Design and Implementation of Event Notification System for Real-time Tracking in Logistics

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Abstract: With the proliferation of smart devices, applications under ubiquitous environment must provide transparent access to computer resources. However, existing u-Logistics systems can not properly react on such requirements, because the status information of objects is input only in fixed milestones by system's operators. In this paper, we introduce an event notification service suitable for u-Logistics environment. The system is based on RFID infrastructure and provides real-time tracking by combining the event of objects with location information received from GPS satellites. The system also provides a graphical user interface based on a state/transition approach, making it easy that clients facilitate definition of profile, and uses XML structure to more easily represent and exchange events.

Keywords: RFID Technology, Event Notification Service (ENS), Profile Definition, Logistics.

1. Introduction

With the proliferation of smart devices for ubiquitous computing, applications have to provide transparent access to computer resources, whenever and wherever they are needed[1]. It is identically applied in logistics area. If clients want to know the current state or location of their items, the systems must be able to support such a service. However, existing systems can not properly react on such requirements, because the status information of objects is input only in fixed milestones by system's operators. Such business processes may lead to an inconsistency problem between the current state of the objects and its information stored in a database. For this reason, we can't expect the existing systems to satisfy the client's requirements mentioned above.

To solve the problem, we propose an event notification service for u-Logistics based on RFID infrastructure (hereinafter referred to as the "RFID Infra"). We can collect the information of the objects by putting a RFID tag on all objects related to the system. The information is commonly called an event. Combining the events with location information received from GPS satellites, it can be used to track and trace the objects.

Our goal is to design and implement a system which can track and trace the objects at real-time. It can be realized by implementing event notification service (hereinafter referred to as the "u-LogENS"). Event messages collected are filtered to clients' interests called a profile, and then notifications are sent to the interested clients. In this manner, u-LogENS can satisfy the requirement of clients.

The service that u-LogENS provides is characterized by the representation of events and the definition of profiles. First, the system provides a graphical user interface based on a state/transition approach. The interface makes it easy that clients access the system to define profiles. Second, the system represents and exchanges event messages using XML structures. Because the XML structure has already been standardized in many industry areas, the system can ensure interoperability between trading partners.

The remainder of this paper is organized as follows. In the section 2, we analyze previous work related to RFID technology and event notification service under logistics environment. The section 3 and 4 describe what event messages and user profiles are and how they are defined. In the section 5, we suggest the architecture of u-LogENS and illustrate data-flow between its main components. Finally, we evaluate u-Log system by comparing to the existing systems and make concluding remarks.

2. Related Work

RFID(Radio Frequency IDentification) is a technology which identifies the objects using communication between tags that emit radio signals and devices called reader that collect the signals within own read range[2]. Auto-ID Center of MIT focuses on developing the infrastructure dynamically extracting, networking, and storing information about products[3]. It is based on EPC(Electronic Product Code), maintaining minimal information of the products. It is called EPC^{TM} Network.

An event notification service(ENS) or alerting service connects the providers of information and interested clients[4]. The providers inform the clients about observable events and the clients define their interests in certain event via an interface of the service. The interest called profile is stored in a database. The event messages are reported either by the providers(push) or by the service actively observing the providers(pull). The event messages are filtered according to predefined profiles by the service and notifications are sent to the interested clients.

There are the systems to realize the service such as A-MEDIAS[4], Siena[5], Hermes[6], and Lesubscribe[7]. TIP[8], a model that combines LBS(Location Based

Service) and ENS, provides mobile users with useful information based on their location, time, profiles, and histories.

ParcelCall[6] ongoing in EU is a GIS-based service for tracking the location of parcels. Its goal is to develop a system that supports real-time tracking, regardless of the frontier, transport companies, and transport ways. The system is also intended to use an opened and standardized communication protocol.

Descartes[9] is an e-frame developed by a distribution company in Canada. The system is a solution for supporting integrated distribution information through network. Nevertheless, they have some disadvantages. First, because it is not based on standardized structures like XML, the system can't ensure interoperability with other platforms. Second, Descartes also sends alerting messages to clients via various formats such as e-mail, mobile device, and system alerting, but situation for alerting is extremely limited. The system uses milestones, agreed points of time to evaluate results about distribution, for reporting. If reporting is out of the range of error, the system makes a message for alerting. The range of error is, For instance, due to delay in delivering, no input of data, and so on.

As explained in the introduction, the works considered here do not support real-time tracking. Therefore, we propose an event notification service based on RFID infrastructure. Event in a certain object combined with location information of GPS enables the system to track and monitor the current state and location of objects at real-time.

3. Event Message

Events are used to represent and exchange events read by RFID readers in logistics environment. In this section, we describe the definition and structure of the events.

1) Definition of an Event

An event may be changes of status in a database, signals in a message system, or the departures and arrivals of vehicles[4]. In view of data to be processed, the ENS differs from an active database system in fundamental ways. The active database system is based on transactions in the system. On the other hand, the ENS is based on messages to be exchanged between components organizing the system because the ENS is commonly applied to distributed environment. Therefore, Event messages must have a timestamp value to distinguish its occurrence.

As mentioned earlier, all the objects in RFID Infra have a RFID tag storing an EPC which maintains minimal data of the object. RFID readers therefore make events by detecting RFID tags within own read range. However, the data detected by RFID readers are only EPCs stored within tags and u-LogENS needs additional information such as location and time. We therefore must consider the use of a broker connecting RFID Infra and u-LogENS. We call it MDA(Mobile Digital Assistant). MDA either regularly reports events by combining the data collected from RFID readers with location information received from GPS or immediately reports as soon as RFID readers detect tags.

Table 1. Event type

Event type	Description
MDA_REGISTERED	When an item is loaded
MDA_TRANSPORT_STARTED	When a truck departs garage
MDA_LOCATION_UPDATED	When MDA regularly report the location of the truck
MDA_ITEM_UNLOADED	When an item is unloaded from truck
MDA_TRANSPORT_ENDED	When a truck returns to garage

In u-LogENs, there are five events as shown in Table 1. It is to model event types observable from when items are loaded on a truck to when the trucks that finished deliveries return to garage. The object may be an item or a truck. When an object is loaded on a truck, a RFID reader attached in the truck detects the tag of the object and an 'MDA_REGISTERED' event is then sent to MDA. As opposed to a 'MDA_REGISTERED' event, a 'MDA_ITEM_UNLOADED' event occurs when the object is unloaded from the truck for delivery. A 'MDA_TRANSPORT_STARTED' event and a 'MDA_TRANSPORT_ENDED' event occur when the trucks depart from their garage and when trucks arrive in their garage, respectively. A MDA may regularly report the location of a truck until the truck returns to garage. This event is called 'MDA_LOCATION_UPDATED'.

2) Structure of Event Message

In u-LogENS, Events occur from not u-LogENS but external RFID Infra. To report these events to u-LogENS, events must be represented and exchanged as messages with a specific format. To do this, we consider the structure of XML. The use of XML takes some advantages as follows.

First, XML syntax is a set of tag elements that contain meaning itself, so XML has a flexible structure to represent events as messages with hierarchy. A computer can more easily represent and parse information on network as well. Second, it can ensure interoperability between trading partners by using XML structure that has already been standardized in many industries.

Fig. 1 shows the example of a 'MDA_LOCATION_UPDATED' event in u-LogENS. All the event messages consist of a <header> element and a <body> element. The former describes meta-data of event messages and the latter describes the information of objects read by RFID reader.

From the <header> element of the example shown above, we see that this message was sent from CIS(Carrier Information Service) component with an identifier 'CIS_001' and that the location of the truck was reported. At this time, the truck containing MDA with an identifier 'MDA-1075707079' is passing a

```
<?xml version="1.0" encoding="EUC-KR"?>
<CISEvent type="MDA_LOCATION_UPDATED">
    <Header>
        <Source id = "CIS_001" />
        <Destination host="#ALERT_HOST_NAME" port="3000" />
        <Timestamp>2004-10-01T15:30:47Z</Timestamp>
    </Header>
    <Body>
        <MDA id="MDA-1075707079" />
        <LocationInfo>
            <SequenceNo>1</SequenceNo>
            <MDASentTime>2004/10/01 15:30:47</MDASentTime>
            <CISRcvdTime>2004/10/01 15:30:48</CISRcvdTime>
            <Latitude>
                <Deg>36</Deg>
                <Min>37</Min>
                <Sec>28.3</Sec>
            </Latitude>
            <Longitude>
                <Deg>127</Deg>
                <Min>27</Min>
                <Sec>50.52</Sec>
            </Longitude>
            <Velocity>33.1</Velocity>
            <Course>120.1</Course>
        </LocationInfo>
    </Body>
</CISEvent>
```

Fig. 1. Representation of event message

location whose geographic position is a (36°37'28.3", 127°27'50.52") pair, with the speed of 33.1Km/h and moving to 120.1-degree angle. Text enclosed with parenthesis denotes a (latitude, longitude) pair. Using this message, u-LogENS is able to track and trace the location of the objects at real-time.

4. User Profile

Clients define their interest in certain events by means of personal profiles. The events also occur in certain objects. Objects in u-LogENS may be items and trucks and they have an identifier to uniquely identify each object. By defining profiles, the clients can be notified about new events occurred in providers' site.

The definition of the profiles is based on the profile language of the service. AMIT of IBM[10] provides step-by-step GUI, so the tool shows next property after defining one property. In contrast to AMIT, u-LogENS provides a tool based on state/transition approach. We call the tool Profile Manager. Each profile consists of both states and transitions, and they have one and more properties. This tool helps clients to more easily and familiarly define the profiles.

Equally important, each profile is distinguished into two parts: The rule part which is used by Filter specifies the events in which the client is interested. The notification policy part which is used by Notifier specifies additional parameters such as receivers, notification methods(e.g., SMS or e-mail), and a notification cycle. Filter and Notifier are mentioned in next section in detail.

Fig. 2 shows the example of the profile by a client. The client wants to know the location of his item every

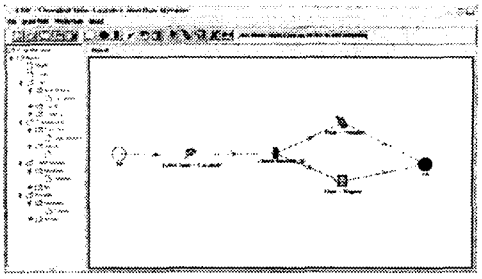

Fig. 2. The example of the definition of profile

20 minutes. He also wants to be notified via both SMS and e-mail. From the requirements specified above, we can extract three states and one transition, and then set the respective properties. Three states are an interested object(the unique identifier of item) and two formats(the number of SMS and the address of e-mail) to send a notification. A transition is an interval(20 minutes) to want to be notified via the formats. Text enclosed with parenthesis denotes properties of both states and transition.

A profile of u-LogENS is processed in a fashion similar to the semantics of Event Action Condition (ECA) rule in active database system. When a relevant event(Event) occurs, the rule part(Condition) of profile is compared to predefined profiles, and then its notifications(Action) are sent.

5. The Implementation of u-LogENS

In this section, we describe the architecture of u-LogENS by analyzing data-flow between the components. Fig. 3 is a diagram which abstracts interaction between main components organizing u-LogENS in distributed environment. That follows the architecture shown in typical ENS, a reference model introduced in A-MEDIAS[4].

1) Observer

The first task of ENS is to collect the stream of events from the providers. A component which performs this task in u-LogENS is called Observer.

As mentioned above, the typical ENSs collect event messages in either of the following ways. The event messages are reported either by the providers(push) or by the service actively observing the providers(pull). As

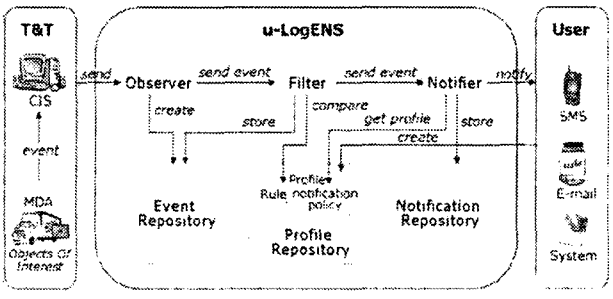

Fig. 3. Architecture of u-LogENS

shown in Fig. 3, RFID Infra largely consists of T&T, u-LogENS, and users. The T&T(Track and Trace) side, the providers of information, realizes a RFID technology to support real-time tracking and pushes the newly occurred events in the object of interests to u-LogENS.

Event messages received from T&T are stored in Event Repository and then sent to Filter. Event messages similar to stream data are by nature append-only.

2) Filter

Filter compares event messages to predefined user profiles. The process is outlined in the following steps.

In the first step, Filter extracts filterable properties from event messages. As mentioned earlier, because event messages are represented using XML structure, Filter uses the SAX parser of J2SDK to parse them.

In the second step, Filter compares the properties to rule part of profiles, defining the clients' interests in certain event. This is commonly called event filtering. If event messages match any profiles or any profiles are covered by the event messages, these properties are sent to Notifier. Otherwise, the properties are discarded.

3) Notifier

Notifier generates a notification message according to notification policy part of the profiles, and then the notification is sent to the interested clients. At the time that generates a notification messages, it may often need to transform a (latitude, longitude) pair into an address. Rather, the ENS adds other information to notification message, in distinction to publish/subscribe system that sends events as it is. It makes a distinction between ENS and publish/subscribe system.

Fig. 4 shows the result sent via SMS and e-mail. u-LogENS provides u-LogENS Manager, a tool which can start/stop the service. It can also monitor messages to be exchanged between u-LogENS and other components, such as predefined profiles, collected events, and sent notifications.

The proposed system can be summarized as follows, comparing to the existing system such as Descartes[9] and AMIT[10]. While AMIT provides a step-by-step wizard to define profiles, u-LogENS provides a state/transition-based GUI. From the service aspect of ENS, both u-LogENS and AMIT provide real-time tracking, while Descartes does not. They also cover large stream data and event messages are represented using XML structures. u-LogENS also informs notifications via SMS as well as e-mail. These characteristics of u-LogENS can apply to the control of traffic flow and the management of stream data.

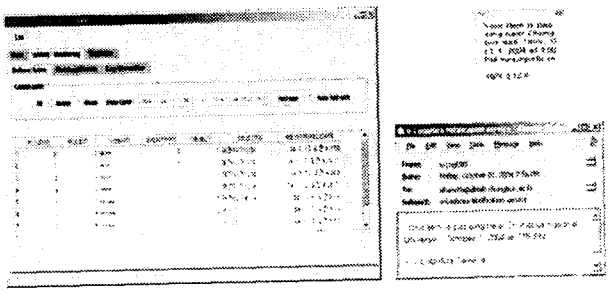

Fig. 4. u-LogENS Manager and the result of notifications

6. Conclusions

So far, we introduced u-LogENS that can track and trace the location of objects on real-time. The system based on RFID infrastructure realized an event notification service. The system provides real-time tracking by combining the event of objects with location information received from GPS satellites. The system also provides a graphical user interface based on a state/transition approach, making it easy that clients facilitate definition of profile, and uses XML structure to easily represent and exchange events.

Currently, we are doing research to improve the semantics of Filter. However, there is a trade-off between profile language and the semantics of event filtering. The definition of profiles is limited by ability of Filter and event filtering is based on filter semantics defined by ENS. For this reasons, profile language and the semantics of event filtering are closely related to. The more sophisticated a profile language is, the more complex the semantics of event filtering is.

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