AN INFRASTRUCTURE FOR CONTEXT DEPENDENT MOBILE COMMUNICATION

John Aa. Sørensen
Kåre J. Kristoffersen
Anders Cervera
Martin Schiøtz
Thomas Lynge
Zoltan Safar
Lars Birkedal

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Copies may be obtained by contacting:

IT University of Copenhagen
Glentevej 67
DK – 2400 Copenhagen NV
Denmark

TELEPHONE: +45 38 16 88 88
Telefax: +45 38 16 88 99
Web: www.itu.dk

ABSTRACT

The initial work on an indoor infrastructure for context dependent mobile communication is described. The aim is to enable simultaneously research and software development at the Application and Service Level, at the System Software Level and finally at the Basic Technology Level. The research is carried out by a loosely coupled community of researchers mostly specializing into work at one of the infrastructure levels. The infrastructure consists of an IEEE 802.11b WLAN coverage of the indoor site, a system for indoor positioning, a generally available Java interface to communication and positioning, and a software repository. The paper describes the initial experiences on the implementation and application of the infrastructure on a part of the university indoor site of approx. 1200 m^2. Finally some future perspectives are discussed.

1. INTRODUCTION

The location of mobile terminals and users might contain important information for the applications accessed through a mobile network. It is expected that location awareness and context dependency, will be increasingly important in the years to come, because it opens for methods which can reduce the amount of information needed for a mobile user before the actual information aimed at, is reached. Furthermore it opens for new applications, which are entirely dependent of the position of a mobile user. An example of the current research on indoor geolocation systems and a review of a selection of applications is presented in [11]. The present paper describes an implementation of an indoor and nearest outdoor neighborhood infrastructure for context dependent mobile communication at the IT University of Copenhagen (ITU) [4]. The aim of the infrastructure is to enable loosely coupled research and development groups, to work simultaneously at three levels, which together constitutes an infrastructure for ubiquitous computing [10]. The three levels are represented as follows:

- Application and Service Level, where mobile services are devised, designed and assessed through user tests and quantitative measurements obtained through the application of the environment.
- System Software Level, where mobile platforms and a software repository for application packages and basic software modules are constructed.
- Basic Technology Level for selected system elements, f.inst. high precision indoor positioning.

The infrastructure is targeted for a multitude of activities at each of the levels, thus contributing to the creation of a rich experimental environment. At the Application and Service Level, research is carried out within location based-games [3], where position dependent games between persons are devised, constructed and assessed. Furthermore, at this level, work is carried out on a Position Dependent Communication System, which is further described in Section 3. At the System Software Level, research is concentrated on devising and constructing modules, f.inst. for verification of speaker identity, or symbolic position models of the building site, targeted for the Application and Service Level. Finally, at the Basic Technology Level, work is carried out on selected problems within High Precision Indoor Positioning, which is of key importance to the infrastructure.

The overall aim is to have standardized interfaces between the layers, thus enable independent work at each level of the infrastructure to the largest possible extent

2. ENVIRONMENT FOR INDOOR CONTEXT DEPENDENT COMMUNICATION

The initial indoor test area covered by the infrastructure for context dependent mobile communication is shown in Figure 1a,b. It consists of parts of three building levels, denoted Level 2, 3 and 4. Level 2 is equipped with 1 access point and Level 3 has 5 access points. In total, 6 access points are used for this initial coverage of a total area of approx. 1200 m^2, including all the three levels. The network is based on an IEEE 802.11b WLAN (Wireless Local Area Network), and the access points used were five Avaya Wireless AP-3 and one Orinoco AP-2000. The antennas used were Avaya Wireless Extender Antennas (omnidirectional) and for the client terminals, an Avaya Wireless PC-Card Silver was used. The final placement of the access points was verified through a site survey of the resulting WLAN coverage of the area of interest.

For indoor positioning the Ekahau Positioning Engine [2] was chosen. The mobile positioning algorithm, is based on classification of measured Receive Signal Strength Indicator (RSSI) in the mobile from the access points [9]. The system requires a manual calibration of the area of interest (AoI), which in Figure 1a,b, is represented by the gray areas. The number of manually calibrated positions at Level 2, 3 and 4 was 60, 102 and 47, respectively. A scatter plot of 3490 position errors within the AoI, is given in Figure 2, which also shows the spread of the location error determined from its variance. The spread is approximately 2 meters. The positioning precision, which is a function of the number of access points, obtained from increasing the number of access points beyond the present configuration, is shown in Figure 3. Here it is seen, that to obtain a precision of 2 meters, in an extended system, requires access to 7 access points. The precision obtained is sufficient for a selectin of indoor applications.

3. MOBILE SOFTWARE PLATFORM AND SOFTWARE REPOSITORY

The aim of the mobile platform and software repository is to obtain a high level interface between the mobile terminals and the positioning system. This will then lead to some degree of independence of the specific principles used for positioning and the selection of software packages operating in this environment [6]. To achieve this, a simple-to-use mobile platform is developed, by using the scalable, open Internet protocols, which are extended to interface the positioning system with an extra set of high layer application programming interfaces (API's) that can be called from any programming language.

The indoor positioning system [2] is originally provided with a standard Java SDK (System Design Kit). It is used to retrieve coordinates from mobile clients within the area of interest, the grey area of Figure 1a,b, and to build Java-based services and applications. To expand the capabilities of integrated services across platforms for mobile clients, an API was developed for http access to the positioning platform [6]. This web API also provides interface to location data from outdoor mobile clients in the GSM network and UTM-coordinate representations on digital maps.

An example of a mobile client retrieving its position coordinates from the positioning server, cf. Figure 4, is as follows:

```
http://server_address/TrackServlet?value=x,y,z
&clientId=192.168.100.102&measure=pixels
```

Here the clientId is the IP address of the mobile client to be tracked, and the x and y values are scaled according to a map of the AoI. The z coordinate is quantized into the building level, thus z can only assume the values 2, 3 or 4.
In addition, the web interface [6] also provides XML-formatted positioning data and a J2ME SDK for GSM phones and the indoor API.

4. POSITION DEPENDENT COMMUNICATION SYSTEM (PDCS)

With the aim of constructing a mobile platform for Location Based Services, the present version of PDCS [8] Figure 4, is designed such that it consists of an indoor routing planner, speech recognition and synthesis. Its aim is to offer a mobile software platform with positioning, and a user interface with speech synthesizer and recognizer and a site specific indoor routing algorithm covering the area of interest. The overall function of PDCS is as follows: Assuming that a user is situated with the current position within the area of interest, then it is possible for the user to request the shortest path from this current position to a destination specified by the user through speech. The shortest path is determined through the Floyd-Warshall algorithm on a discretization of the physical space. To ensure portability between mobile platforms the PDCS is programmed in Java. The ViaVoice speech package was selected for the speech I/O [5], [8].

5. RESULTS AND FUTURE PERSPECTIVES

The infrastructure was used for a selection of activities [6] within location-based information exchange systems and location-based games. Examples of subjects within these areas are “Location Model Supporting Location Awareness”, "Location Notification API", "Design of Location Based Service to Deliver Spatial Information to Mobile Clients" and within games examples are "Location Aware and Context Aware Mobile Games – An Experience in Time and Space".

The future perspectives in the development of the infrastructure is to extend it into a complete indoor and outdoor coverage of the coming IT University site, situated at a new suburb area near Copenhagen downtown [1]. Furthermore it is our goal to gradually build location-based systems initially targeting ITU systems and services, and based on enhanced resolution positioning.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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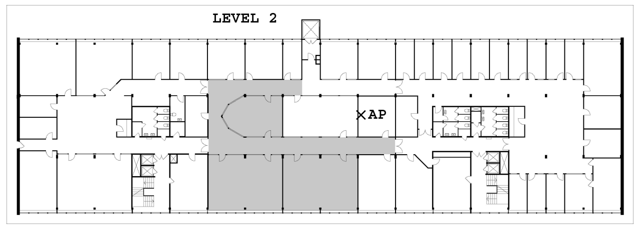

Figure 1a. WLAN 802.11b coverage of a part of the ITU building.

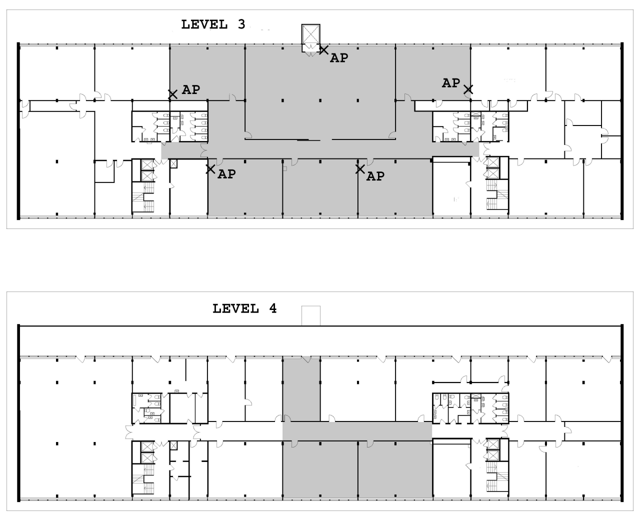

Figure 1b. WLAN 802.11b coverage of a part of the ITU building.

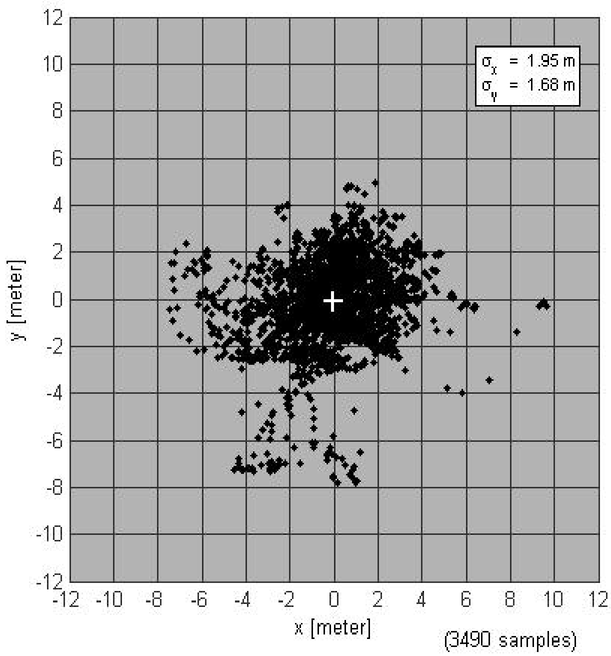

Figure 2. Scatter plot of measured position errors in the ITU building.

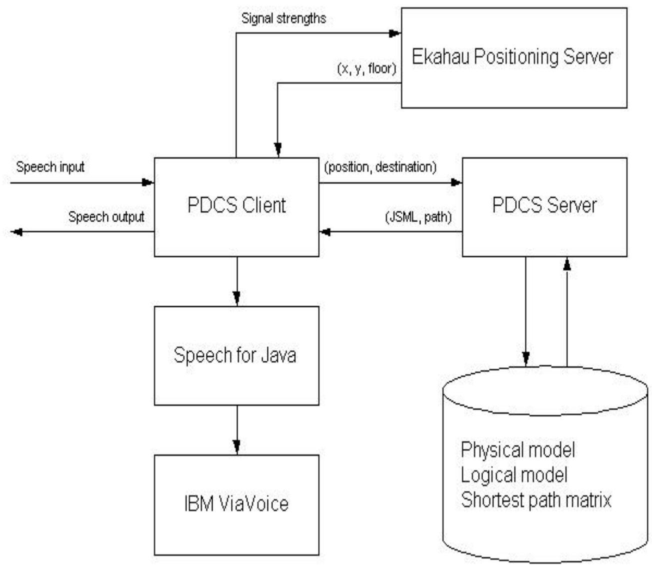

Figure 4. Position Dependent Communication System

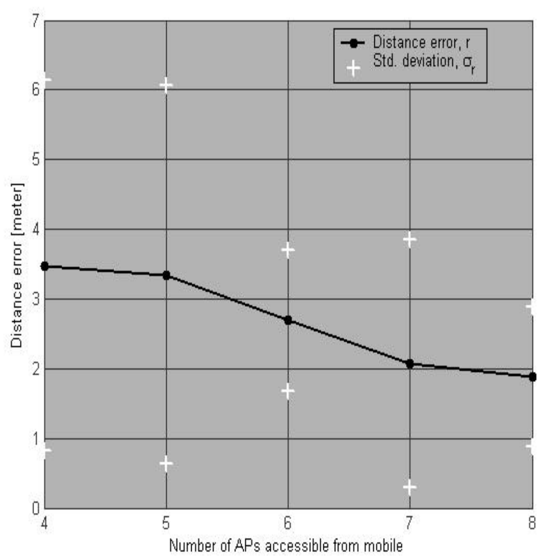

Figure 3 Positioning precision dependent of the number of access points.