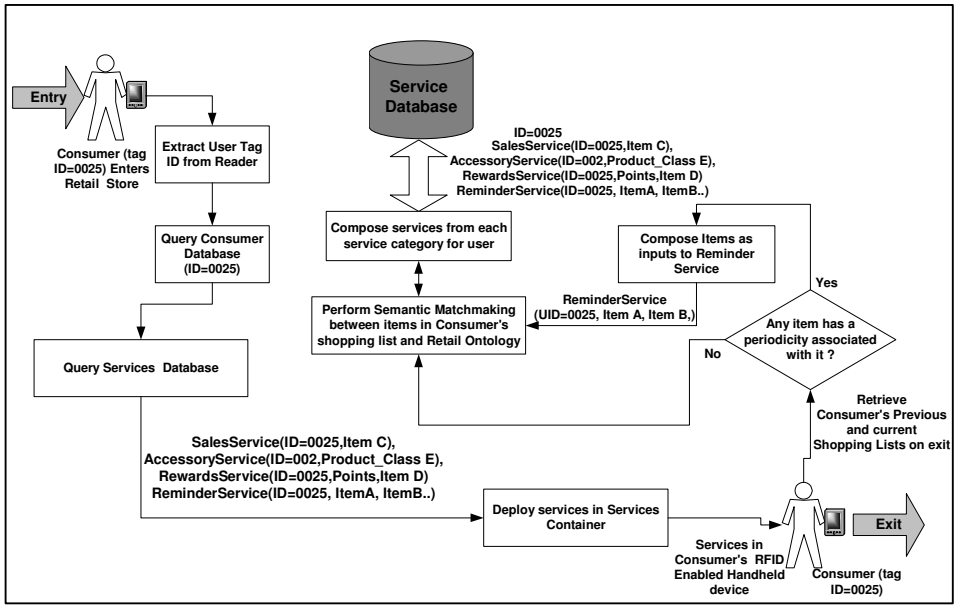

Fig. 5. Overall flow of events in Semantics Aware RFID Middleware

3) The event processor then queries the Services database, with the new list of relevant items obtained from semantic matchmaking, to retrieve the list of personalized services that can be provided to the consumer.
4) These services are then composed and deployed in the service container, so that this information reaches the consumer.

6 Conclusion and Future Work

In this article we have proposed a basic idea for Semantic-aware RFID middleware for providing rich services to consumers in retail stores. We have also envisioned the use of RFID enabled mobile phones to with RFID cards to identify users as we believe RFID is the future trend. We have explained how semantic-based services could be more useful to provide personalized services. We also believe that RFID aware semantic middleware architecture is a step towards u-commerce initiative. As a further extension to our work we will be implementing this concept and evaluate the usefulness of our semantic based web services as against normal web services to the consumers.

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