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Redirecting Communication in a Pervasive System

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Abstract: Communications systems have evolved at a dramatic pace over the last two decades spawning a new era of ubiquitous computing. Devices are becoming capable of handling different types of communication such as SMS, MMS, email, voice calls, audio or video streaming and allowing the user to send or receive any of these at any time in any place. However, the user needs to have control over which device will be used to deliver the content and in what format it will be delivered by configuring a set of preferences for his devices based on his context information. This paper describes the design and implementation of such a service, allowing users to manage any type of incoming communication to suit their needs.

1. Introduction

Communication systems are becoming ever more complex with different forms of communication – voice calls, text, images, video streams, etc. – providing different facilities from different devices. As our environments become increasingly communication-intense, users need to be able to access content and communications ubiquitously through a variety of networks and stationary or mobile devices. Thus, one vision of communication in the future lies in a user-oriented universal communication system that can accommodate versatile communication needs and provide information wherever and whenever it is needed and in the form required [1 – 3].

But even if we do provide universal access to information and communication, this is not enough. Users need to be able to control when, where and how communications are delivered. Thus whenever a communication of some form arrives for the user, the system should determine what action to take depending on the context of the user at the time.

One of the goals of pervasive computing is to provide an intelligent environment to enable the user to manage this situation of growing numbers of services, networks and devices with minimal intervention on the part of the user [4, 5]. This includes providing the facilities through which the user can exercise greater control over the process of delivery of communications. This is particularly relevant in a pervasive system where the proliferation of devices facilitates considerable flexibility in the delivery of communications, while the mobility of the user increases the need for such functionality.

Redirection of communications is concerned with determining what to do with an incoming communication of whatever form depending on the user's preferences and his/her current context and then performing whatever action is necessary.

This paper is concerned with some of the issues and the approach used to achieve redirection in the Daidalos pervasive system.

2. Objectives

In designing a redirection capability for a pervasive system, the approach adopted needs to be completely general in several respects:

(1) The same system should handle redirection of different forms of multimedia communication. This includes text messages of different forms (SMS, email, etc.) as well as images, video or audio (telephone calls). As far as the user is concerned, the interface for specifying user preferences for redirection should be very similar for these different forms of communication even though at a lower level very different mechanisms may be required to handle this.

(2) The system needs to provide different conversion routines to enable redirection to occur amongst a range of different devices. In the simplest case if one wants to redirect an image to a mobile phone or to a PC one might need to apply a conversion routine to enable it to be displayed (depending on format, size, colour depth, etc.). In a more general case one may want to be able to convert text to speech or speech to text in order to redirect to the device selected.

(3) Since redirection must depend on the context of the user, a very general approach is needed to cater for mobility of the user in a pervasive system. Besides the obvious attributes such as the identity of the sender/caller and the time of day/day of week, one also needs to take account of the location of the user, the locations of others and possibly even the current activity of the user.

In the case of Daidalos the particular focus is on the mobile user in a pervasive system. This determines how dynamic the system will be as redirection needs to be more dynamic in a system where the user is on the move – around the house, from house to car, in the car, at work, in a shop, enjoying recreation facilities (e.g. on the golf course).

Within the Daidalos system our prime objective in this area has been to design a completely general system and to progressively implement different facets of the functionality in successive prototypes.

3. Methodology

In the first phase of Daidalos two prototypes have been developed and demonstrated following a scenario driven approach.

For the first prototype the focus was on message redirection. One of the scenarios demonstrated was that of a young lady with diabetes, wearing a blood sugar monitor. If her blood sugar level should fall below a particular level, the blood sugar monitor will send a text message to her to warn her. If she does not respond, the message is redirected to her parents if at home and they are nearby, or to any friends who might be nearby. And so on.

In the second prototype, the focus has been on call redirection. Bart, a chauffeur, is at home when a phone call arrives from his boss. Based on his user preferences the system makes the decision to redirect the call to his PDA. However, while still talking to his boss, Bart goes to his car and the call is automatically transferred to his car phone.

In the first case a simple SOAP messaging system is used. In the second scenario a VoIP call is handled via the SIP protocol. More detailed analysis is included in Section 4.

4. Developments

Figure 1 shows relationships between the Personalised Redirection Service (PRS) and other major components within the Pervasive Service Platform (PSP). The PRS communicates with the Context Management subsystem (CM) to request up to date context information on the user, the Rules and Events subsystem (REM) to register and listen to incoming communications destined for the user, and the main Personalisation subsystem which handles the user preferences of the particular user and uses them at various points in the

setting up of services. Figure 1 also shows how the PRS links to the lower layers, using the Multimedia Call Control Service interface (MCCS IF) provided by the MultiMedia Service Provisioning Platform (MMSPUA) (part of the Service Provisioning Platform (SPP)) for redirection based on the SIP Protocol (call, audio, video streams). For message redirection, it uses a messaging server based on the SOAP protocol. In this paper, we address the decision making process for redirecting communication before the packets start propagating on the network rather than the mechanism of the actual redirection at the network level. Therefore, an analysis of the underlying network architecture is not relevant here.

The Personalised Redirection Service consists of three components: a) the Decision Making Engine b) the Redirection Manager which uses the Decision Making Engine to identify where the incoming communication should be redirected to and c) the Graphical User Interface through which the user can modify the preference rules which the Decision Making Engine uses when deciding where to redirect the incoming communication. Each of these components are analysed further in the following sections.

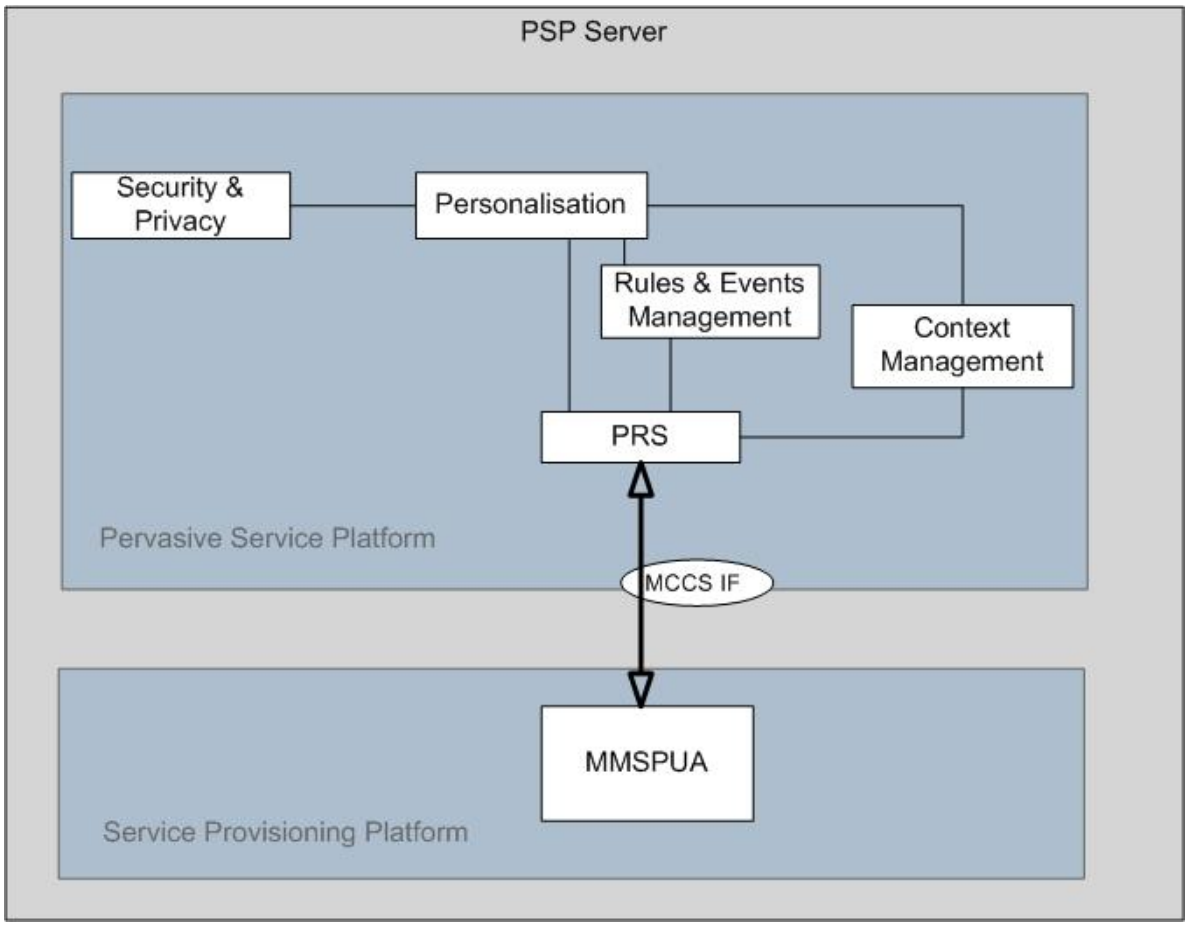

Figure 1. The Relationships between the Personalised Redirection Service and other components.

4.1 The Graphical User Interface (GUI)

The simplest component of the subsystems is the interface in which the user enters the basic rules of redirection. Based on context conditions, the user can select to redirect a call, a message, an incoming video stream or any kind of incoming communication to his desired device. Figure 2 shows a screenshot of the first implementation of the redirection GUI designed for message redirection. Future work in Daidalos will include the addition of dynamic rules inferred by monitoring the user's behaviour. The GUI will also allow the user to modify the dynamic rules deduced by the Learning subsystem.

Basic context conditions such as time, date, the identity of the caller exist statically in the GUI but other context information such as location can be added dynamically. The location sensor for the user registers with the CM and the CM supplies the Redirection Service with all the sensor information that the user is registered for. Likewise other types of sensors can register with the PRS. This is only partially implemented in the first phase but will be further developed in the second phase of the Daidalos project.

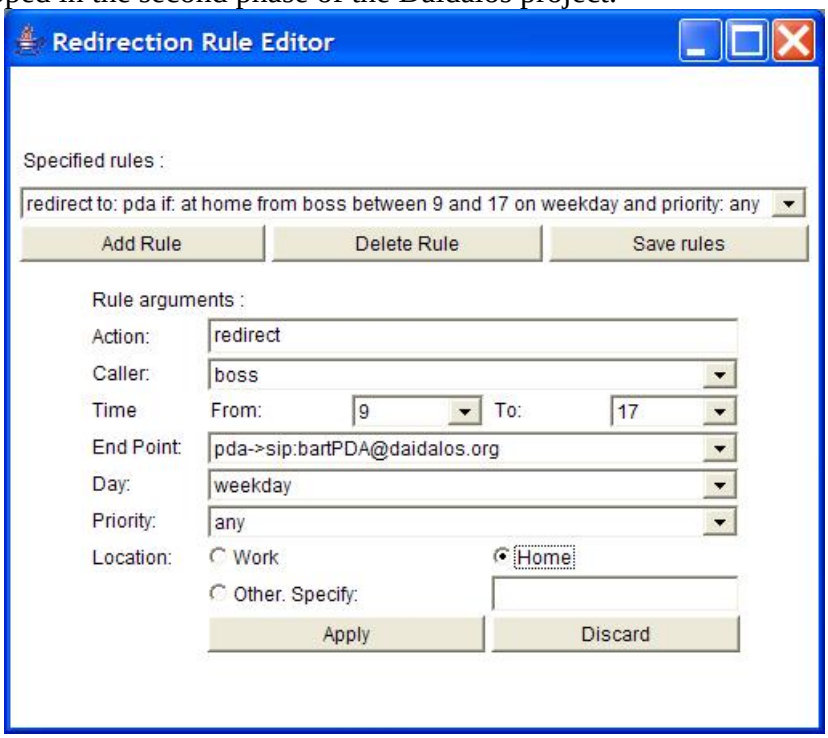

Figure 2. The Redirection Rules Editor

4.2 The Decision Making Engine

The engine is responsible for deducing which endpoint device or person the incoming communication should be redirected to. The Engine looks at the rules and cross checks them with context information to deduce the rule that applies at the particular moment when the call or message comes through. The BNF specification of the engine is the following:

```
<condition'>::=   <realValue> '=' <valueInRule> |
                  <realValue> '<' <valueInRule> |
                  <realValue> '>' <valueInRule>
<condition>::=    <condition'> |
                  <condition> <and> <condition> |
                  <condition> <or> <condition> |
                  <not> <condition'>
<endpoint> ::= 'person' | 'device'
<action> ::= <block> | <redirect> to <endpoint>
<rule> ::=  <action> |
            If <condition> then <rule> |
            If <condition> then <rule> else <rule>
```

A simple condition takes the form of checking an instance of the context information against the value set in the user preferences. A complex condition would be to combine two or more simple conditions with Boolean operators. Simple or complex conditions are then used to create rules the same way an "if statement" is written in a programming language.

4.3 The Redirection Manager (RM)

The Redirection Manager is responsible for listening for any incoming communication and using the Decision Making Engine to redirect it to the appropriate endpoint. The Redirection Manager registers itself with the Event Subsystem for incoming communication events. The Event Subsystem (the producer) will notify the Redirection Manager (the consumer) of the event and in turn the Redirection Manager will supply the Decision Making Engine with the information of the incoming communication event. The Engine will deduce, using the user preference rules, where the communication should be redirected to and return this information to the Redirection Manager. Then the Redirection Manager will use the MCCS IF of the MMSPP to redirect the communication to the appropriate endpoint. As seen in Figure 3, the Redirection Manager uses agents for each protocol, thus there is a Redirection Agent for the SIP protocol, that handles redirection of voice calls using the MCCS Interface and one for the SOAP protocol that handles the redirection of messages using the interfaces of the messaging server.

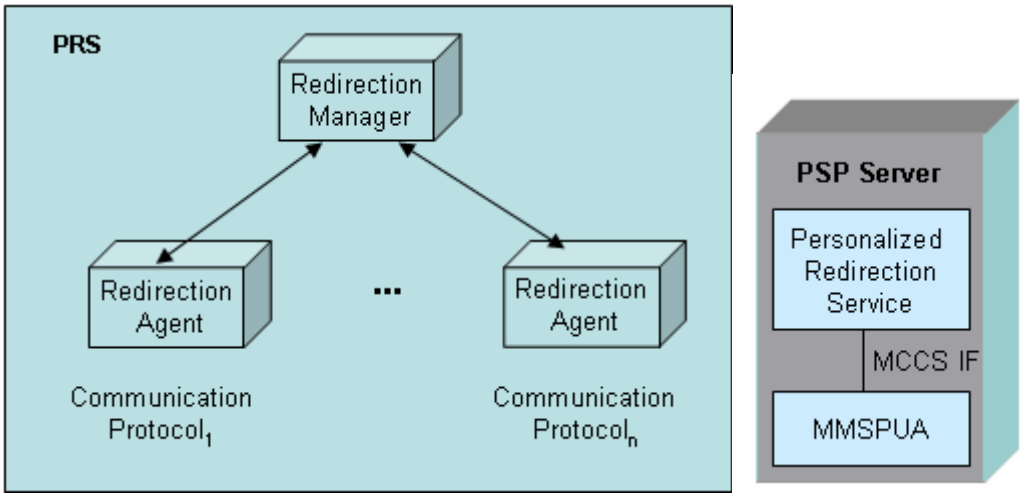

Figure 3. A Simplified View of the PRS

5. Automotive Scenario

Consider one of the steps in the Automotive scenario. Bart is at home watching a TV-like Newscast when his boss puts through a voice call to him. Figure 4 shows how the PRS is set up in advance.

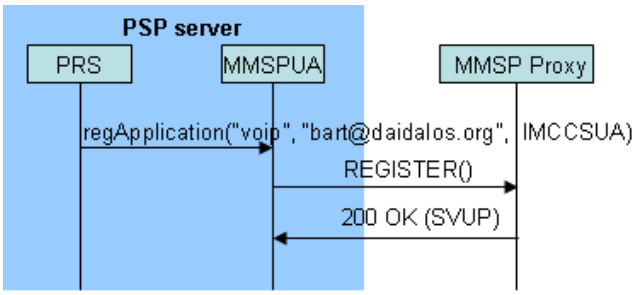

Figure 4. Pre-Setup of PRS

When Bart's boss initiates the call via the VoIP application on his PDA, the request is passed to the PSP server containing the Redirection Manager with Bart's preferences. This then takes the decision as to what to do with the call – in this case, connect to Bart's PDA. Figure 5 shows the sequence diagram of the steps involved from initiation to connection.

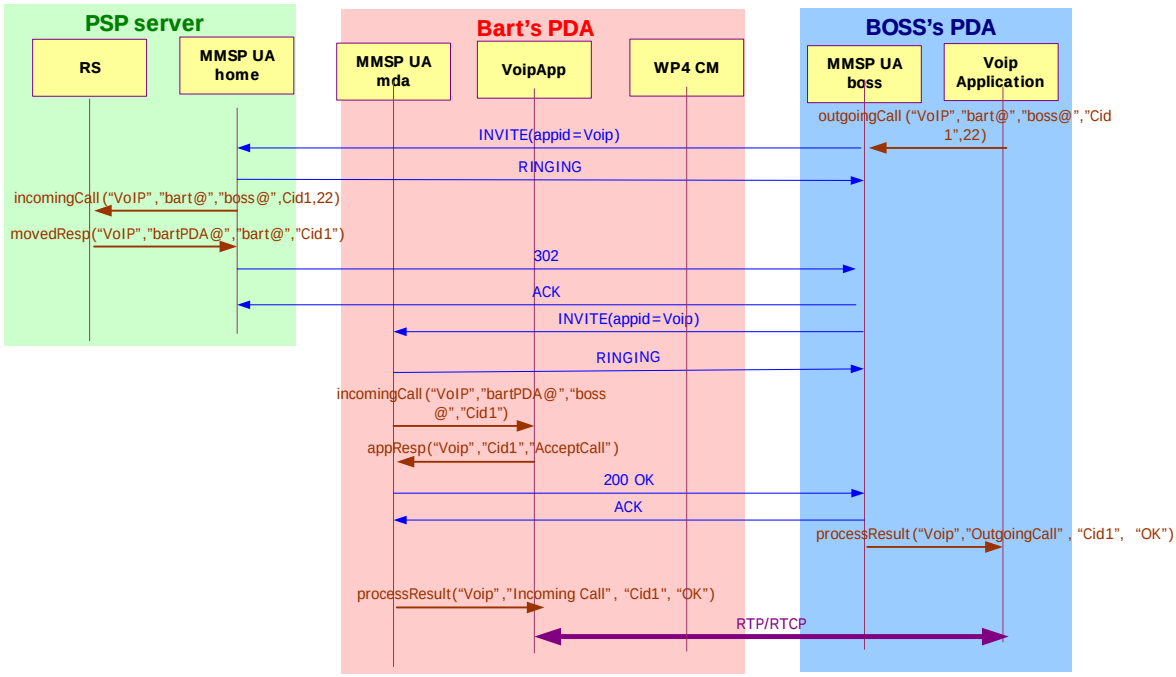

Figure 5. Redirecting An Incoming Call.

6. Privacy in Personalised Redirection

Being accessible at any location and at any time creates great concern about privacy among potential users [6]. To protect privacy, it is necessary to incorporate techniques for specification and enforcement of user personal preferences. Users should be able to specify who is authorized to reach them and under what conditions (one may want to restrict the list of users who are allowed to "wake up" the mobile device to send a message to it).

In the implementation of the Personalized Redirection Service, every effort has been made to ensure the privacy of the user by protecting his/her user preferences from access by other users. Moreover, in the PRS, a user who sends a message to another should not be able to determine anything about the recipient's current context (especially location) from the response of the system. This has been fully considered while designing and realizing the PRS as it allows the recipient to have full control over incoming communications without exposing his/her privacy to the sender, who might try to speculate about the recipient's personal information.

7. Business Benefits

The scenario driven approach for design and implementation of the prototype used in Daidalos proved to be very useful in defining the business exploitation of such a pervasive service in the real world. In the diabetes scenario, a serious medical situation arises that needs to be dealt with as soon as possible and the Redirection Service is able to alert the appropriate people to the situation so that they can take action.

8. Conclusions

The notion of redirection of different forms of communication is important in a modern communication system. However, in order to provide effective support for a mobile user in a pervasive environment, such a system needs to be both general and dynamic. Within Daidalos the design has been kept as general as possible. Through the context management subsystem a range of different context attributes are catered for. In the future as different devices connect to the system the flexibility of the system will be enhanced.

The ideas have been tested with a number of small scenarios and demonstrated at public workshops. In the second phase of Daidalos the developments will be generalized further and subjected to wider testing.

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