Abstract

The ability to reason from context allows a large amount of implicit information to be conveyed with a small amount of explicit descriptions. If this ability can be provided to a context information center for an M-commerce application, this application can then be regarded as a context-aware M-commerce application that can adjust its behaviors according to the available implicit information in the environment. This paper proposes a context information center to support M-commerce applications. In this context information center, five types of context information are taken into account and a unified format, RDF, is used to present the context information.

Keywords

M-commerce, context information, context-aware, RDF

1 Introduction

Do you want your mobile device receive an e-voucher when you are pass by a shopping mall? Do you want your mobile keep silent when you are attending a meeting? In order to accomplish the above outcomes, it needs a M-commerce application that has the ability to deliver relevant information to the right users at the right time in the right way. The M-commerce application is called a context-aware M-commerce application since it uses the context information.

1.1 Context

There are two primary meanings for the term of context according to the Oxford English Dictionary: “1) the words around a word, phrase, or statement which are often used to help explain (fix) the meaning; 2) the general conditions (circumstances) in which an event, or action takes place”. Clearly, the first meaning is more closely related to the linguistic meaning and the linguists' use of the term, whereas the second meaning is closer to the definition of the context in the computer science (Varol Akman, 1996).

Based on the second meaning, context can be defined as any information that is used to characterize the situation of an entity or an action. For example, while you are reading this paper, the entity contexts include the paper in your hands and the chair you are sitting on. On
the other hand, this paper and the chair are also parts of your reading action -- the context of an action.

1.2 Context-Aware
Humans are inherently context-aware agents. When we talk with each other, we are able to use implicit situational information, or context, to increase the conversational bandwidth (P.J. Brown, 1999). For example, when a person in the room tells you, “turn on the light please”, you are able to reason that the person is asking you to turn on the light in this room, but the one in the next room, although the person hasn’t explicitly indicated which light he or she wanted you to turn on.

The fact that you are able to choose the correct light to turn on actually contains three important things. First of all, you and the person in room have to share a common communication language and share the meaning of vocabularies in the conversation. Secondly, the person needs to be able to physically communicate with you, in this case by using sound. Thirdly, you need to be able make sense out of what you have heard, that is the ability to reason. Only after you have understood the semantics of the request, based on your interpretation, can you take the action to choose to turn on the light in the room.

Based on the above example, it is easy to conclude that the following are the three necessary capabilities that enable humans to become context-aware: 1) the capability to share a common ontology, 2) the capability to sense context and 3) the capability to reason over context.

1.3 The Context Information Center
A M-commerce application usually provides different services to mobile devices, such as SMS and MMS for example. However these services are not context-aware. If a context information center is combined with the M-commerce application and it provides context information when needed. The M-commerce application can make further decision whether the information is relevant. We propose to combine three centers in a M-commerce application. They are user information center, content information center, and context information center. Figure 2.1 is the system architecture of the whole M-commerce application. In this paper, we only focus on the context information center.

![Figure 1.1 our proposed M-commerce application](image-url)
The user information center includes a user manager and a user model. It is designed to provide user’s information to the M-commerce application, for example, user’s activities, user’s preference.

The content information center contains a message manager and a message model. It is designed to manage the merchants’ product information.

The context information center includes a context manager, a context model, and context providers. It is designed to make use of the context to provide task-relevant information to users and make them context-aware. Also it needs three necessary capabilities to support the context-aware ability for the M-commerce applications.

First of all, the capability to share a common ontology: Five types of context information are taken into account in this context information center. They are user’s activities, location, user’s preference, weather and Date-Time.

Secondly, the capability to collect and represent context: All the context information is presented in a uniform format – Resource Description Framework (RDF) (Ora Lassila, 1999), a data model for representing metadata. By using the RDF, the context information center then can sense the context from the context providers.

Thirdly, the capability to reason over context is: This capability is actually to set specific rules on some pieces of context information. For example, a user likes to go to the church every Wednesday.

In this paper, we start with a brief analysis of related work in context-aware application, followed by the proposed design of our context information center.

2 Related Work

To date, there are few clear examples of developed application that explicitly separate the context information and unify the context information for easier exchanging. Most context-aware applications take a few kinds of context information to support the context-aware ability. For example, Forget-me-not (Lamming M., 1994), a system developed at Rank Xerox Research Center, is to help user’s recall events by using context, as if a cue for remembrance. This system takes the personal location, user’s activities into account. Another example is the CyberMinder (Dey A.K., 2000), a reminder-based system. This system takes into account user’s activities, location, time and user history as the context information. It can notice simple events (e.g., notifying a user of a meeting just based on time) or complex situations (e.g., reminding a user of an event using other people’s context). This means that the CyberMinder may offer more support than the traditional ‘to-do’ list does. More contexts taken into account to an application improve the ability to deliver relevant information to its users. GUIDE system (Cheverst K., 2000) utilizes a user model and provides context such as visitor’s interest, preference, and so on. Based on the context information, the system tailor or constrain the city-based hypermedia presented to users.

There are many other context-aware applications that take into account corresponding context information; they do not explicitly consider the format that presents different types of context information. In the context information center proposed in this paper, five kinds of context information are taken into account to provide context-aware ability for the M-commerce applications. Different kinds of context information can be gathered from different methods. For example, location comes from MPS (Mobile Positioning System). While user preference and user’s activities come from user model. In order to combine and efficiently use the context information, the RDF is introduced to provide a uniform context information format, as described in the following part.
3 The Design of the Context Information Center

Figure 3.1 is the architecture of the context information center. It includes a MPS (Mobile Positioning System), which provides location information; Some context information providers, those provide weather and Date-Time context information; a context model, which stores all context record as a context library for each user; and a context manager. The context manager is the core of the context information center, it takes the responsibility of exchanging information inside the context information center and outside the information center.

Four sections will be included to describe the design of the context information center. The first section describes the presentation of the context information. The second section describes the five kinds of context information taken into account in the context information center, followed by the third section that describes the functionalities. Finally, the fourth section describes the modules in the context manager, which is the core of the context information center.

3.1 Context Information Presentation

The main task of the context information center is to provide context information to the M-commerce application. For convenience and efficiency, Resource Description Framework (RDF) (Ora Lassila, 1999) is introduced in the context information center to present the context information. It is a foundation for processing metadata. It provides interpretability between applications that exchange machine-understandable information on the Web/Wap. RDF itself is not a language; it is a data model for representing metadata. In the current RDF specification, RDF metadata is encoded in XML to make it possible to specify semantics for data based on XML in a standardized and interoperable manner.

The foundation of RDF is a model for representing named properties and property values. RDF properties may be thought of as attributes of resources.

The RDF data model consists of three object types:

1. **Resources:** All things being described by RDF expressions are called resources. Resources are always named by URIs (Uniform Resource Identifiers, short strings that identify resources in the web) plus optional anchor ids.

2. **Properties:** Properties are specific aspects, characteristics, attributes, or relations used to describe resources. Each property has a specific meaning, defines its
permitted values, the types of resources it can describe, and its relationship with other properties.

3. **Statements:** Each statement consists of a specific resource, its named property, and the value of that property for that resource. These three individual parts of a statement are called, respectively, the subject, the predicate, and the object. The object of a statement (i.e., the property value) can be another resource (specified by a URI), or it can be a literal (a simple string or other primitive data type defined by XML). The subject, predicate, and object together constitute the triple representation of the RDF statement.

In the RDF data model, any given resource has its property. It can be the subject of one triple statement. At the same time, it can be the object of another triple statement. For example, the following shows some sample RDF statements:

```xml
<Document rdf:about="docInst"/>
<Person rdf:about="personInst">
  <holding rdf:resource="docInst"/>
</Person>
<InRoom rdf:about="inroomInst">
  <person rdf:resource="personInst"/>
</InRoom>
```

The two corresponding triple statements are the following:

- **T1:** Subject(inroomInst), Predicate(person), Object(personInst)
- **T2:** Subject(personInst), Predicate(holding), Object(docInst)

This property allows flexible information aggregations. For example, one information source might make the statement that “a person is holding a document” (see the following textbox).

```xml
<Document rdf:about="docInst"/>
<Person rdf:about="personInst">
  <holding rdf:resource="docInst"/>
</Person>
```

Another information source might make the statement that “a person is in a room” (see the following textbox).

```xml
<InRoom rdf:about="inroomInst">
  <person rdf:resource="personInst"/>
</InRoom>
```

By aggregating these two statements, one can draw the conclusion that the person who is in the room is also holding a document. Furthermore, another one can reason that the document is also in the room, since the person who is holding it is in the room.

Since RDF is a metadata (“data about data”) with the XML format, it can be used to present any content that is in the standard format described above. Different kinds of context information can be obtained by different ways. They may have different formats. By converting different formats of context information to the RDF format, it decreases the difficulties and enhances the compatibility in building the context information center.
3.2 The Context Information

There are many types of context information that can be used, for example, location, weather, and Date-Time. The more context information a context information center can reason from, the better context-aware ability the context information center provides. However, there exist limitations that prevent all context information from being combined into only one context information center. For instance, it’s almost impossible to get patient’s information from a hospital in order to recommend relevant medicine because of privacy limitation. Therefore we cannot have all context information to be used in a context information center. In this paper, five kinds of context information will be used, which are user’s activities, user’s preference, user’s location, whether and Date-Time. These five kinds of information provide relative complete information to reason from and provide relevant information to the users. By using these five kinds of context information, the M-commerce application can judge the situation that whether it is a good timing to send an e-voucher to a user, or whether it should send a message to a user who is attending a meeting.

3.2.1 User’s Activities

In the M-commerce application we proposed to build, all users can arrange their daily activities through Web/Wap/SMS (Some company has developed corresponding application to support Web, Wap, and SMS channels for mobile devices, for example, Ericsson). When user’s activities information is passed to the context information center, it is converted into the RDF format. If a user’s activity is a recurrent one, the context manager will store this RDF format information into the context model for later use. For instance, Tom has a meeting every Monday at 9:00am. Therefore, if today is Monday, the context manager will then send a reminder message to Tom. The following text box is an RDF example of a meeting activity for a user.

```xml
<Meeting rdf:about="Weekly Meeting" />
<holding rdf:about="TimeInst" />
<holding rdf:about="Meeting Room" />
<holding rdf:about="Tom" />
</Meeting>
```

3.2.2 Location

Location context information plays an important role in the context model. All context-aware application would take into account this type of context. For example, the Cyberguide system provides a context-aware tour guide to visitors to a “Demo Day” at a research laboratory (Long, Kooper et al. 1996; Abowd, Atkeson et al. 1997). It uses a hardwired infrared positioning system to get the location information. The In/Out board, another application in Georgia Institute of Technology, uses context widget sensor to get the context information (http://www.cc.gatech.edu/fce/contexttoolkit/#sampleapplication). There are also many other ways to get the location information, such as GPS (Global Positioning System). For M-commerce applications, because of cost and other limitations, most of the mobile devices do not have a built-in sensor that can get the location information. To overcome this limitation, a new way, called MPS (Mobile Positioning System), is introduced. MPS actually is a service center that can get the location information through the return signal of user’s mobile device. Several leading mobile and LBS (location-based services) companies like Nokia, Ericsson, Locationet provide MPS products and services. MPS has its advantages and drawbacks in comparing with other methods. It is easy and
convenient to get a lot of users’ location information over a wide range of area, but its precision of location is only approximately 100 meters, which means it cannot provide information such as whether the user is on floor 10 or floor 11. MPS can provide a roughly location information, and needs to be combined with other kinds of context information to provide more accurate information to the user. Following text box is an RDF example of a user in a place.

```
<InPlace rdf:about="Meeting Room">
  <person rdf:resource="Tom" />
</InPlace>
```

### 3.2.3 User’s Preferences
User’s preference is a critical factor that affects user’s behavior. If the user does not like fast food, it is unlikely that he/she would like to receive message that contains a McDonalds e-voucher even if the user is passing by a McDonalds.

As described in the introduction, the user information center provides user’s preferences. There are two ways for the user information to get the user’s preference. First, as a registered user, the user information center asks the user to specify his/her preferences, for example, what food he/she like. Second, when the user uses the M-commerce application to seek information, the user manager traces the user’s behavior. Based on the user’s behavior, the user information then induces the user’s preference.

The following text box is a RDF example of a user’s preference that indicates that he or she likes Chinese food.

```
<Person rdf:about="Tom">
  <like rdf:resource="Chinese food" />
</Person>
```

### 3.2.4 Weather
Weather is another important context information that reflects the user’s activities. If it is raining, it is not suitable for the M-commerce application to send message to user and ask he/she to attend an outdoor activity. Weather information is available in weather forecast websites, e.g. Hong Kong Observatory (http://www.hko.gov.hk/contente.htm). Following text box is an RDF example of weather information.

```
<Weather rdf:about="Hong Kong">
  <Time rdf:resource="TimeInst" />
  <Weather rdf:resource="Cloudy" />
  <Temperature rdf:resource="27" />
</Weather>
```

### 3.2.5 Date-Time
Date-Time exists in all daily activities, for example, Date-time for a meeting, or for an activity. Date-Time information is available in each computer for use. Following text box is an example to show the Date-Time context information.
3.3 Functionalities of the Context Information Center

3.3.1 Convert Context Information
In the context information center, five kinds of context information are taken into account. Different kinds of context information are in different formats and collected in different ways. Location information is provided by the MPS, user preference information and activities information are provided by user information center. Date-Time and weather information are also in different format and collected in different ways. In order to unify the formats of different kinds of context information, the context information center needs to convert the context into corresponding RDF format as described in section 3.2. The conversion will be done in the context manager.

3.3.2 Update the Context Model
The context model stores all context records for each user. For example, a user does not want to receive any information when he/she is in a meeting. But this condition may change as the user change his/her habits or he/she may permit some very important information sent to him/her. The user information center can obtain some context records directly from the user when they are explicitly specifying his or her preferences. Others may be obtained through indirectly ways. In the User information center, a user model is used to study the user’s behavior or preference. If a new context record occurs, the context manager needs to add it to the context model. If a record expires for some reasons, the context manager also needs to update the corresponding context record in the context model.

3.3.3 Exchange Information with a User Information Center
The context information center aims to provide context or reminder to the M-commerce application, so that the M-commerce application can “deliver relevant things to the right people at the right time in the right way”. The context manager takes the responsibility to exchange three kinds of information with the M-commerce application. First of all, the context manager updates the context model according to the user’s preferences and activities that come from the user information center. For example, there is a piece of user preference information that Tom likes Chinese food comes from the user information center. The context manager first convert the information into RDF format, then store it to the context model. Secondly, the context manager replies and sends relative information to the user information center. Thirdly, when some context for an event occurs and match the corresponding context record in the context model, the context manager will send this event to user information center. For example, give the user some recommend place to have dinner when the user is near (because of the limitation precise provided by MPS, this distance is about 100-500 metres) a food court at dinnertime.

3.4 Design the Context Information Center
This section will describe the design of the context information center. As described in section 3.1, RDF is used to present all the context information. So the information exchanged
between the context manager and context model is RDF-based information. Inside the context manager, Java is proposed to develop the four modules to communicate with MPS, weather, Date-Time context information, context model, and user information center. DOM is proposed to manipulate the RDF-based context information. Four modules are describes as follows:

### 3.4.1 Convert Context Information to RDF Module

This module is designed to handle the context information that is not in the RDF format. Location information, weather information, and Date-Time information are in different formats. In this module, three independent methods are proposed to convert those three kinds of context information. The user’s preferences and user’s activities, which provided by the user manager, are already in RDF format.

Let’s use an example to show how a piece of meeting information can be converted to corresponding RDF format. The source information is string “John (the unique ID) has an annual meeting in conference room at 2003-01-15 14:00”. This information can be divided into several key words, which are “John”, “annual meeting”, “conference room”, and “2002-01-15 14:00”. By using DOM, A piece of RDF-based user’s activity context information can be built up with the four key words as following:

```xml
<Meeting rdf:about="Annual meeting" />
<holding rdf:about="2003-01-15 14:00" />
<holding rdf:about="conference room" />
<holding rdf:about="John" />
</Meeting>
```

### 3.4.2 Update Context Model Module

This module is designed to update the context model according to the change of users’ preferences or activities. In the context model, each user has his or her own context records that indicate his or her preferences and activities. When the context manager receives new context record of a user, it search the context model, if the context record exists in the context model, the context manager will update it, else the context manager will add this context record to the context model.

### 3.4.3 Process the User Information Center Request Module

The user information center may send request to the context manager for some information regarding context. This module is designed to provide this kind of services. When a request is sent to the context manager, the context manager firstly interprets the request to obtain what context the user information center wants, then to search the corresponding context information. Finally it returns this context to the user information center. For example, if the user information center sends a request for context information that who is around a specific building (because of the limitation precise provided by MPS, the distance is about 100-500 metres), the context manager processes request and sends a request to MPS. MPS will send back user information center the information concerning people around the specific building.

### 3.4.4 Remind user Module

This module is designed to send reminders to the user information center when some events occur and match the context record in the context model. When this situation occurs, the context record will be changed to a reminder and will be sent to the user information center.
4 Discussion and Future Work
Since the background and motivation to develop this context information center is to support the M-commerce application, two issues are considered in this paper for future research.

4.1 Context Type
There is no standard rule to decide how many types of context information are enough for a M-commerce application. It actually depends on many aspects of the application. Five kinds of context information are taken into account in this paper, but they may or may not enough for the application. One thing we plan to do is to add more types of context information to the context model. By using the RDF to present the context information, it is easy to add new types without fundamentally changing the existing model.

4.2 Algorithms
There are many information exchanging between the context manager and the context model. For example, the change of a user’s preferences involves updating information to the context model. Another example includes the change of context from the context provider involves retrieving information from the context model. Moreover, context varies from time to time, huge volume of information will flow to the context manager. In order to improve the efficiency of the context information center, efficient algorithms should be proposed.

5 Summary
There are many kinds of context information being used in context-aware M-commerce application, and it is difficult to manipulate them. In this paper, an integrated presentation format (RDF) is introduced in a context information center to represent different kinds of context information. RDF can unify all kinds of context information into a single RDF format that is easy to use and brings efficiency. Based on the unified format of context information, this paper describes the design of a context information center and points out the functionalities and modules in a context information center. The design can serve as the guidelines for the development of a similar context-aware M-commerce application.
References


