Who's onCampus: A Campus-Wide Location System

Michael Wallbaum, Andreas Dieckmann, Peter Russell, Thomas Stachelhaus

wallbaum@informatik.rwth-aachen.de
{dieckmann, russell, stachelhaus}@caad.arch.rwth-aachen.de

Abstract: Wireless Local Area Networks (WLAN) do not only provide a means for wireless communication, they can also supply terminal positions to location-aware services and applications. This paper presents a location-aware mobile learning platform and its underlying location service. The system extracts sensor data from a university-wide WLAN infrastructure to determine user locations.

1 Introduction

In the context of a university or corporate campus, the use of Wireless Local Area Network (WLAN) infrastructure as location sensor for location-aware applications offers some advantages compared to other solutions. Firstly, WLANs and respective end-user devices have become wide-spread in the past few years and thus operators of location systems are relieved from the burden of installing a dedicated location sensor infrastructure, such as proposed in [WH92] and [PCB00]. Secondly, location services based on WLAN sensors offer an accuracy sufficient to meet the requirements of many location-aware applications. Depending on whether simple cell-id or more complex schemes are used, location estimates can be given with an accuracy ranging from hundreds down to a few meters. This can easily compete with currently deployed schemes in mobile communication networks. Finally, in contrast to satellite-based systems, such as GPS, WLAN-based location services work indoors as well as outdoors, which facilitates the provision of a wide range of location-aware services such as indoor navigation.

This paper presents a location-aware mobile learning platform for students of the Faculty of Architecture at the RWTH Aachen University, as well as the underlying location service. The system makes use of the university's WLAN, which currently comprises of 192 IEEE 802.11 a/b/g access points (APs) spread over roughly 40 buildings. The majority of APs cover indoor areas such as libraries, cafeterias and lecture halls. However, around 20% of APs provide coverage in outdoors areas, mainly used for recreational purposes, like cafes, the market square and the main train station. At present the network is employed by approximately 4,500 users equipped with notebooks and PDAs. The following section explains the concept and implementation of the WLAN-based location service proposed by the authors. As an example for the interworking between the location service and location-aware services, section 3 then describes the *Who's onCampus* service, which is an integral part of the Faculty of Architecture's web portal.

2 The Location Service

The university's location service follows a modular approach with well-defined interfaces. Such an approach ensures that the system can easily incorporate new data sensors and positioning schemes without substantial changes to the overall architecture and without the need to modify existing location-aware applications. The location service thus can be put to dual use, namely as a research platform for the development and evaluation of new location techniques as well as a live service integrated into the university's communication service framework.

2.1 Design

In principle the location service consists of five modules, which are briefly described here. The *sensor module's* task is to collect all data relevant for locating a terminal. This includes dynamic as well as static information. The former refers to data collected continuously at run-time such as radio signal strength (RSS) measurements and associations between terminals and APs. The latter includes all quasi-permanent information such as building layout plans and the location of APs. The *processing module* computes terminal locations based on the information provided by the sensor module. The module entails one or more positioning schemes, which are selected by the third module, namely the *controller*. The choice of the scheme deployed depends on the parameters of a location request, such as response time and desired accuracy, and obviously on the available information provided by the sensors. The computation can be performed periodically or be triggered through a location request. The *access control* and the *distribution modules* are tightly coupled. The latter receives location requests from location-aware services and passes these on to the controller. This is only done however, if the requestor can provide valid credentials and is granted access by the access control module. This is of utmost importance considering that the location service is run in a live network and handles sensitive data relevant to thousands of users.

2.2 Implementation

The implementation, depicted in Figure 1, closely follows the generic design presented in the previous section. To this date three sensors have been integrated into the system, two of which deliver RSS samples recorded at WLAN APs and terminals. The terminal-based sensor measures the RSS of all visible APs in the terminal's vicinity, whereas the AP-based sensor only provides RSS measurements for its associated terminals. Alas the terminal-based sensor is of an experimental nature and thus is only used for research purposes. The third sensor simply consists of a database which contains mappings from Internet Protocol subnet addresses to locations. This data can be used for determining the locations of stationary terminals, such as desktop PCs. The scope of the database is currently limited to

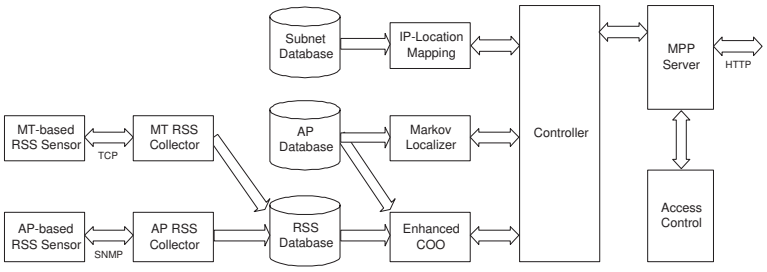

Figure 1: Location Service Architecture.

institute subnets of the RWTH. Clients which are connected via a Virtual Private Network connection thus cannot be located. Several location techniques have been developed and implemented for research purposes. Examples include the RSS pattern matching scheme proposed by Bahl et al. in [BP00] and the RSS-based Markov-Localization scheme as put forward in [WW03]. These schemes can locate terminals with an accuracy down to a few meters. They require RSS readings relative to three or more APs and thus call for data from the experimental terminal-based sensor. Consequently, in practice only two (less accurate) schemes are provided to location-aware services and applications. The first is called Enhanced Cell Of Origin (E-COO) and simply returns the position of the AP a terminal is associated with and possibly the cell's footprint. An upper bound on the distance to the AP is provided by making use of the RSS measurement to calculate an estimated distance from the AP. The second scheme is the IP-location mapping for stationary terminals. The distribution module implements a subset of the functionality of the Mobile Positioning Protocol (MPP) [Eri01], which provides a standardized interface to location-aware applications. MPP is an application-level protocol originally designed for GSM-based positioning and exchanges XML messages using http. Its advantages are its simplicity, generality and a large application code base. The specification of position requests and responses had to be slightly modified to allow for IP-based addressing of located-terminals, as MPP originally uses telephone numbers to identify terminals. Privacy is enforced through a decoupling of user identity and deployed terminal. The location service simply locates terminals – the respective terminal's user is unknown to the service. The mapping between user and terminal (and hence location) is done by the location-aware services and applications as described in the next section. The access control module contains a list of well-known services (such as *Who's onCampus*) which are allowed to issue location requests; location requests from other sources are denied.

3 Who's onCampus: A Location-Aware Service

The location data generated by the location service is put to use in the *Who's onCampus* service of the web portal *myREIFF*. The position data of the logged-on users are utilized for simplifying user interfaces, filtering of information and generating a common context for communicating with one another.

3.1 myREIFF

myREIFF is an Internet platform used by all members of the Faculty of Architecture of the RWTH Aachen University; its name is derived from the name of the main faculty building, the Reiffmuseum. The platform serves as a means of communication between students and educators and also comprises a number of administrative tools for managing all the courses in the faculty. In a certain sense, *myREIFF* is the 'fifth floor' of the faculty, a virtual floor, where all faculty members can meet regardless of their whereabouts in real (physical) space. An organizational unit such as the Faculty of Architecture has an inherent need for such a way of communicating as its students mainly work in private, off-campus studios due to limited faculty space and its institutes, libraries and seminar rooms are spread out over several buildings. Thus, the platform labors to increase informal contacts and opportunities for the exchange of information (the 'chat in the hallway') [DRS03]. Moreover, under these conditions it is helpful to explicitly display the physical location of the communicating partners in order to create a common context shared by all users.

3.2 Who's onCampus

Who's onCampus is the central communication service of the *myREIFF* platform. Basically, it is a frame that reloads periodically and displays all logged-on users with their photograph, name and location in real space. Similar mechanisms have successfully been applied to virtual design studios in the past, for example the Compadre system [Jo00] or the Netzentwurf platform [Ru01], but the added location information takes the underlying concept of community-building one decisive step further. The list of users can be filtered individually with preference to e.g. people that work at the same institute or take the same classes or people in a so called buddy list that every user can define for himself. With this filtering mechanism it is possible to instantaneously find out whether people that one works or studies with are online and where their location is in real space, creating the opportunity to contact these people online or in real space on campus. Due to the platform's privacy policy, the use of the service is voluntary, i.e. users must actively decide to participate in *Who's onCampus* and can revoke that decision at any time. For every participating user a user profile can be accessed that includes further contact data (again actively declassified by that user) and several means of interaction. This interaction through *Who's onCampus* can take place in several forms: Instant Messaging within the platform, use of external Instant Messengers, web mail or cooperative work in a whiteboard environment (which can accommodate parties of more than two participants). The location information of a user gains further practical use through its application as a filter for finding people in one's vicinity. In the integrated competence broker *mySkills*, users can enter skills that they possess or search the database for other users that have a specified skill or knowledge about a specified topic (e.g. how versed someone is in the use of a certain CAD-software). The results of such a search do not only display the skill level of the users found but also their location. Users can therefore get assistance from other users in their vicinity. Thus, *myREIFF* provides students with an infrastructure to find and help one another.

4 Conclusion

Who's onCampus is a popular service with an ever-growing number of users since its introduction in October 2002. So far, more than 25% of all active users (currently 452 of 1722) have decided to use the service. Participants of *Who's onCampus* log on to the platform more frequently and stay online for longer periods of time than those who do not make use of the service; almost half of the participants regularly use the Instant Messaging functions the platform provides. The use of mobile computers and wireless networks in combination with the described location based services that let people find one another has proven highly beneficial – especially for an institution like the Faculty of Architecture that has very limited space at its disposal and therefore cannot offer studio space to its students. Insufficient spatial conditions can, at least to some extent, be compensated for. In the last three semesters, one could observe a change in the way students at the faculty made use of space, even in hallway areas: a shift from consumption (i.e. attending seminars) to production (i.e. small teams of students collaborating with notebooks). Plans for the future include the development of additional location based services, e.g. a tool for booking seminar rooms in one's immediate vicinity, the integration of the existing location based services in the university's web portal *CAMPUS* and an increase in accuracy for the location service through use of new location techniques.

References

[BP00] Bahl, P. and Padmanabhan, V.: RADAR: An in-building RF-based user location and tracking system. In: *Proceedings of IEEE Infocom*. March 2000.

[DRS03] Dieckmann, A., Russell, P., and Stachelhaus, T.: Healer, heal thyself!: Information management in an architecture faculty. In: *Proceedings of the 20th CIB W78 Conference on Information Technology in Construction*. University of Auckland. 2003.

[Eri01] Ericsson Software Technology AB: *Mobile Positioning Protocol, Version 4.0*. 2001.

[Jo00] Johnson, B. R.: Sustaining studio culture: How well do Internet tools meet the needs of virtual design studios? In: *Proceedings of the 18th eCAADe Conference*. Bauhaus University Weimar. 2000.

[PCB00] Priyantha, N. B., Chakraborty, A., and Balakrishnan, H.: The Cricket location-support system. In: *Proceedings of the Sixth Annual International Conference on Mobile Computing and Networking*. 2000.

[Ru01] Russell, P.: Creating place in the virtual design. In: *Proceedings of the 9th CAAD Futures Conference*. Technical University Eindhoven. 2001.

[WH92] Want, R. and Hopper, A.: Active badges and personal interactive computing objects. *IEEE Transactions on Consumer Electronics*. 38:10–20. 1992.

[WW03] Wallbaum, M. and Wasch, T.: Markov localization of wireless local area network clients. In: *Lecture Notes in Computer Science*. volume 2928. pp. 1–15. Springer Verlag. 2003.