

Semantic Platform for Context-Aware Publish/Subscribe M-Commerce

Shlomo Berkovsky and Yaniv Eytani
Computer Science Department, University of Haifa
{slavax, ieytani}@cs.haifa.ac.il

Abstract

With the increasing popularity of mobile handheld devices, there is a pressing need for context-aware publish/subscribe systems over mobile environment. Publish/subscribe systems connect between information providers (publishing information in form of events) and the interested information consumers (subscribing to a particular category of events). We propose a novel approach for semantic context-aware publish/subscribe systems. Our approach replaces the traditional notion of manual subscription with a new form of automatic context-aware subscription, based on the user's location, personal preferences and interests. This has a potential of raising the quality of use in mobile publish/subscribe applications.

1. Introduction

Traditional electronic commerce resources usually base on stationary computers as the end-user device. Recently a new alternative emerges, as a wide variety of wireless mobile devices (cellular phones, PDAs, and pocket PCs) also offer access to these services. In traditional E-Commerce the location of the users is irrelevant. However, knowledge about user's location allows providing to the user more sophisticated services in an "anytime-anyplace" manner. This is the essence of mobile commerce (M-Commerce).

Mobile devices are characterized by limited interactivity due to the inconvenient keyboard and small screen size. Thus, finding information that is relevant to the mobile user is one of the main concerns for mobile applications. Development of smart personalization techniques resolving this problem is crucial for success in the M-Commerce realm.

We propose to base information personalization on the user's context. The term 'context' is any information that can be used to characterize the situation of a person, or object that is considered relevant [1]. From the M-Commerce point of view

user's context is comprised of information about the user's current location and a list of personal preferences (profile). Integrating user's context into the personalization process allows creating context-aware applications.

This work focuses on obtaining context-aware personalization through publish/subscribe systems [2]. These systems match users' mutual interests using shared registration system. The users express their interests by subscribing to events of a given type. When a new event is published, the system compares it against all existing subscriptions and notifies interested users. In the state of the art publish/subscribe systems both operations are done explicitly. Users manually define the events they publish and manually inform the system about the events they are interested in.

We propose a novel semantic approach to the publish/subscribe paradigm, where the user's dynamically changing context serves as an implicit subscription. The system automatically translates the user's context into a semantic query, performs matching, and notifies the other side. In this way the users are not required to specify their interests manually and personalized information is delivered automatically. This reflects the dynamic nature of mobile environments, where location and availability of the user change frequently.

This work employs techniques presented in HyperCup [3] and UNSO [4], previously developed semantic infrastructures for Peer-to-Peer (P2P) applications. These systems use semantic approaches to identify matching resources in E-Commerce applications. The resources are organized in a multi-layered hypercube graph, providing an efficient infrastructure for semantic search and routing operations.

To adapt the approaches of HyperCup and UNSO to mobile applications, we developed new context-based semantic hierarchy representing the current location and personal preferences of the user. We currently implement a prototype system that extends the existing

UNSO system to act as a platform for M-Commerce applications.

The rest of the paper is organized as follows. In section 2 we briefly review context-awareness and mobile context-aware systems. Section 3 discusses the publish/subscribe paradigm. In section 4 we describe semantic data management techniques. Section 5 presents a novel approach for semantic context-aware publish/subscribe systems over mobile environment. Finally, we present our conclusions and further research directions.

2. Mobile and context-based systems.

As computing becomes more portable, there is a growing need to provide information access “anytime and everywhere”. Mobile applications propose a model that enables information support to mobile users. Usually, they are run over a device with limited computing and communication power and tiny screen with low-level graphics. This restricts the amount of data that can be sent to mobile user and requires the data to be highly relevant. One way to achieve it is to personalize the data by exploiting the user’s context.

The term ‘context’ has several different meanings. It can be referred to as a location, identities of the people around the user, the time of day, temperature, etc. [5], or as the subset of physical and conceptual states of interest to a particular entity [6]. It can be viewed as a collection of information characterizing the situation of a person, or object that is considered relevant to the interaction between user and application [1].

We define accordingly the components of context:

- The situation a mobile user is currently involved in (user’s location, social situation and physical environment).
- User’s informational needs that are determined by user’s profile.
- Technical characteristics of users’ mobile device and wireless network state.

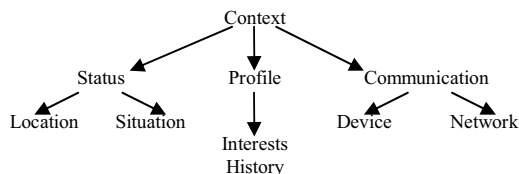


Figure 1. Schematic model of context

Context-aware applications are applications that adapt their behavior according to the user’s context [7]. There is a large body of research on context-awareness for mobile applications. Adapting behavior of the

applications to the user’s context enables them to extend their limited capabilities for providing best user experience [8]. Authors of [9] discuss mobile distributed applications and describe the context-aware mobile applications as systems that update their behavior according to an operating environment. They discuss the components of context information and emphasize the importance of location. They also mention components such as proximity, user identity, device identity, time, history, activity and so forth.

3. Publish/subscribe paradigm

Publish/subscribe systems act as natural mediators between information providers and information consumers in distributed environments [10]. Information providers publish information in a form of events, while information consumers subscribe to a particular category of events. The publish/subscribe system is responsible to check the event against all current subscriptions and deliver it to the users whose subscriptions match the event category.

Publish/subscribe systems are highly anonymous, robust and use multicasting communication model [11]. Anonymity means that users do not know (and actually are indifferent to) the identity of the other side. Instead, they simply describe the characteristics of the events they want to receive. These systems are able to adapt quickly to a dynamic operational environment, where the publishers and subscribers frequently connect and disconnect and users. The multicast communication model allows a publisher to send the same event to all relevant subscribers with a single publish operation.

Research in publish/subscribe systems focuses on statically connected computer networks [2]. However, the combination of anonymity, robustness and multicast communication makes publish/subscribe model well suited to the dynamic nature of mobile wireless environment. Anonymity and robustness allows adapting quickly to frequent connections and disconnections of mobile users. Multicasting helps the system to function properly over the limited bandwidth of wireless devices. It restricts publishing of an event to the interested users only, overcoming the information overload problem.

4. Semantic data management

Publish/subscribe systems over mobile environment require deployment of highly scalable and dynamic mediating platform. Such platform can be implemented using “smart” semantic matching techniques.

A key concept in semantic matching and data management is ontology [12]. It provides both human-understandable and machine-processable semantic mechanisms, allowing enterprises and application systems to efficiently collaborate. Techniques for ontology-based data management were developed in HyperCup [3] and further extended in UNSO [4]. These works implement a distributed data structure that enables the execution of semantic queries.

HyperCup [3] proposes a flexible ontology-based hypercube graph topology for P2P networks. A predefined ontology determines the location of a user in the hypercube. Users providing the same or similar content are organized in “concept clusters”. These clusters allow efficient semantic routing of queries that are constructed as a logical combination of ontology concepts. Routing of queries is restricted only to the users that can potentially answer them.

UNSO [4] extends these ideas by developing non-fixed and hierarchical ontology. The resulting topology can be depicted as a multi-layered hypercube, where each vertex recursively contains another hypercube. This approach improves the clustering mechanism of HyperCup by creating smaller homogeneous clusters while preserving the property of routing semantic queries to the relevant users only.

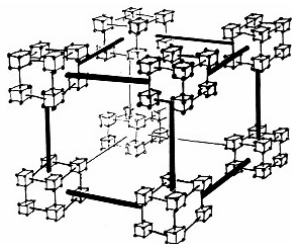


Figure 2. Multi-layered hypercube

In this work we employ the above semantic techniques to achieve context aware publish/subscribe functionality. We develop a novel notion of implicit context-aware publish/subscribe systems over the platform of mobile devices.

5. Semantic context-aware publish/subscribe

In traditional publish/subscribe systems user’s interests should be explicitly defined when performing the subscription. As the interactivity of mobile users is inherently limited, many potential customers may be deterred from using advanced personalized services.

This can prevent widespread use and dissemination of such services.

Creating a mechanism for automatic subscription based on user’s personal interests can overcome these problems. Our approach replaces the traditional notion of explicit subscription with a new form of semantic context-aware subscription. This allows a dynamic adaptation of applications’ services to the user’s transitory needs.

Developing publish/subscribe functionality over UNSO’s semantic infrastructure provides a flexible way to match between service providers and the interested users. Hashing mechanism (mapping each property in the context to the respective hypercube coordinate) automatically translates user’s context into a semantic query. The query acts as an implicit subscription to the underlying hypercube data structure.

Given ontology of users’ contexts (all possible users’ interests and locations), we map particular user’s interests to the data structure. Relevant service providers are also mapped to the same semantic location. When the user’s context changes, a new subscription is dynamically created. The new query is matched with the existing service providers and the subscriber is notified.

A critical issue in semantic data management is the correct construction of the ontology. UNSO was developed as a hierarchical ontological data structure where each hierarchy level represents a level of generalization. Higher levels of ontology provide coarse conceptual differentiation between topics, while the lower levels serve for a fine-grained partitioning of roughly similar topics.

We agree with [9] that knowledge about user’s physical location is the most differentiating information in the user’s context. This is based on the observation that users location changes much more frequently than personal interests and preferences. Thus, when building the ontology, location must act as the most important classifier and determine the mapping in the upper hypercubes. Location itself should be represented in a hierarchal manner (for example, “state, county, city, street”) to reflect degree of physical proximity.

The next level of differentiation is based on content similarity between provided services. As a result, the lower levels of the ontology form natural “concept clusters”, where similar services with close physical proximity are found in the same hypercube.

When user’s location is changed, the update of the context will lead to a re-subscription to the similar “concept cluster” in the new location. User’s personal interests will be matched against the publishers in the new “concept cluster” to find relevant service

providers. In this way we extend the fundamental publish/subscribe paradigm using natural clustering property of semantic hierarchy.

This work mainly focuses on the implicit context-aware subscription. However, this platform also facilitates a convenient mean for adaptive publishing of transitory commercial services. A service provider can easily inform the subscribers about a new service using multicast in a respective “concept clusters”, as flooding is not a viable option in the mobile environment. This is an essential functionality for M-Commerce systems. We prevent overloading users with information (in the case of many relevant matches) by bounding the number of messages a user might receive.

As a typical scenario of the system usage, assume a user, which had defined in her personal profile that she would like to be informed about Italian restaurant nearby at the lunchtime. The user’s context at lunchtime can be abstractly viewed as “a person who likes to eat Italian food at close vicinity”. When the user goes to a business trip she changes her location and her context also changes. She will be re-mapped to a new low-level hypercube, and since her culinary preferences remain the same, they will be matched against Italian restaurants nearby. As a result, during the lunchtime she will be informed about Italian restaurants at a close physical proximity.

6. Conclusions and future work

Finding information that is highly relevant to the mobile user becomes one of the main concerns for mobile applications. Integrating user’s context into the personalization process allows creating context-aware applications improving interaction with mobile users.

We focus on obtaining context-aware personalization through publish/subscribe systems. The user’s dynamically changing context is automatically translated into a semantic query and serves as an implicit subscription. The query is built and answered using the techniques of previously developed ontology-based infrastructures. These platforms have implemented “smart” semantic matching mechanisms. To adapt these techniques to mobile applications, we developed new context-based hierarchical ontology representing the current location and personal preferences of the user.

In the future works we intend to replace the static part of the user’s context, namely the user’s preferences, with dynamically learned user profile. To improve the accuracy of the information we plan to develop the ranking of the received information. We plan to evaluate the proposed platform by building an

application and analyzing responses of real users. We believe our platform can substantially contribute to the development of mobile context-aware services and facilitate their extensive use.

7. References

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