

# Presence, location and instant messaging in a context-aware application framework

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**Abstract.** A mobile user's presence and location information often forms important input for those applications and services that must anticipate on the user's context. Additionally, the ability to let a mobile device determine its location in an indoor environment at a fine-grained level supports the creation of a new range of personalized mobile Internet applications. The framework described here joins the concepts of presence, location and instant messaging (PLIM) in an extended existing instant messaging system, and uses a Bluetooth network infrastructure to let a mobile device determine its indoor position. Experiments show that location determination can be realized with a room level granularity.<sup>1</sup>

## 1 Introduction

Context-awareness is an important new paradigm in the mobile arena ([1], [2]). The majority of context-aware applications are focusing on location awareness. However, many other types of context information, such as, environmental information, social situation, and physiological state, exist. Next to location information we also consider presence information, as used in existing presence and instant messaging services, as an important contextual indicator. It provides information about the current state and activity of the user. Presence information is adequately handled by existing software on traditional computing platforms and increasingly also on mobile platforms. In traditional instant messaging systems, the presence context information is "tied" to the messaging functionality. In fact, presence is now an often-used form of context information due to the rise of instant messaging. We want a flexible and scalable mechanism for the distribution of location and presence context information, between end-users, but also from user to context-aware service. We also want the user to be in control, at all times, which other parties receive the user's context information. In this paper we describe a context-aware mobile application framework that implements such a mechanism, using and adapting an existing instant messaging system.

Given the availability of presence and location context information, as well as instant messaging functionality, it is easy to think of mobile applications that benefit from a framework that combines the concepts of presence, location and instant messaging (PLIM) in a single model. A usage scenario is a calendar/scheduling

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service that automatically changes the user presence into “in a meeting” at the moment that he enters the meeting room. Although the framework’s functionality is useful by itself (mobile instant messaging using presence and location as context information), it is specifically targeted at being an environment supporting rich mobile applications in the areas of personalization and pervasive computing.

Other systems also combine one or more context elements and incorporate this in a mobile application. Examples of these are [6] and [3]. Also, messaging systems or clients for mobile environments exist. Some of them incorporate position information obtained through a cellular (WAN) network ([8], together with scheduling information). Additionally, many different technologies exist that provide location, for both outdoor and indoor environments ([4], [5]). We believe, however, that our framework provides a unique combination: the unification of presence and location context information as part of an (existing) IM system together with an indoor position determination mechanism based on Bluetooth.

The framework’s location determination mechanism focuses on applications that need to be able to obtain the user’s indoor position with a room-level granularity. We have implemented the framework based on various existing components and technologies and on our own additions and extensions. We have performed a number of experiments with the system, focusing on position determination, and are encouraged by the results.

The remainder of this paper describes the conceptual and technical details of the framework. In section 2, we address the framework architecture, followed by the implementation and experiments in section 3. Section 4 describes the conclusions.

## 2 The PLIM framework architecture

The *PLIM framework* consists of an infrastructure for the distribution of presence and location information and, loosely coupled with that, an infrastructure for determining indoor position information. Through the historical connection between presence and instant messaging, IM functionality is also part of the framework. The PLIM framework primarily is focused at supporting research and prototype mobile applications in the area of context-aware and pervasive computing.

For the handling of presence, location and instant messages, the framework provides a PLIM server, as well as a number of client libraries. One client library is available for PDAs that run the Microsoft Pocket PC / Windows CE 3.0 operating system. The PLIM server is an extended Jabber server [7].

The framework can distribute any kind of location information from any source, although here the focus is on indoor location with a room-level granularity. The indoor position is retrieved from an infrastructure of stationary location provider devices (access points) with a Bluetooth interface of the lowest radio power class (3). Each location provider knows its own location. The general principle is that if a Bluetooth-enabled mobile device is close to such a stationary device, it can “ask” the location provider’s position by setting up a Bluetooth connection. If the mobile device knows the position of the stationary device, it also knows that its own position is within a 10-meter range of this location provider (Figure 1). The PLIM PDA client

library supports the application in automatically retrieving location information from nearby location providers, and in interacting with the PLIM server. Naturally, a stationary Bluetooth access point could well be an existing device such as a desktop PC. We expect that, when Bluetooth becomes widely deployed, many existing devices can serve as location providers.

The usage model for the PLIM framework applications is based on the following. An application user owns a PDA that is equipped with an interface to a (short-range) Bluetooth network and with the PDA client software. The user interacts with the PLIM server through the application PDA client program which itself uses the PLIM PDA client library. The PDA client software makes sure that, using the PLIM PDA client library and underlying Bluetooth infrastructure, the user's position is updated when necessary.

## **2.1 PLIM information handling**

The PLIM server is based on the existing Jabber instant messaging platform [7]. In the Jabber environment, the IM client connects to the IM server where the user is registered. The communication between client and server is based on the exchange of messages formatted in XML. The server communicates with other servers in order to watch or update presence information and sends and receives messages to and from users that are registered at the other servers. As such, the combined Jabber servers form a distributed network. The primary functionality used for the PLIM framework is the publish-subscribe mechanism that handles the distribution of presence data.

As enhancement to the Jabber platform, the PLIM framework adds functionality in the form of a publish-subscribe mechanism for location information. When necessary, the client sends a location update to the server. The location handler in the PLIM server makes sure that the users who subscribe to the location information of the updating user get the location update. Note that the client actively retrieves its location from the current environment. This means that the client is in control of providing the location information to the PLIM network. The client software may support the user in NOT providing this information if the user does not want to reveal his location to the system. If a user wants to receive presence or location updates from another user, the other user must allow him to do so. However, subscription to presence and subscription to location are not linked. In this way, a user may for instance allow another user to receive his location updates while not allowing presence updates.

## **2.2 Location determination mechanism and IP connectivity**

The location information stored in the stationary Bluetooth access points indicates its logical position in a building (see Figure 1). The server does not handle position information at the semantic level. The framework assumes one or more access point available in all the rooms where location is relevant. To improve the accuracy of the location determination process, we measure the link quality of the connection to the Bluetooth devices that are location providers.

A user may be in range of more than one location provider Bluetooth cell. We assume that the access point that is closest to the user provides the most accurate position information. We also assume that the link quality of the connection between the mobile device and the access point is a good measure for distance between them. The results in [9], primarily using the signal strength, support this assumption. The link quality of a Bluetooth link is expressed as an 8-bit unsigned integer value. The higher the value, the better the link quality of the connection. The link quality value is relative, i.e. by comparing two values, it is only possible to say that the link quality of one connection is better than another. Also, the way link quality is measured is manufacturer-specific.

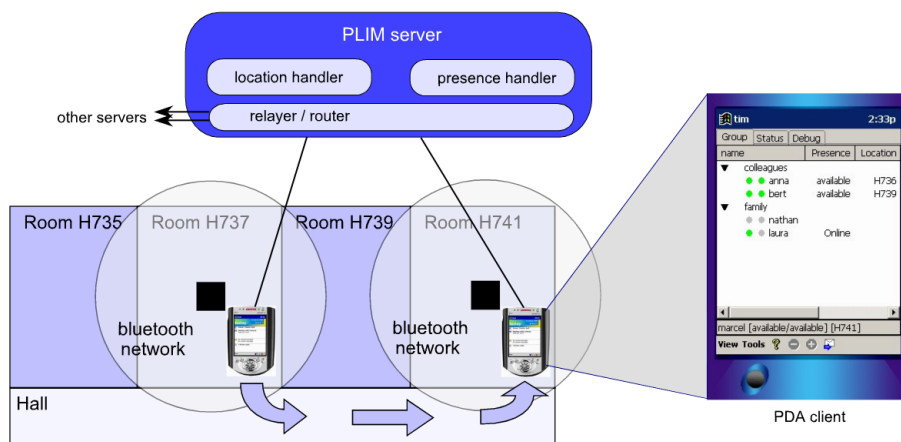


Figure 1: Mobile user moving from room to room, sending location updates to PLIM server

To determine the location provider that most likely will give us the best position information, we use the following mechanism:

1. Do a Bluetooth device discovery at regular intervals (like every 20 seconds).
2. After device discovery, ask the name of the newly discovered devices. The location information is part of the name string.
3. Set up Bluetooth links to the devices that provide location information, and add them to the set of already existing links to location providers.
4. Measure the link quality of the links to all the location providers every few seconds, until it's time to restart device discovery (step 1). For every link, a history of measurements is recorded in a sliding window fashion. The window keeps track of the most recent 10 measurements.
5. The preferred location provider is the one with the highest average window link quality. At least three valid measurements must be in the window, before the location provider can be selected as preferred.

Obviously, this mechanism does not support real-time location determination (say, within 1 second), because the device discovery is at intervals and the window averaging causes a delay. For users that do not constantly move, this is not a problem.

In the system described above, no assumptions are made about how the network connectivity between PLIM client and server is established. A number of configurations are possible. The Bluetooth access points may not only provide

location information, but also IP connectivity to the intranet/internet. In this case, the Bluetooth access point additionally has a fixed network interface. Alternatively, an overlay network, such as GPRS, may provide IP connectivity.

### 3 Implementation and experiments

The implementation of the PLIM framework and application consists of a number of components. The Jabber server is extended in order to handle the new protocol elements. The PDA client location determination software is implemented by the PLIM Bluetooth middleware. Furthermore, a PDA application uses the associating PLIM client libraries.

The server extensions consist of a number of new modules, for handling basic location and location subscriptions, and some minor changes in the core of the session management and the core of the overall server. The server as well as the set of extensions are implemented in C. We run the server on a Linux machine.

The PLIM Bluetooth middleware implements the location determination mechanism on the Windows CE 3.0 Pocket PC operating system and is part of the PLIM PDA client library. In order to execute the necessary Bluetooth actions, the library must be able to access the Bluetooth functionality through an API. We use the Digianswer Bluetooth demo card for Windows CE [10], as this was one of the very few products, at the time of design and implementation, which came with support for Windows CE as well as an SDK. The Bluetooth infrastructure also provides the IP connectivity for the application. The middleware support the application in dynamically initiating and terminating emulated Ethernet connectivity using the Digianswer Bluetooth Ethernet profile. When the middleware determines a new best location provider, the application uses this functionality to disconnect from the old access point and reconnect to the new access point.

The PLIM PDA client application uses the PDA client library to provide presence, location and instant messaging functionality to the mobile user. It is implemented in C/C++ using the Microsoft embedded Visual C++ environment. The PLIM PDA client library uses a low-level extended Jabber library to handle the XML messages between client and server.

We have executed a number of indoor experiments with the PLIM framework, using the PLIM PDA application. At different locations in the building, two Bluetooth access points were placed in adjacent rooms. The access point cells partly overlap, i.e. the distance between the location providers was between 7 and 12 meters. Each access point is a Windows 2000 machine with two interfaces: a (fixed) Ethernet interface connecting to the Internet and a Bluetooth PC Card. The Windows 2000 operating system is configured to enable Internet connection sharing on the fixed interface. The Bluetooth interface provides emulated Ethernet functionality through the enabled Ethernet profile. The PLIM server runs on a Linux. The PDA moves between the two rooms.

We found that the location determination mechanism selects the access point that is closest to the mobile user as the best location provider. In most cases this is the access point in the current room. Also, after the indication of a new best provider, the switch

from one access point to another takes place within a second in the majority of cases, resulting in only temporary loss of IP connectivity. When quickly moving from close to one access point to close to the other, it usually takes between 20 and 40 seconds before the new access point is selected as the best location provider.

## 4 Conclusions

In this paper, we presented a context-aware mobile application framework that uses and handles presence and location information and incorporates instant messaging functionality. The framework provides a model that deals with location at the same level as presence, and defines a separate subscription mechanism for both. It incorporates the handling of location information in such a way that the user is always in control of who receives this information. Furthermore, a mechanism for location determination is part of the framework. The indoor location of a mobile user is obtained through an infrastructure of Bluetooth access points. This mechanism measures the link quality of nearby location provider access points to determine which access point is closest to the user and thus is most likely to provide the best location information.

We have performed a number of experiments, which showed that the location determination mechanism provides a good indication of the actual location of the user in most cases. Some inaccuracy is inherent to the way location information is obtained using the Bluetooth infrastructure.

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