AN INFRASTRUCTURE FOR CONTEXT DEPENDENT MOBILE MULTIMEDIA COMMUNICATION

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ABSTRACT

The initial work on an indoor infrastructure for context dependent mobile multimedia communication is presented. The aim is to enable simultaneously research and software development at the infrastructures Application and Service Level, System Software Level and finally at the Basis Technology Level. The research is carried out in a loosely coupled community of researchers mostly specializing into work at one of the levels. The infrastructure consists initially of an IEEE 802.11b WLAN coverage of a part of the IT University indoor site, a system for indoor geographical routing planning, positioning and tracking of mobile terminals, which have a general speech recognition, synthesis interface. The aim is that the infrastructure makes available Java interface to communication and positioning, and a software repository for the support of development of location based services and the multimedia signal processing functions needed for these. 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.

1. INTRODUCTION AND MOTIVATION

A consequence of the still more dense covering of daily life physical in- and outdoor environments by wireless communication, is that dynamical information on a mobile terminals physical location is becoming available in a spatial resolution, which is suitable for a still wider selection of applications. This, combined with usual video, audio, speech and text communication, including speech synthesis and recognition, opens for the design of real-world context dependent communication systems, targeting at ubiquitous computing environments, as envisioned by Mark Weiser [1].

The objective of the present research, is the design of an in- and nearest outdoor neighborhood infrastructure for context dependent mobile communication at the IT University of Copenhagen (ITU). The aim of this infrastructure is to enable loosely coupled research and development groups, to work simultaneously at three levels, which together constitutes an infrastructure for ubiquitous computing.

The three levels are as follows:
- Application and Service Level, where mobile location dependent services are devised, designed and assessed through user tests and quantitative measurements obtained by the application of the context dependent environment. Typical design problems at this level are devising services and servers, designing human-system interfaces and dialogues, designing indoor security and tracking, and quality of service assessments.
- System Software Level, where mobile platforms and a software repository for application packages and basic software modules are devised, designed, tested and assessed.
- Basis Technology Level for selected system functions, f.inst. high precision indoor positioning and tracking, indoor security surveillance, and speech, audio and video streaming and communication.

Presently there are widespread activities targeted the design of location dependent environments. In [2] is presented a system for indoor geolocation, based on three different positioning algorithms. This system delivers an event notification of a mobile terminal, if the terminal is within 10 meters from a predefined indoor position. In [3] is presented an indoor location system with a mobile terminal tracker using an IEEE 802.11b WLAN. Recently a commercial system for positioning using the IEEE 802.11b WLAN became available from the Finnish company Ekahau, www.ekahau.com. A recent review on signal processing for geolocation is presented in [4]. The present paper extends the work of [2] and [3], into an environment where the mobile terminals have speech I/O and automatic route planner, positioning and tracking for indoor environments. Furthermore it is an objective to gradually build an environment, with modular software support for a variety of location based services, and the multimedia signal processing functions needed for these.

2. ENVIRONMENT FOR INDOOR CONTEXT DEPENDENT COMMUNICATION

The initial indoor test area covered by the infrastructure for context dependent mobile multimedia communication is shown in Figure 1, [5]. 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 for all three levels. The network is based on an IEEE 802.11b WLAN, 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 was chosen. The mobile positioning algorithm, is based on classification of measured Receive Signal Strength Indicator (RSSI) in the mobile from the access points. The system requires a manual calibration of the areas of interest (AOI), which in Figure 1 are 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 selection 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, cf. lacomoco.itu.dk. 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 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 areas of Figure 1 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. 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 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 [6] Figure 4, is designed such that it consists of an indoor routing planner and 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. RESULTS AND FUTURE PERSPECTIVES

The infrastructure was used for a selection of activities, cf. www.lacomoco.dk, 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", "Long Term Location Analysis of Mobile Users", 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 suburban area near Copenhagen downtown, cf. www.itu.dk. Furthermore it is our goal to gradually build location-based systems initially targeting ITU systems and services, and based on enhanced resolution positioning which is also extended into indoor environment surveillance using basic WLAN system components.

6. ACKNOWLEDGEMENTS

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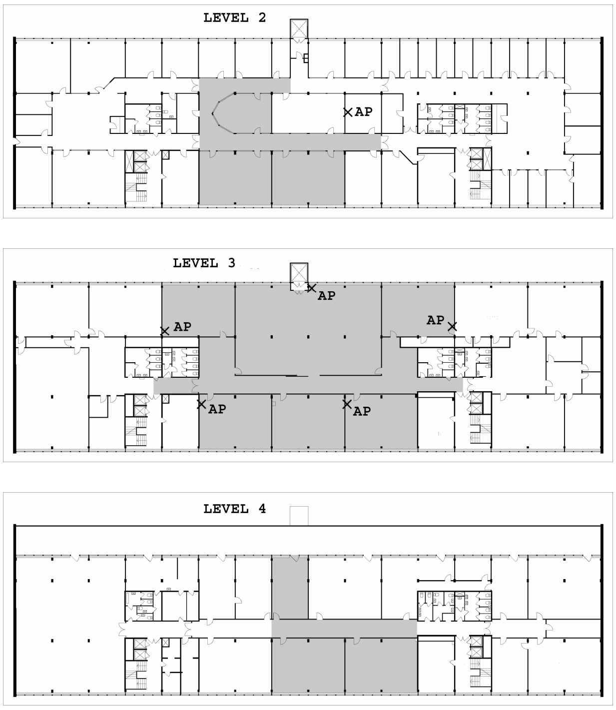

Figure 1. WLAN 802.11b coverage of a part of the ITU building.

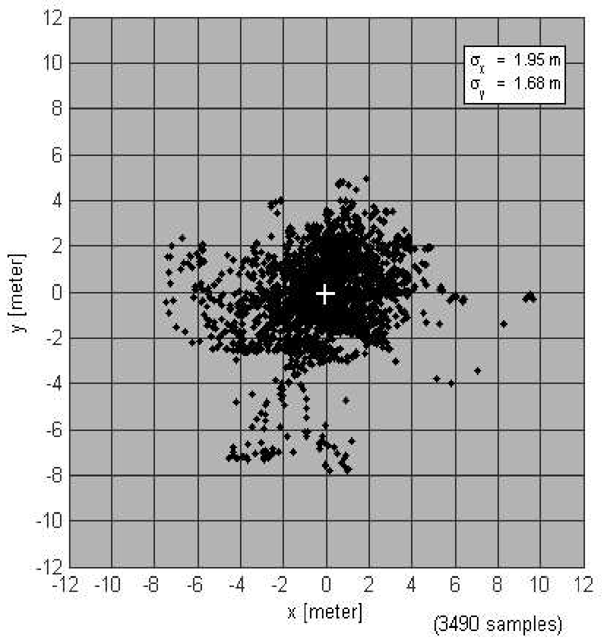

Figure 2. Scatter plot of measured position errors in the ITU building.

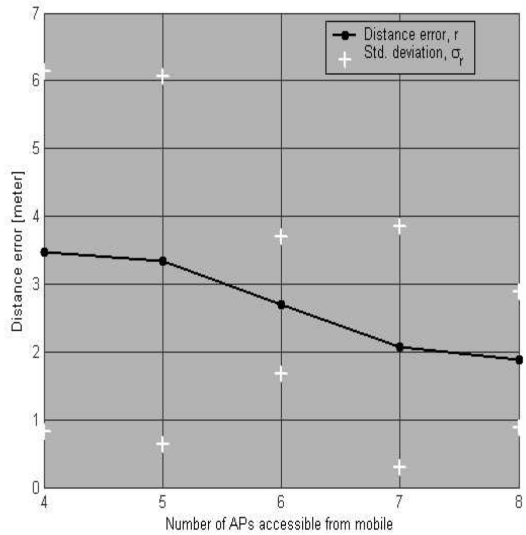

Figure 3 Positioning precision dependent of the number of access points.

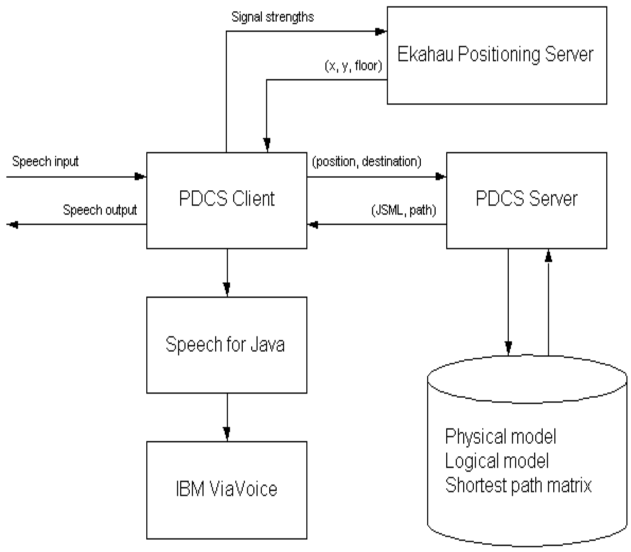

Figure 4. Position Dependent Communication Sys tem