Context Awareness in Smart Environments:

Case Studies from a University Context

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1.1 Introduction

'Intelligent Environments' have always been a key research area of pervasive computing research. Initially, technology-driven research investigated on the potentials of embedded systems, sensors and actuators for automation, novel services or an enriched user experience [8]. After more than a decade of research in pervasive computing, and many exiting technological developments, the scale of these intelligent environments is just about to change significantly: While formerly smart rooms (e.g. [45, 7, 33]) or buildings (e.g. [53, 9, 32]) have been at the center of the research interest, with the advent of the Internet of Things (IoT) (c.f. [3] for a survey), the scale changes to future smart cities. These future environments, at the intersection of augmented buildings and the Internet of Things (IoT), have the potential to change the way people interact with technology and enable a multitude of new applications.

However, the ubiquitous possibility to exchange information and share (also personal) data poses challenges with respect to privacy and user acceptance that have to be addressed and taken seriously into account in the course of deployment efforts of smart environments. Sensor-augmented personal portable devices (PPD) with rich computation and communication capabilities, smartphones and tablet computer, have become a ubiquitous companion to the user and became one of the most important interaction proxies to intelligent environments. Today's mobile devices are providing rich context information for the environment (c.f. [10] for a survey, and [18, 38]). The current trend here is also to scale: to go from the lab to conduct research in the large [30, 21].

University environments have classically been amongst the first ones to be investigated – e.g. due to wireless network coverage. Context-Awareness and Context-Based Services (CBS) need that coverage as still many algorithms need to be calculated in the cloud. Furthermore, universities are public places where vivid interaction takes place between diverse groups of people. We therefore chose the university as a scenario for investigating different dimensions of context-awareness and adaptability in smart environments. We conducted the presented research out of the laboratory scale, incorporating e.g. app stores as distribution mechanisms, and with a significant number of users in their familiar environment, that is, with users as domain experts. Context-based systems are a prerequisite for successful innovative and efficient, effective and enjoyable services. In this chapter, we investigate and, by the individual use cases, focus and highlight selected aspects.

We present four case studies: In Section 1.2, we describe a secure Single Sign-On solution working seamlessly between public displays and personal mobile devices, which is applicable for a variety of context-aware services. In Section 1.3, we report on survey results reflecting the demand for mobile services in a university context. Subsequently, we describe UbiVersity, a location-based social network application deployed at the university and discuss evaluation results in Section 1.4). Finally, in Section 1.5, we investigate how mobile, context-sensitive application can foster learning and teaching at the example of MobiDics, a mobile didactics toolbox.

1.2 Case Study 1: Secure Single-Sign-On to Public Displays from Mobile Devices

1.2.1 Introduction and Motivation

Internet services have become an integral element in daily activities. Modern cloud-based services like Google, Facebook or other social community platforms make use of a lot of personalized and contextualized information of its users. It is essential for the users of these services to protect their privacy by protecting the access to the account.

The standard today still is to use authentication by providing a user name and password, as defined in the HTTP standard [16], despite more recent approaches targeted of increasing the the security of the process e.g. by introducing two-factor authentication or adding side communication channels (like mobile TANs for authenticating online banking transactions, or more general approaches as e.g. presented by Mayrhofer et al. [40]). As many users in light of the Web 2.0 are using many different services, they usually have to have different logins for the different services – but, due to comfort reasons, often only have one password and probably only one login (typically the email address). Therefore, the security of many services depends on the security of the weakest service being used. Given the growing size of the user base of the popular services, such as Facebook having recently reached 1,000,000 users[1] or Google, the need for individual logins for different sites poses a security threat. This, amongst other concerns, has lead to the development and eventually to the user acceptance of so-called Single Sign-On (SSO) solutions. Many sites nowadays offer to login using a Facebook or Google account and thereby remove the burden of memorizing many different passwords.

Single Sign-On solutions are one possible option facilitating both comfort and safety requirements. 'Single Sign-On (SSO) is mechanism whereby a single action of user authentication and authorization can permit a user to access all computers and systems where he has access permission, without the need to enter multiple passwords. Single sign-on reduces human error, a major component of systems failure and is therefore highly desirable but difficult to implement'[2]. However, with the rise of mobile devices, the classical web-based SSO solutions are not feasible anymore. Instead of a single desktop computer, multiple personal and private displays might become part of the interaction. In this case study, we report on a solution for cross-system, public-private display interaction with a mobile device using Single Sign-On.

1.2.2 Related Work: Token-based Login and Single-Sign-On

With the rise of modern mobile phones as truly ubiquitous devices, the possibilities and paradigms for interaction change. Users do not longer only use one computer, one keyboard, one mouse, and only one screen to interact with information. The classical WIMP paradigm for interaction is complemented by others more suitable for mobile interaction. The mobile device has, in many situations, become a secondary screen, e.g. when watching TV [39]. Mobile devices such as smartphones or other mobile interaction devices such as e.g. Tangible User Interfaces (TUIs) or other unconventional interactive systems [62, 31, 29] can sense the user's input and facilitate distributed or more natural interaction [12], no longer limited to certain locations next to a desktop [12]. We also see that the mobile device is used for public-private display interactions, e.g.using the device's camera [27]. An overview on the usage of the mobile phone for personalized interaction with public displays is provided by Rukzio and Schmidt [49]. For this case study, we will employ the user's mobile device for secure and convenient authentication on a public terminal.

[1] `http://www.businessweek.com/articles/2012-10-04/facebook-the-making-of-1-billion-users`
[2] `http://www.opengroup.org/security/sso/`

With the rise of cloud computing, the computation moves away from mobile devices and desktop computers, towards a virtual infrastructure. The classical limitations on computing resource are no longer real limits. Armbrust et al. [2] give an overview on the potentials of cloud computing. To allow a user to access her computing resources, reliable authentication is required. Classical cloud-based services such as Google, Facebook, YouTube, MSN, Yahoo, and others are currently extending their authentication processes by additional information: the registration of a mobile phone number, an alternative e-mail address or other means. The idea behind all these efforts is to increase security, or at least to notify the user on additional channels in case important changes to his account have been made. Another reason is the users' laziness: many desire to have the same login name (e.g. firstname.lastname) or are obliged to use their (same) email address as user name and then chose often (only) one password, identical for all services. While this increases convenience for the user, it poses an immense threat to the security of the user's data (and to the service providers, e.g. by facilitating spamming, scam or unauthorized shopping).

Approaches like OAuth [20], OpenID [48], 'Facebook Connect', and others can reduce the duplicate usernames (and thereby the duplicate passwords) for such web services. The basic idea consists in moving the authentication to a trusted IDentity Provider (IDP). The user authenticates himself against a well-known login mask of the IDP and is redirected to the calling resource provider that is requesting the authentication. The calling service and the IDP have to trust each other for this procedure. Once the user authenticates himself against the IDP, he gets authorized to use the requested service from the resource provider. The IDP can provide the calling service also with additional information like the users identity.

The basic idea of Shibboleth [15] – as depicted in Figure 1.1 – is to separate a resource provider from the authentication provider. The system providing a service no longer stores and manages login credentials at all. All authentication and authorization requests are redirected to an authoritative server. The client is now supposed to authenticate against the authentication server – called SSO server.

Additional challenges are posed towards this approach when the process is no longer confined towards a single standard desktop system, but involves potentially untrusted public terminals. In this case, novel methods for authentication are needed, both with respect to authentication and the human-computer interaction involved in the process. This is our motivation for the work presented in the following. In addition to re-using as many as possible components from established services, we aim to add contextual parameters. This will, as we will see later, involve the scanning of a dynamically created visual code, a so-called Quick Response (QR) code. This code is only accessible, i.e. scannable, in close proximity of the public terminal (given the limitations of today's camera systems in mobile devices). Scanning this information is also an intuitive and convenient way for the user to exchange data between two systems.

1.2.3 A Method for facilitating Authentication of a Mobile Device User against a Public Display

Token-based Login

The idea of token-based login (or, more general, service access) is that the user provides his credentials (commonly his user name and password) and in return obtains a token. This token can the be presented to the resource provider in order to access a given service. To provide a *token-based* login, the website (or, more general, the resource provider) needs to register its own identity first with the authenticationprovider. In this step, the resource provider and the authentication provider negotiate their (mutual) trust level. Every service is able to communicate in the background with the authorization provider. Therefore, a resource provider needs to specify once which information the service

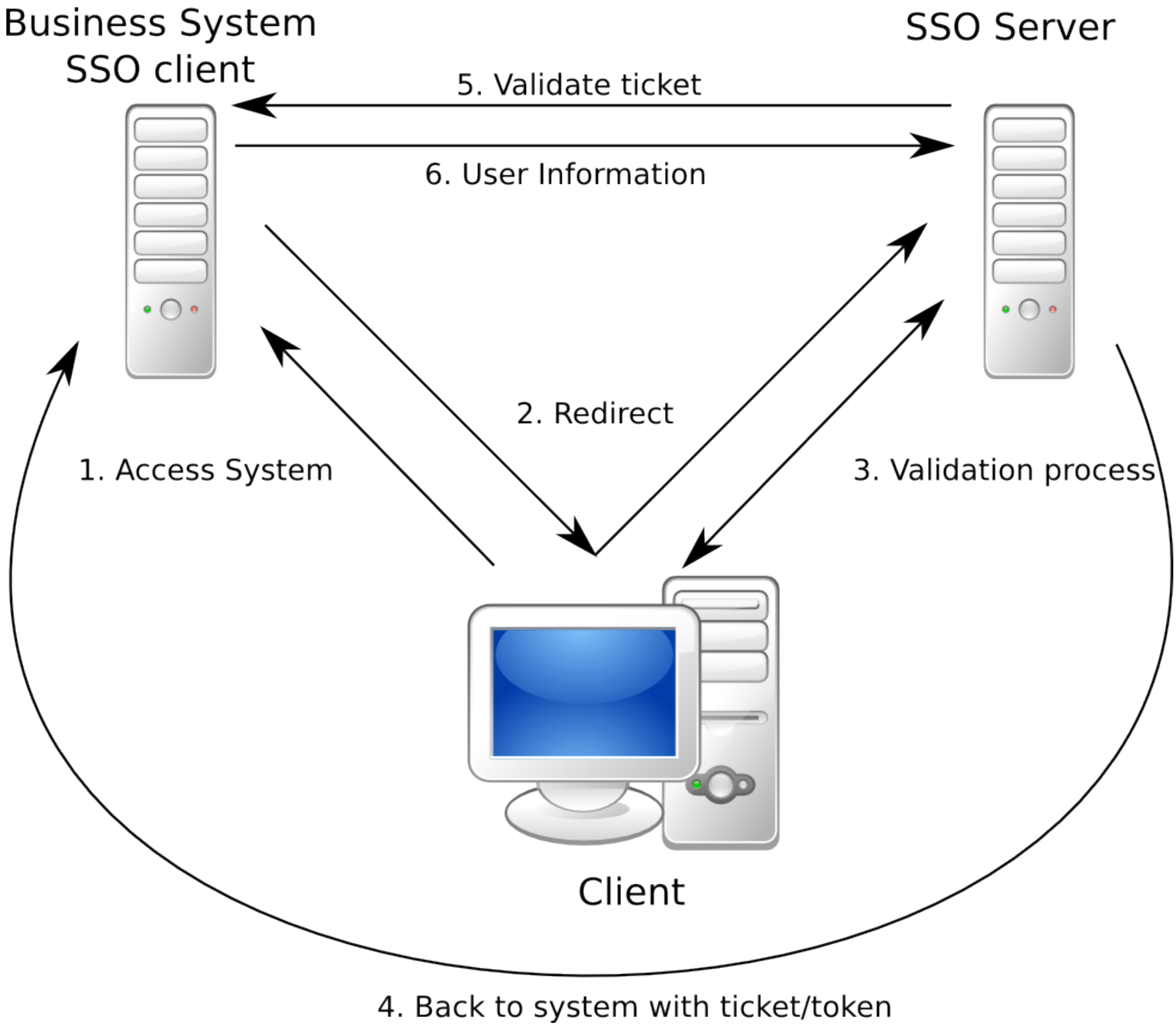

Figure 1.1: A Single Sign-On (SSO) system consists of a set of computer systems which need to trust each other. The client (service consumer) will be redirected from the requested service (resource provider) to the login server (authentication provider). The service (the requested resource) itself will just get a notification about a successful login (authentication). Neither the service nor the resource provider will request the user's password directly any more.

needs to run as used to. Similar to the AX (attribute exchange) record specified for OpenID, the service defines which values the resource provider should be provided with by the authentication provider. The user can check which information will be passed to the resource provider and the service by the authentication provider during the authorization process. This added transparency is provided in the process when using Shibboleth.

With the negotiation between resource provider and authorization provider the service gets a unique service id which is used to identify the in the QR code. This reduces the possibilities of token hijacking because the token can easily be revoked and renegotiated between service and authentication provider. Comparing to other standards as already mentioned the service provider can also communicate during the authentication process with the SSO server. This connection builds up the backbone of the system and helps protecting the user's privacy against hackers.

In our approach towards facilitating secure and convenient authentication involving a user's private mobile phone and a potentially untrusted public display, we try to reuse existing systems like OAuth, OpenID or Shibboleth as basis for our solution to incorporate the security features they provide. The current disadvantage of all systems is that they cannot be used without keyboard. This poses a significant restriction, as typing on mobile devices is still cumbersome, especially if this involves typing long and arbitrary alphanumeric sequences of letters which are typically forming the token. All systems are built on top of the basic username/password authentication mechanism. Also with Google Authenticator[3], there is a token-based two-step authentication system, which requires the user to type in her token.

In addition to those usability issues, there are other reasons for having the user *not* type his password on public displays: first of all, the display (or the system behind it) could have been hacked – and usually public displays do not authenticate themselves towards users (as similarly still most automated teller machines (ATMs) do not authenticate themselves to the user or his card). Second, typing on a (reasonable large and fixed mounted) touchscreen makes it easy for a third person to oversee the password. There are also indirect reasons for not having the user touch displays, such as hygiene concerns.

To remove the keyboard and the possible *man-in-the-middle attack* of a hacked public display, the authentication is no longer done as redirect from the service website. An example of such an authentication form is shown in Figure 1.2.

QR Code Token for Authentication and Authentication Process

Once the resource provider and the authentication provider are knowing and trusting each other, the service of the resource provider can generate a *QR Code Token* using the authentication provider. The Quick Response (QR) Code always encodes a URL with specific hash codes. To protect users against phishing, the QR Code Token is generated by the authentication provider and *always* references an URL to the authentication provider which is to be used in the further process. Furthermore, the QR Code helps to filter this URL (e.g. by asking for a special handling and thereby asking for a specific *Intent* to be issued on e.g. Android-based smartphones) on smartphone applications providing a more comfortable login method than showing up a website.

For our proposed authentication process for authenticating a mobile device (user) against a service running on a public display, we employed the authentication mechanisms found in OAuth and OpenID. The proposed novel authentication process is shown in Figure 1.3. The following steps map to the steps presented in Figure 1.3 and denote the actions the user has to take to authenticate himself (his smartphone) against the resource provider:

1. The user requests a resource/service (e.g. a file or mail).

2. The RP searches for a valid running session within the SSO Server (IDP)

[3] `http://www.google.com/support/a/bin/answer.py?answer=1037451`, last visited Oct. 2011

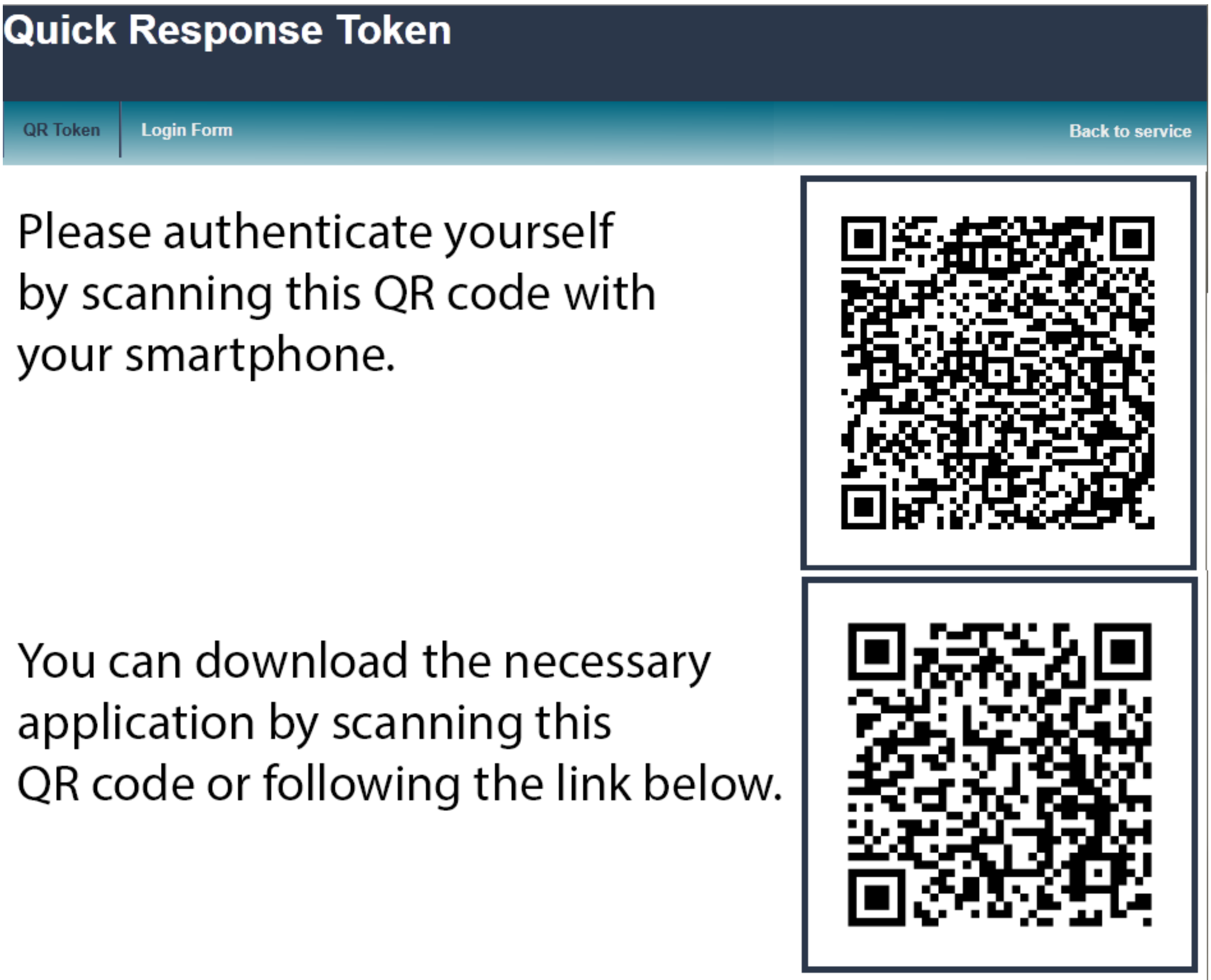

Figure 1.2: For a QR Code Token-based login, the user does not need to provide his username and password combination any more. He is presented a QR Code for authentication (with respective parameters encoded in the QR code, please see the full text for the details). In case the authentication method is used for the first time, the user will be offered to download the respective Android application facilitating this novel authentication method by scanning the link to the Google Play store. In case the user lost his smartphone or there is no network coverage for the smartphone, at the top he can switch to standard username/password login form.

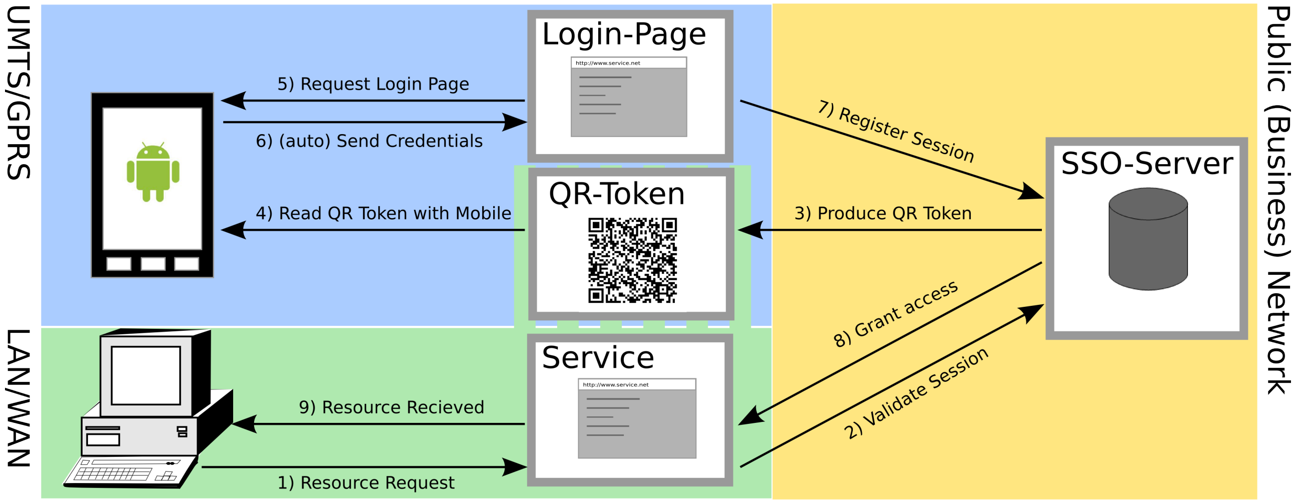

Figure 1.3: Mobile Authentication: (1) The user requests a resource/service (e.g. a file or mail). (2) The RP searches for a valid running session within the SSO Server (IDP). (3) The IDP produces a token for the terminal. (4) The user scans the code and gets an URL. (5) The user requests his login-page. (5) The user sends his credentials to the IDP (or is authenticated by a native application). (6) The IDP registers the session for the user. (7) The RP gets informed the access has been granted. (8) The RP can provide the user with the resource.

3. The IDP produces a token for the terminal.
4. The user scans the code and gets an URL.
5. The user requests his login page.
6. The user sends his credentials to the IDP (or is authenticated by a native application).
7. The IDP registers the session for the user.
8. The RP gets informed the access has been granted.
9. The RP can provide the user with the resource.

The user needs to scan the QR Code with his smartphone. The QR Code gets decoded by the smartphone's software and a website optimized for mobile use is opened. This process is shown in Figure 1.4. If the user has no native application installed on his smartphone he can be redirected to a download page or conventional login page on his mobile phone (Figure 1.4). The difference to existing systems is in the part that no username needs to be filled in any more.

Android Application

We have implemented an Android application as technology demonstrator to be used as interface to the authentication server, facilitating the process as described above. This application automatically detects any redirection to the authentication provider and complements these calls with its own information. The app allows the user to authenticate himself against the authentication provider using his smartphone after the user has once provided his user name and password. Once the authentication provider knows the user, they negotiate an authentication token (with jointly defined properties and time limits) which replaces the usage of a password or password hash. In Figure 1.4, these basic information is shown to the user, providing thereby transparency.

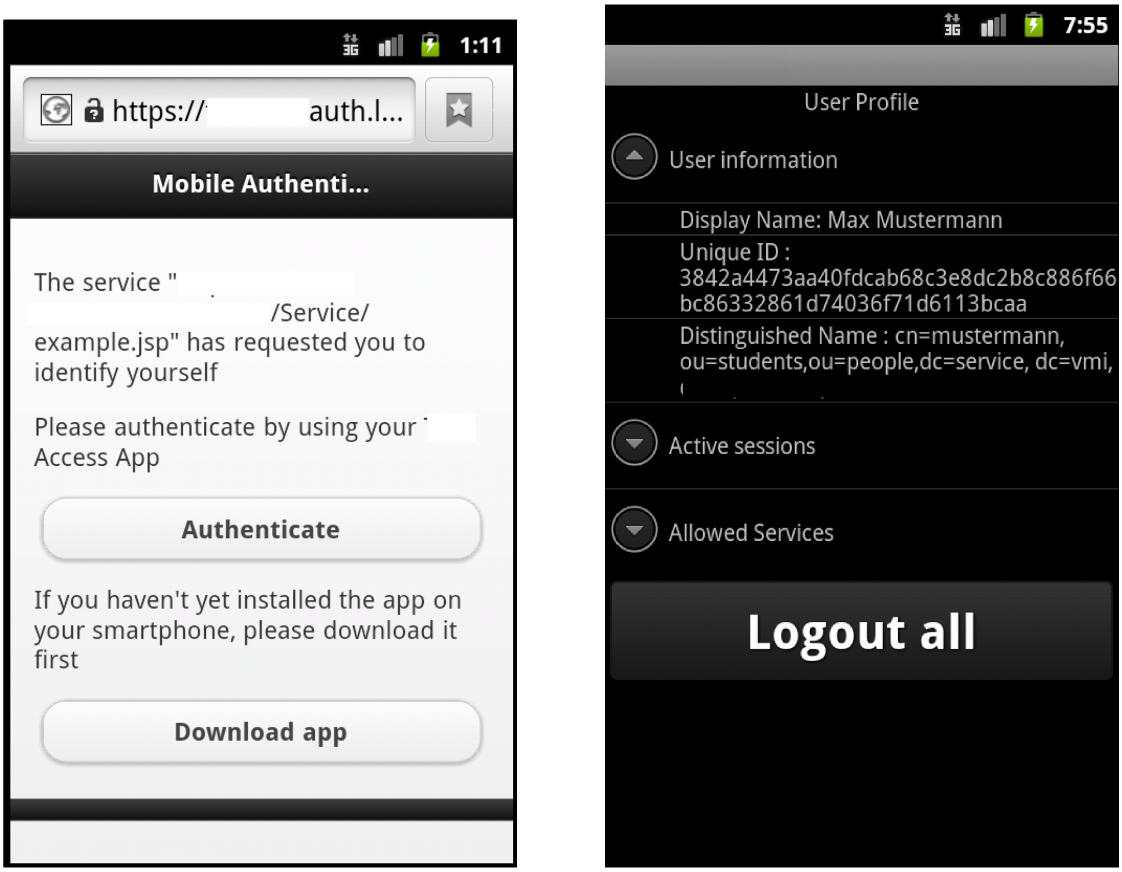

Figure 1.4: Left: When the user scans a QR Code, he will be redirected to a mobile website of the authentication server. If the user has no application installed he has the possibility to download the application instantly. Otherwise (not shown), the user can also authenticate using his user name and password. Right: The user can show up the information currently stored on the authentication server. As you may see there is no password stored, neither at the mobile application nor on the server. The only credential both systems are using is a hash which includes the user's hash and a timestamp value. On the go the user has the possibility to view and invalidate your sessions.

In this application, the user also gets an overview of his active sessions. Here the user can directly interact with the authentication server, e.g. invalidate active sessions or transfer session cookies with him to another computer.

1.2.4 Summary and Discussion

We have motivated the need for an intuitive and effective authentication process, allowing the user of a smartphone to request services from a resource provider by authenticating himself using a dedicated authentication provider. This allows the user to use services with a single user name and password combination (Single Sign-On). The authentication process follows the steps for authentication as defined by OAuth and OpenID, but has been tailored towards the specific needs of mobile device users and potentially untrusted public terminals. We have verified the approach by building a technology demonstrator, including the components for the public display and an Android App. Instead of the public display, it would also be possible to use the described process with a (public) desktop computing system. In this case, the login manager, e.g. the XDM, GDM, etc. would have to be replaced by a component to providing a QR code in an identical way as described for the public display above. Given the rise of interaction opportunities due to the availability of public displays, we believe that our approach can be used to provide a more intuitive yet secure authentication. Future research will include the sketched extension to desktop computing and the verification of the effectiveness, efficiency and user acceptance in field trials and user studies.

The system will, in one of the first application scenarios, be employed in a university context. The users will be students, allowing to book resources such as meeting and learning rooms, after authenticating towards the room booking service using their Single Sign-On credentials. Their credentials are at our university used to access all kinds of resources, such as networked attached storage (NAS) file systems, the EduRoam wireless network, the computing facilities, etc. The room booking service will be an additional service provided by a resource provider set up by us. To increase trust, we will defer authentication towards an existing and already trusted authentication provider. We hope that by providing an innovative and simple interaction method for authentication, we can encourage users to experiment with the service and make more efficient use of the (physical room) resources provided by our university for the students.

1.3 Case Study 2: Mobile Services at the University

1.3.1 Introduction and Motivation

Since the rise of internet-connected smartphones, they have soon been discovered and adopted as useful companions in every day, but also as valuable components for education and learning contexts and environments. Plenty of concepts for mobile campus services, tools and e-learning applications have thereupon been presented in the last decade. The recent years' transition from WAP cell phones and PDAs towards large-screen smartphones with fast processors, large high-resolution displays, innovative interaction concepts, and a multitude of sensors opens up new possibilities. Today's and future applications go along with novel interfaces and ways of interaction, converging towards the vision of *Ubiquitous Computing* on campus [59].

After giving a brief introduction in current mobile support of learning and university-related services, this case study provides an up-to-date overview of the demand on mobile services in higher education and learning environments. We conducted a survey among students and academic staff at a university of technology to investigate the present and potential future use of such services. We gathered information how online campus services at our university are currently used, and what users' wishes and needs for mobile services are. The findings summarized in this case study can help to design new services and indicate directions how existing services can be adapted for a better adoption on mobile devices, in order to provide context-aware mobile learning systems.

1.3.2 Related Work: Mobile Services at Universities

We in the following consider mobile services as context-based services where real-world and digital data are utilized to deliver a certain service or experience to a mobile user. We also report on educative environments.

Classroom 2000 [1] at Georgia Institute of Technology was one of the first deployed projects to support learning with mobile devices. Besides instrumented rooms that support lecture capture, mobile personal interfaces (tablet PCs) were used for live-annotating lecture slides, which could afterwards be accessed as HTML pages. In the next step, rooms were instrumented with cameras, microphones and electronic whiteboards as 'living laboratory'.

Mobile learning support has since then continuously grown, supporting all different categories of activities (for a review, see [44]). E-Learning is meanwhile widely adopted by colleges and universities, e.g. by introducing and using online, collaborative tools such as the Moodle platform[4]. Also,

[4] http://www.moodle.org

distance-based learning is nowadays facilitated with the established e-learning tools (for a review, see [17]). Newer trends address e.g. context awareness in learning [58] and the role of mobile learning systems in teacher training [51, 43].

Universities often also offer mobile services for course management, internal news and campus maps that go beyond the conventional websites viewed on mobile devices. As examples shall be mentioned iLancaster[5], MIT Mobile[6] and the CMU App[7]. Berg et al. [5] suggest a stronger integration of social networks and campus services, while Wheeler et al. [61] present ways how cloud computing could contribute to new services and applications.

1.3.3 Survey on Mobile Services in Education and Learning

The young and technophile population at colleges and universities suggests a high smartphone coverage (backed up by the number of 6,000,000,000 mobile phone subscriptions worldwide in 2011[8]), making ubiquitous services useful and willingly adopted. In order to investigate this potential and current smartphone and mobile service usage habits, we conducted an online survey with 93 participants. About 65% were students at our university, about 21% were academic staff. 2% were students at other universities and 12% belonged to neither category (e.g. other faculty staff). The invitation to the survey was distributed using a university-internal mailing list (mainly addressing staff), the faculty's online discussion board (mainly visited by students) and via Facebook.

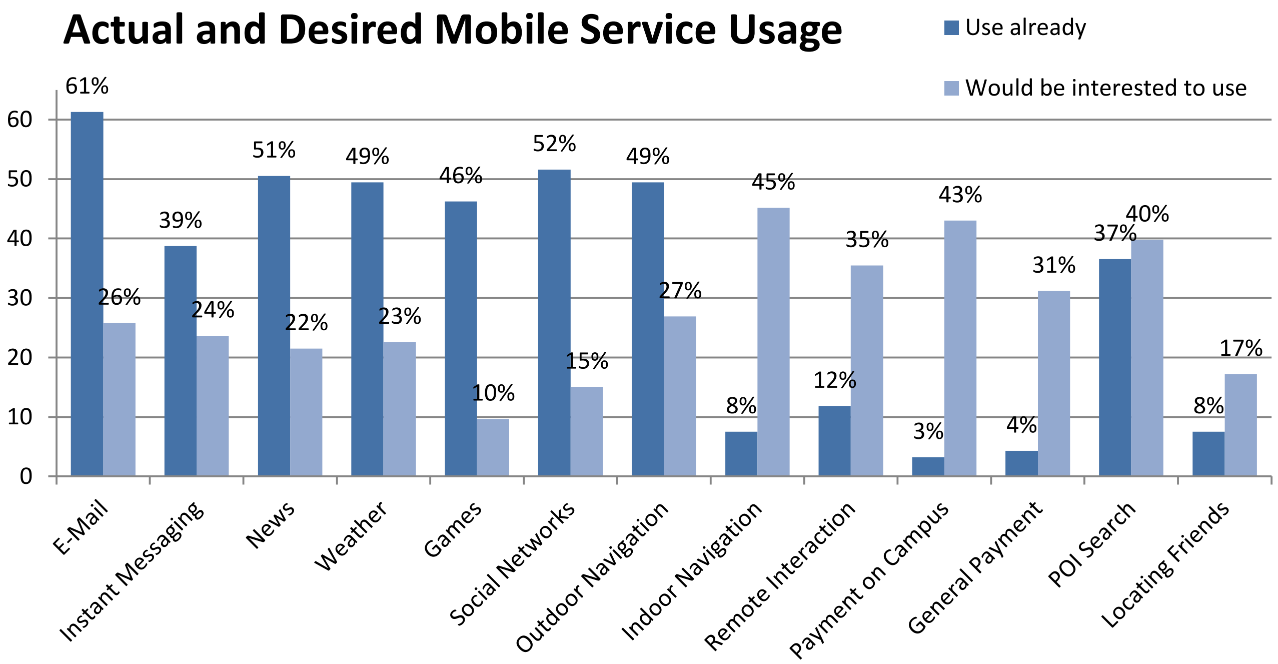

Figure 1.5: Usage of mobile services on smartphones. 'Classic' activities and applications such as email, weather forecasts and social networks are widely used, but there is also a demand for novel applications like mobile payment or indoor navigation.

[5] https://market.android.com/details?id=com.ombiel.campusm.lancaster
[6] http://itunes.apple.com/us/app/mit-mobile/id353590319?mt=8
[7] www.cmu.edu/cmuapp/
[8] http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats/a#subscribers

The survey consisted of three parts. First, we asked for the *mobile phone internet usage*. Access to 3G internet or free university WLAN is a requirement to use online services. We asked how often users' phones are connected to the internet and which services they use. Second, we gathered information about which *university services* people use frequently (not necessarily mobile). This helped us to get an impression of what information and services are actually popular with users. Third, we wanted to know which *mobile university services* users would like to use with mobile phones. This helped us to identify how services can better be adapted to mobile devices in order to be adopted by users, and which novel services and applications could be provided to satisfy users' demands, using the potential of state-of-the-art smartphones.

Results and Discussion of the Study

Mobile Phone Internet Usage *Results:* Android (40%) and iOS (37%) were the most frequently used platforms according to our survey, followed by Windows Mobile with 24%, Symbian with 23% and RIM (BlackBerry) with 8%.[9] 39% of the survey participants have a permanent internet connection on their mobile phone; 18% are online via WLAN on campus, and 17% establish a connection when needed. 28% state they don't use mobile internet, because they either don't need it, find it too expensive or don't have an internet-capable mobile phone.

E-Mail (61%), social networks (52%), news (51%) and weather information (49%) belong to the most frequently used services on smartphones (see Figure 1.5, 'use already' columns). Out of the more uncommon services we had added to the questionnaire, subjects would be most interested in using indoor navigation (45%), payment with their smartphone on campus (43%), searching for nearby POI (40%) and remotely communicating with interaction points in the environment (35%).

Discussion: The survey reveals that a significant amount of users does not only use the major platforms Android and iOS, suggesting that services should also be available as web applications to be usable with all operating systems, or that separate apps should be created at least for the major platforms. Native apps have the advantage that they can access sensor information for more functionality and allow location- and context-aware functionality, richer interaction, and a more sophisticated user interface.

Hence, a good three quarters of users can be addressed with mobile services on campus, while the user group owning non-capable phones will most likely further decrease in the next years. To further foster the spread of mobile services at universities, two measures can help: A university-wide free WLAN (such as the world-wide available WLAN network EduRoam[10]) addresses users with no free data plan, and attractive services motivate users to activate their internet connection to be able to participate.

As Figure 1.5 indicates, such attrative desired features are indoor navigation, payment for university services (digital wallet), search for points of interest and interacting with the environment. Here is actually a potential for future applications to implement them by making use of new possibilities that modern smartphones offer.

Stationary University Services Usage

Results: Figure 1.6 illustrates how campus-related services are currently used at our university, which is a University of Technology in Germany. Results might differ e.g. for universities focusing on social sciences. For each service, participants could indicate whether they use it regularly, occasionally, not at all, or whether they do not even know about it. The room finder website and the online course management tool are most frequently used regularly or occasionally by 84% and 81% of participants,

[9] The percentages add up to more than 100%, as multiple answers were allowed.

[10] `http://www.eduroam.org`

respectively, followed by the canteen menu website (77%) and the university's main website (69%). The canteen menu is by far more checked out *regularly* (66%) than the other tools, which are often only occasionally used.

Discussion: Many of the major university-related services we selected are not too frequently used. Particularly the *interactive* services are willingly adopted, like the room finder or the course management tool. The comparatively high amount of people who know about, but do not use the library site (25%) and main web portal (24%), which are both static websites, shows the demand for more interactive, user- and task-centric offers. One option to more widely raise interest in other services could be to piggyback information e.g. in the canteen service.

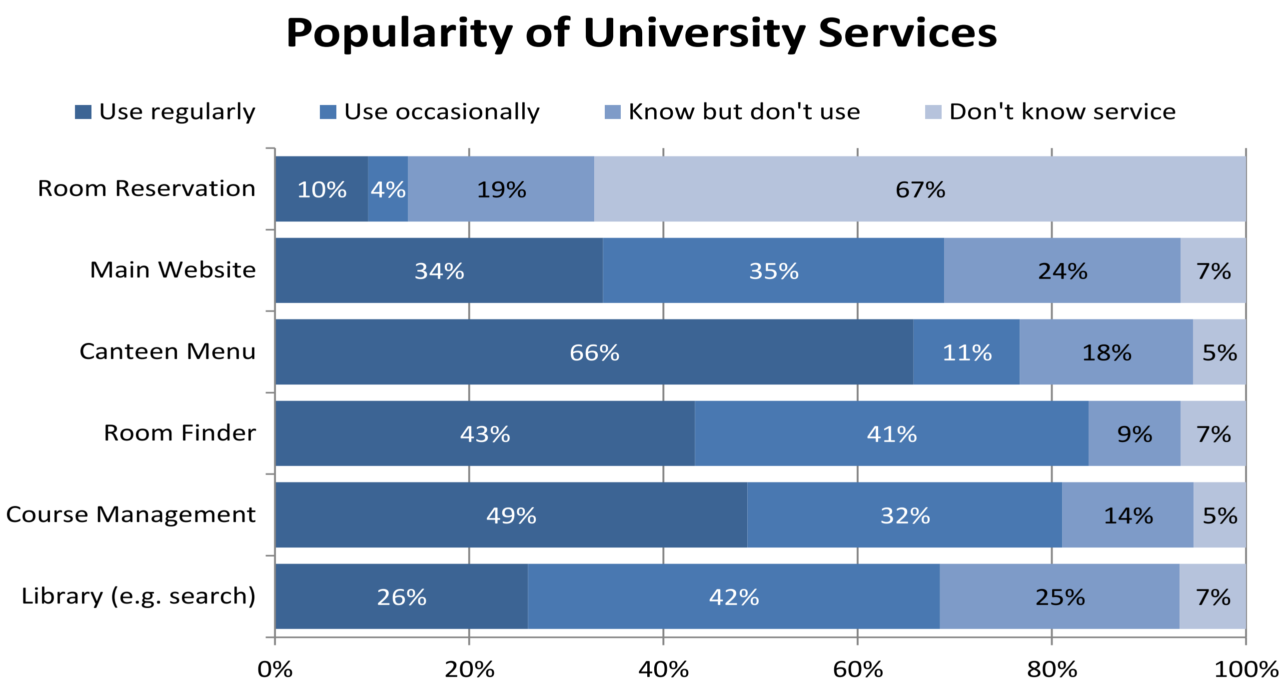

Figure 1.6: Usage of selected university services (stationary and mobile).

Actual and Desired Mobile University Services Usage

Results: Figure 1.7 summarizes the participants' attitude towards selected mobile university-related services, and their actual usage. For each service, participants could state whether they already use it, or if not, whether they would be interested to use it on a five-step scale from 'like to use' over 'neutral' to 'not interested'. The highest interest was attested the room finder and indoor navigation. 61% of participants would like to have this as mobile service; 15% would maybe try it. Subjects would also like to be able to reserve rooms for learning (30%), manage their courses on the go (28%) and use instant messaging (IM) with fellow students (28%). Library search, locating other students in a Foursquare-like manner and using mobile payment (e.g. for photocopier or canteen) found 22%, 19% and 15% interesting. There was also a demand for accessing the university's main website in an optimized mobile version (17%).

Discussion: Except for the canteen menu which is used by 39% of subjects on mobile devices, university services have not yet really found their way towards smartphones. The results for this survey question suggest two things: Firstly, there is a desire for entirely new services, such as social applications with focus on the university (instant messaging students) or indoor navigation. These are applications that are technically feasible, using the features of state-of-the-art smartphones such

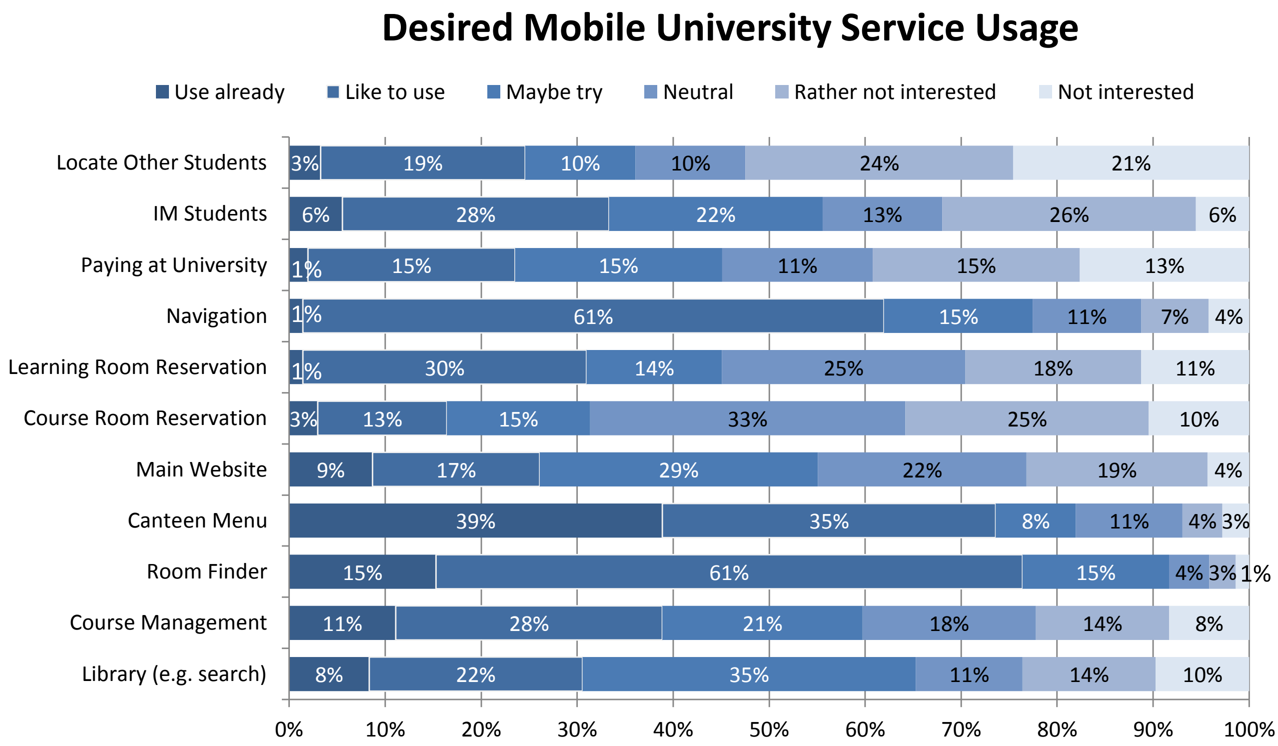

Figure 1.7: Students and university staff are particularly interested in navigation, room finder and social services like instant messaging.

as NFC for campus payment, or WLAN localization for indoor location-based services. Not for all services infrastructural changes are required; indoor positioning can e.g. be realized by WLAN localization or by other RF-based communication systems [26, 28], just using the existing access point infrastructure. If novel vision-based approaches are used [42, 23], the environmental infrastructure even does not have to be changed at all.

Secondly, there is a desire to use existing services on smartphones, even though they are theoretically usable by their standard websites. This is apparently not appealing enough, indicated by the fact that e.g. the room finder is only used by 15% on mobile devices. However, especially such location-based search and navigation are predestinated to be used from mobile devices. They should be ported to mobile versions, e.g. by adaptions to screen sizes, limited text input possibilities and mobile interaction paradigms like gesture navigation, or by creating individual apps that better support specific tasks. Implicit knowledge provided by the device (e.g. proactive services based on the user's location or preferences) can further simplify the usage of such services on mobile devices.

Summary of the Study

Our findings can be summarized in three main points.

- There is a high coverage of mobile devices that are connected to the internet, providing a strong basis for mobile services and applications on campus. The survey suggests further a *demand* for using such services on mobile devices among university students and academic staff.
- More existing services and applications should be provided for mobile usage to satisfy this demand. The discrepancy between actual and desired usage of such applications indicates that services need to be improved for a higher acceptance on mobile devices. They need to be stronger

adapted to the special possibilities and requirements of these devices – and the learning environment. This includes adaption to smaller screens and different ways of interaction with the device (e.g. gesture navigation), as well as between device and environment (e.g. remote interaction through near field communication or visual markers). The use of implicit information, such as user context (inferred e.g. from sensor or usage data), can further simplify usage of applications and facilitate situated services tailored to the users' need.

- There is not only a demand for *adaption* of existing services, but for novel applications as well. These include payment applications, e.g. for photocopiers, coffee machines or in cafeterias; remote interaction with e.g. situated displays, and particularly location-based search of and navigation to 'campus POI', such as the nearest photocopier, the nearest free room for learning, or a faculty member's office. Such services need to go along with appropriate intelligent interfaces in order to make them accessible from mobile devices and to make their usage attractive and simple.

Some key requirements are needed for these points. First, the university must provide a good WLAN coverage in order to achieve a wide user basis and to incorporate users with phones without permanent online connection (flat rate). Second, an indoor positioning system is a requirement not only for navigational instructions that were an explicit desire of users, but also the basis for other indoor location-based services like search of nearby POI. For a survey on WLAN-based indoor positioning systems, see [26]. With the present denseness of access points in universities for 'everywhere WLAN', positioning on room-level accuracy is possible with state-of-the art fingerprinting methods. For large-scale public indoor environments, such as universities, visual localization [22, 41] could also be an interesting alternative. Finally, as in our survey participants sometimes stated that they would 'like to use' mobile services which are already available, a good information policy regarding new applications is important, in combination with transparent privacy statements giving users control over their data.

1.3.4 Summary and Discussion

In this case study, we investigated on current mobile phone and university service usage (stationary and mobile), and the demand for mobile services and applications related to the campus. We identified a demand for mobile adaptions of existing services as well as a high interest in novel applications like indoor location-based services and interaction with the environment. Based on our results we pointed out directions towards more ubiquitous applications on campus, improving the service level and fostering the connectedness of staff and students.

1.4 Case Study 3: UbiVersity

1.4.1 Introduction and Motivation

The university is, at least should be, a place designed to support learning. While one aspect of effective teaching is trained teaching staff [6], another aspect is peer learning. Methods like peer learning or problem-based learning [19] work effectively in small groups. However, the problem in today's university contexts often is to find a place to meet. Rooms are usually a scarce resource, the number of rooms accessible or bookable by students is low, thus finding a room and meeting there is a severe issue. As an example, Technische Universität München, Germany is proud to announce on their websites that there are in total 11 group work rooms for students[11] and in total 24 individual

[11] `http://www.ub.tum.de/gruppenarbeitsraume`, last visited Oct. 2012

work rooms[12] – at three geographically distributed campus locations and for about 30,000 students (data from winter term 2012). Thus, finding another location and spontaneously meeting there is a topic for future university services. In this case study we investigate on the potential privacy-related issues with sharing this location information with other people.

Location sharing systems often entail concerns about privacy when disclosing one's position [11]. Users worry that their location could be traced by people they do not know sufficiently well – a side effect of large friend lists in social networks. Earlier research observed large-scale networks such as Foursquare or Google Latitude. In this case study, we investigate how a spatially limited location sharing system affects check-in habits. We evaluated our work in a two-week explorative field study with an on-campus location sharing system we implemented for that purpose.

Our results indicate that users tend to disclose more willingly their location if it is limited to a local area, even those who refrain from using large location sharing systems like Foursquare. We also found that reasons for disclosing one's location in a local context are different from those in large social networks. The smaller spatial distances of check-ins simplify meet-ups with friends and are a motivational factor for location sharing.

1.4.2 Related Work: Social Networks and Location Sharing

With GPS-enabled smartphones and increasing 3G/4G coverage, mobile location-sharing systems enjoy rising popularity. The trend goes from *purpose-driven*, one-to-one sharing like Glympse[13] towards *social-driven* location sharing [54], like Foursquare[14], Gowalla[15] and Latitude[16], where a large amount of friends shares their locations with each other. This allows users to discover new places and people, earn discounts and benefits, play games, or enable ad-hoc meetings with nearby friends [37]. These systems follow the *check-in* principle: users publish their current location and associate it with a meaningful place name like an address, a shop or bar. Check-ins can then be retrieved by members of the user's friend list, or by everyone using the service if the check-in was made public.

Location sharing does not only take place among intimate friends. Often, social networks' friend lists contain a lot of weak relationships and acquaintances [60, 14]. In a survey [37], 58% stated to have Foursquare friends they don't know personally. In that case, usage of location sharing systems resembles the concept of 'following' people (like in Twitter or Google+) who visit interesting places, in order to discover new locations. However, this requires active publishers that share their location with people they potentially do not know very well.

Location sharing, in general, coincides with privacy considerations and concerns [4, 35, 11], all the more in one-to-many location sharing systems where the relationship to followers is not that tight. People do not want to share in detail their daily routines with people they barely know. Foursquare users [37] even expressed their concerns of being stalked, that strangers can track them, or that someone could break into their home when others can see that they are away.

Various motives for sharing one's location in large-scale networks have been identified [37]: besides the social connectedness, people use these systems for self-representation ('I have been at event X') and from gaming motives (e.g. becoming the 'mayor' of a place in Foursquare). The possibility to earn badges and rewards for check-ins are an important factor to motivate (especially novice) users.

Driven by these findings, our research interest is to identify how these motives, and thereby the sharing behavior, would change if the scope of the system was limited to a certain area (and implicitly a certain group of users). We therefore implemented a university-wide location sharing application

[12] `http://www.ub.tum.de/carrels`, last visited Oct. 2012

[13] Glympse. `http://www.glympse.com`, last visited Sept. 2012

[14] Foursquare. `https://foursquare.com`, last visited Sept. 2012

[15] Gowalla. `gowalla.com`, last visited Sept. 2012

[16] Google Latitude. `www.google.com/latitude`, last visited Sept. 2012

as a working, live example for such a system, and gained user experiences during two weeks in an explorative field study. We are aware that both duration of the study and the number of participants is too low to provide results with statistical significance, but the quantitative results are nevertheless helpful in designing future campus services and e-/m-learning applications. The contributions of this case study are twofold:

1. We present the survey and interview results on usage motives for spatially limited location sharing systems. We found that these motives differ from those valid for large location sharing networks, as identified in earlier work.

2. We present indications that users are less concerned about privacy in local location sharing, compared to sharing in large networks like Latitude or Foursquare.

The case study description is structured as follows: We introduce our prototypic system in the subsequent section. After that, we describe the proceeding of the field study and survey, and present and discuss the results. We conclude the case study with a summary and discussion of our findings and implications on future work.

1.4.3 UbiVersity - A Location-Sharing App on Campus

As an example for a local location sharing system, we developed *UbiVersity*, a location-based social network focusing on our university campus, operating on room-level granularity. The system allows to accurately view and monitor the location of friends around the university area. Usage scenarios of *UbiVersity* are e.g. locating a specific friend on campus for a meet-up, find fellow students for collaborative work, or nearby friends for having lunch together.

Functionality

The system consists of a server and smartphone clients. Users can check in to the room they are currently in and share this location with their friend list or a subgroup thereof. We provide several ways to accomplish check-ins to simplify the procedure. Firstly, users can pick a candidate location out of a ranked list that is generated by a WLAN indoor localization system. As alternative check-in methods, we equipped the door signs of rooms in our department with Quick Response (QR) codes (visual markers) and NFC tags (physical markers). A check-in is then performed by photographing the QR code or touching the NFC tag, respectively. Finally, users can also manually select the building and room where they want to check in.

Friends' location updates can be viewed as a news feed, i.e. in a list beginning with the most recent check-ins, or on a map (see Figure 1.8, left). The map view displays people around one's own location as little icons (see Figure 1.8, right). We use maps from the university's room information service to be able to visualize detailed floor plans.

Design Decisions

The user group was intentionally limited to students at our university and not connected to other services like Facebook or Twitter. Likewise, the geographical scope for check-ins is limited to the campus area. For the manual check-in, however, any custom label can be entered, e.g. 'commuting' or the name of an off-campus location like a nearby café. No GPS location is associated with this label.

We did offer the possibility to select groups of people or individuals to share a location with, as previous work has shown that people seem want to adapt their sharing habits according to the receiver, not to the location [35]. We did not enable automatic check-ins, although it would be possible based

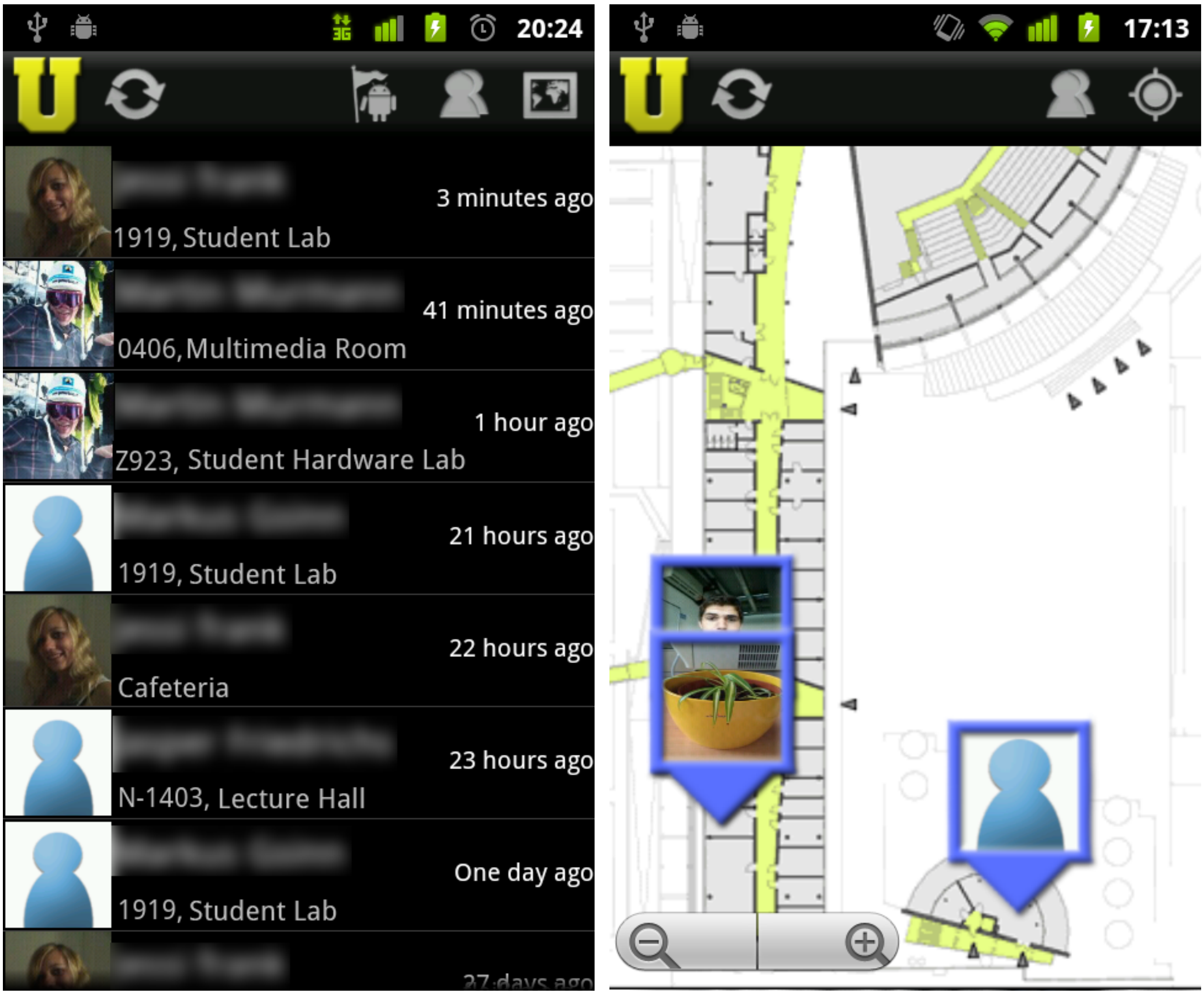

Figure 1.8: Left: The friend feed shows in which rooms people have recently checked in. For privacy reasons, real names have been blurred. Right: The map view visualizing nearby friends with and without photos on a floor plan of one of our campus buildings.

on an existing WLAN indoor localization system. Instead, check-ins have to be initiated by the user, being preferable from a privacy point of view [4]. We did not artificially limit the accuracy of the specified location (e.g. in a way that people can indicate the building they're in, but not the exact room), because once people decide to disclose their location, they tend to want to enter their location precisely [11].

Implementation

The *UbiVersity* service is implemented as Django web application. The clients (implemented in Android) request data like the list of check-ins via HTTP, receive a JSON array as result and visualize the information. For the QR code recognition, we used the open-source ZXing[17] library. Check-ins using indoor location retrieval is made possible by analyzing WLAN received signal strengths (RSS) and employing a fingerprinting algorithm [26], which works sufficiently well for room-level accuracy due to a good access point coverage in all university buildings. QR code, NFC and manual check-ins serve as ground truth for training the system.

[17] ZXing. `http://code.google.com/p/zxing/`, last last visited Sept. 2012

1.4.4 Evaluation of UbiVersity

We evaluated *UbiVersity* in an explorative field study to find out how often and in what way such a location sharing system is used. In light of high privacy concerns that became evident in earlier studies, we investigated how a *local* location sharing system could affect users' willingness and motives to disclose their position.

Six subjects (5 males, 1 female; n = 6) with an average age of 23.3 years (AVG = 23.3, SD = 1.1) installed a *UbiVersity* prototype on their personal Android smartphones and added each other to their respective friend lists. We recruited students who knew each other before, in order to lower the inhibition threshold for check-ins and to make the study more realistic. Subjects were asked to regularly use the prototype for two weeks in their everyday routine on and around the university campus. All check-in activity was server-logged. Prior to the study, subjects answered a questionnaire on their previous experience with location sharing systems. At the end of the study, participants reported again their experiences in a questionnaire. The surveys were filled out online. Additionally, structured face-to-face interviews were conducted with three participants to get deeper insights about their experiences and motives.

The feedback on our app was very encouraging. In the following, we present the results of questionnaires and interviews by category. For each item, the average agreement level, ranging from 1 (totally disagree) to 5 (totally agree) on a Likert scale, and the standard deviation (SD), are indicated in brackets. Table 1.1 gives an overview of all survey items.

Experience with Location Sharing Systems

We asked about the former experience with location sharing systems in general, and in more detail, with Foursquare, Facebook's location sharing option (formerly Facebook Places) and Google Latitude. Two of six participants declared to use such systems regularly, four do not use them on a regular basis. The two 'active' users mainly used Latitude (subject A), and Latitude and Foursquare, respectively (subject B). A and B stated to use these services 'several times per day'. One of the remaining 4 participants 'tested but abandoned' Latitude, the other three never tried location sharing services at all. They mentioned privacy reasons (concern of publishing too much information, commercial interest of platforms) as main barriers.

Check-in Behavior

All subjects regularly used the system, with in total 110 check-ins during the study. As expected, they checked in more frequently to locations on campus (AVG = 3.5, SD = 0.8) than off-campus (AVG = 2.2, SD = 1.3). Examples for those were nearby coffee houses and squares. Subjects stated that they considered *UbiVersity* mainly as 'university app'. Consequently, they used the manual check-in mainly for nearby locations and very rarely for places like 'home'.

Participants liked seeing their friends' location with an average of 4.3 (AVG = 4.8, SD = 0.7). Interestingly, they averagely agreed with 4.8 (AVG = 4.8, SD = 0.4) that they like their friends to know their position (AVG = 4.8, SD = 0.4). Participants stated to check in with a certain purpose in mind (AVG = 3.8, SD = 0.9), e.g. to signal that they are available for having lunch or hanging out together. Likewise, they checked in without purpose (AVG = 3.7, SD = 1.1) just to indicate their position and to enable random meet-ups. One subject reported a feeling of 'pleasant anticipation' when checking in, because he was curious who would possibly pass by.

Check-ins were mostly shared with the entire friend list (AVG = 4.6, SD = 0.7), and much less with subgroups of friends or individuals (AVG = 2.0, SD = 1.0). However, in the interviews, the possibility of limiting location updates to circles was considered useful. It was due to the small number of users in the study that this feature was not used extensively.

Question	AVG	SD
Frequently checked in within campus	3.5	0.8
Frequently checked in outside campus	2.2	1.3
Frequently checked in with certain purpose	3.8	0.9
Frequently checked in without certain purpose	3.7	1.1
Like the friend feed	4.2	0.4
Like the map view	3.8	0.9
Like the idea of seeing my friends' location	4.3	1.0
Like the idea that my friends can see my location	4.8	0.4
Shared location with entire friend list	4.7	0.7
Shared location with subgroup of friend list	2.0	1.0
Felt concerned sharing my location	2.0	0.6
Felt less concerned than sharing with other services	4.3	0.7
Should be connected to other services	2.5	1.3
The app was easy to use	3.7	0.9

Table 1.1: Usage patterns and feedback on the UbiVersity prototype. The average agreement rates on a Likert scale, ranging from 1 (fully disagree) to 5 (fully agree), are given with the standard deviation for each statement. (AVG = Average, SD = Standard Deviation)

Friend Feed and Map View

The friend feed was slightly more popular than the map view. Participants agreed to the item that they like the friend feed with averagely 4.2 (AVG = 4.2, SD = 0.4), and that they like the map view with 3.8 (AVG = 3.8, SD = 0.9). This indicates that it was considered more important *when* someone checked in to a location than *where* exactly the check-in was (in the map view, the location update's recency was not visible). In the interview, one participant stated that the location would not matter that much for him, as the distances on campus are small anyway. By contrast, it was important for him to know that a friend *recently* checked in at a location, in order to be sure that she would still be there when he wants to meet her.

Privacy

The privacy concerns subjects had with our system were moderate. They agreed only with an average of 2.0 (AVG = 2.0, SD = 0.6) that they were concerned of sharing their location. They agreed with an average of 4.3 (AVG = 4.3, SD = 0.7) that they felt less concerned than when sharing their data with Latitude, Foursquare or Facebook Places. The higher inhibition on sharing with other systems was associated to the fact that the scope of these systems is global, and not limited as for *UbiVersity*. Further mentioned aspects were the commercial interests of these platforms and the concern that they might use location information in other contexts and associate it with other personal data. It is not surprising that subjects did not miss a connection to Facebook or similar platforms. In average, they only agreed with 2.5 (AVG = 2.5, SD = 1.3) to the item that such a feature would be useful.

Usability

Subjects agreed with averagely 3.7 (AVG = 3.7, SD = 0.9) that the *UbiVersity* client was easy to use and that the user interface did not raise any questions. Two comments of individual subjects addressed a missing history view of own check-ins to assure that they were successful, and a possibility for direct room entry in the manual check-in view. Currently, building and floor have to be selected from a drop-down menu before the pre-filtered room list appears. For checking in, participants used mostly the indoor localization, followed by manual room selection, QR codes and NFC tags. The reason for the low usage of QR codes and NFC was that only our institute, and thus a small part of the campus, was equipped with this technology, and not all subjects own a NFC-capable smartphone.

Discussion of the Study

The survey of this case study results indicate an unexpectedly high willingness to share one's own location, even slightly more than seeing the location of friends. In the survey and in interviews, users declared that they were more motivated to share their location in *UbiVersity* than in Foursquare or Latitude. We identified several reasons. Firstly, check-in motives in Foursquare etc. are often gaming aspects, earning badges or gratifications, or showing to have been at a 'cool' event. Self-representation can also be a limiting factor, e.g. because of a potential bad image of frequent check-ins to fast food restaurants [37]. By contrast, motivational factors for *UbiVersity* check-ins were the personal benefits of meeting people: finding fellow students for doing homework together, meeting friends after lectures, collective lunches, etc. The chance of being 'found' was even a check-in motivation for subjects who did not see much use in Foursquare and co. They related this motivation to *UbiVersity*'s local scope and the small distances on campus. Users can quickly approach the specified location and meet the person there. In other location sharing systems, distances are typically larger, so that people might already have left when another person approaches the check-in location. Unplanned meet-ups with friends become more likely in *UbiVersity*, so that the perceived benefit rises. This correlates with subjects' preference for the friend feed over the map view: for a local scope, timeliness of location data was more important to them than the check-in location (as distances are short anyway).

Results indicate that privacy concerns played a subordinate role for most subjects and that they seem to be more eager to share their location, compared to services like Foursquare, Facebook or Google Latitude. Again, this is related to the local scope of the system, both in terms of users and of space. Most users will be fellow students, and check-ins are limited to the campus area. This minimizes the risk that 'strangers' learn too much about one's daily routines, which was a frequent concern on large-scale social networks. The information of being in a certain room on campus, by contrast, was apparently not a privacy concern of our subjects.

Trust in the platform itself turned out to be an important factor for subjects – this aspect has, to our knowledge, not yet been addressed in previous research so far. Concerns in earlier work affected being tracked or stalked by strangers [37], whereas several of our participants raised concerns regarding what the platform owners could do with their data, e.g. interconnect it to other personal information.

1.4.5 Summary and Discssion

We have investigated how users' location sharing behavior changes when the social network is limited to a local scope. We have presented a campus-wide location sharing service and collected experiences in a two-week explorative study. Although the number of users in this first experiment was too small to provide significant results, our findings indicate that users share their information more willingly and show less privacy concerns when the network's location is limited. Users then see more benefits in checking in at a place, since the chance of meet-ups initiated by these check-ins is higher than in a wide-scale social network. We bring up 'trust in the platform' as an additional aspect of privacy that has barely been addressed yet, but has likewise to be considered. A university-scale system here entails a higher level of trust than large commercial networks.

Motivated by these results, we will further investigate how the spatial scope influences check-in behavior in location sharing systems. This will probably help us understand better what intrinsically motivates location sharing, and what factors prevent users from doing so. These research questions will have to be examined in further experiments and surveys with a larger base of users.

1.5 Case Study 4: MobiDics

1.5.1 Introduction and Motivation

Mobile learning has recently gained in importance, fostered by the rise of multi-functional smartphones. These devices enable learning activities and access to educational material where and whenever the learner wants, independent of time and location. Mobile learning can take advantage of unused time, like waiting at the bus stop. This is e.g. well suited for vocabulary tests, that easily can be interrupted and continued ('interruptable learning'). Mobile phones can be an important instrument for lifelong learning [52, 46]. Areas with high mobility like the medical sector [24, 52] greatly benefit from mobile learning, as well as the education in classrooms [55]. Only mobile learning supports the necessary mobility for problem-based and experiential learning [52, 24]. Often, other forms of learning are, e.g. for business professionals, not adequate any more.

Research on mobile learning so far focuses on systems directly used by students. We present MobiDics, a mobile didactics toolbox for teaching staff in higher education, like professors, lecturers, PhD students, or teaching assistants. Didactic methods are instruments e.g. for student activation and for adequate support of different learning phases (like generation of knowledge, levels of learning and understanding, or rehearsal) [47, 36]. The use of mobile pervasive learning tools also by the teaching side has the potential to improve teaching and thereby to provide better university education. Further goals and motivations for our work are

- higher satisfaction among teaching staff
- the support of further education of university faculty members, academic staff, teaching assistants and student tutors
- improvement of social mobility, in order to foster equal opportunities in access to educational programs
- innovation in professional education and training, and the integration of professional and academic education
- reaching target groups that would not as good be addressable without mobile learning [57]
- creation of mobile learning programs that support ad-hoc needs for learning during work, or the personal wish for improvement
- special programs for mobile acquisition of basic competences (e.g. for young teaching staff).

We provide insights about user wishes in the target group and present results of the reception of a mobile didactics toolbox, based on a comprehensive study.

1.5.2 Related Work: m-Learning and e-Learning

Electronically supported learning (e-learning) has become mature (for an overview of technologies see e.g. [63]), and moved from research labs to the field, e.g. the Moodle platform [13]. Learning on mobile devices is recently explored more extensively, defining the new field of m-learning [52, 55]. Mobile learning is seen as addition (not a replacement) to traditional e-learning, when learning material would otherwise not be available. MLE (Mobile Learning Engine) is a plugin for the Moodle platform on mobile devices [24]. It presents information chunks called MILOs (Mobile Interactive Learning Objects) supporting explorative learning, and abrupt pauses and resumption for intermittent use. The independent discovery of content increases learning motivation according to the authors, but they admit that the system is rather suited for advanced users, as there is no rigid learning path. X-Media Learning Objects [25] extend MILOs to pervasive learning on multiple devices like MP3 players, PDAs and television sets.

Multimodal Learning Mobile learning can also take place by using ‘smart’ objects and tangible user interfaces (TUI). They allow for multimodal interaction and especially support experienced-based and situated learning, often in a playful way (e.g. the DisplayCube [34, 56]). As human memory is multimodal, physical activity can foster and support learning, as e.g. demonstrated by SensorVirrig [50].

Didactics Information on didactics and course preparation for electronic use is provided by teaching portals[18], wikis[19], or training videos[20]. However, these contents are not particularly suited or optimized for mobile use.

1.5.3 MobiDics – A Mobile Didactics System

With MobiDics, we present a system supporting course preparation and structuring on mobile platforms. The integrated content was provided by the Centre for Learning and Teaching in Higher Education associated with our university.

Functionality

MobiDics is intended as supplement to professional training courses on didactic methodologies. Its advantages are:

Everywhere Use: It can be used at every time and location, also without internet connection through offline caching, the-reby enabling sensible use even of short periods of time.
Better Understanding: It incorporates multimedia content (images, animation, video) to illustrate appropriate use of didactic methods, going beyond the possibilities of traditional learning material.
Context Sensitivity: MobiDics includes filtering of didactic methods according to course type, audience size, goals, room equipment, seating, learning phase and more, tailored to specific teaching and contextual needs. This enables loca-tion- and context-sensitive functionality, e.g. suggestions of methods according to the room, substitute methods if planned equipment is not available, etc.
Academic Exchange: Users benefit from expert knowledge like usage examples and scenarios of didactic methods and can share their experience in method usage through a comment and rating system (‘peer learning’). Feedback about successful method application in different contexts, as well as the ability to upload and share new methods make MobiDics a growing, vital system.

An additional web-based frontend offers the same functionality, but is designed for conventional desktop use and WIMP-based interaction methods. It supports more traditional learning scenarios, and more comfortable data and feedback entry.

[18]http://www.teacherstoolbox.co.ok
[19]http://www.teachshare.org/wiki/index.php
[20]http://www.classroomobservation.co.uk

Implementation

The content is stored centrally and accessible by MobiDics clients, running on smartphones or tablets, as well as through a AJAX web interface. The mobile client interface is implemented on Android, supporting a resolution-independent experience on a broad basis of devices, using intuitive smartphone interaction (e.g. swipe navigation and pinch zoom). Content can be searched-as-you-type using free text and predefined filter categories to reduce necessary user input. Users can also create favorites of frequently used content. The user interface can be seen in Figure 1.9. User accounts allow managing private content, as well as sharing own content and comments with the community. After users log in with their account, content is synced with the server, and latest additions from other users are downloaded to the user's device.

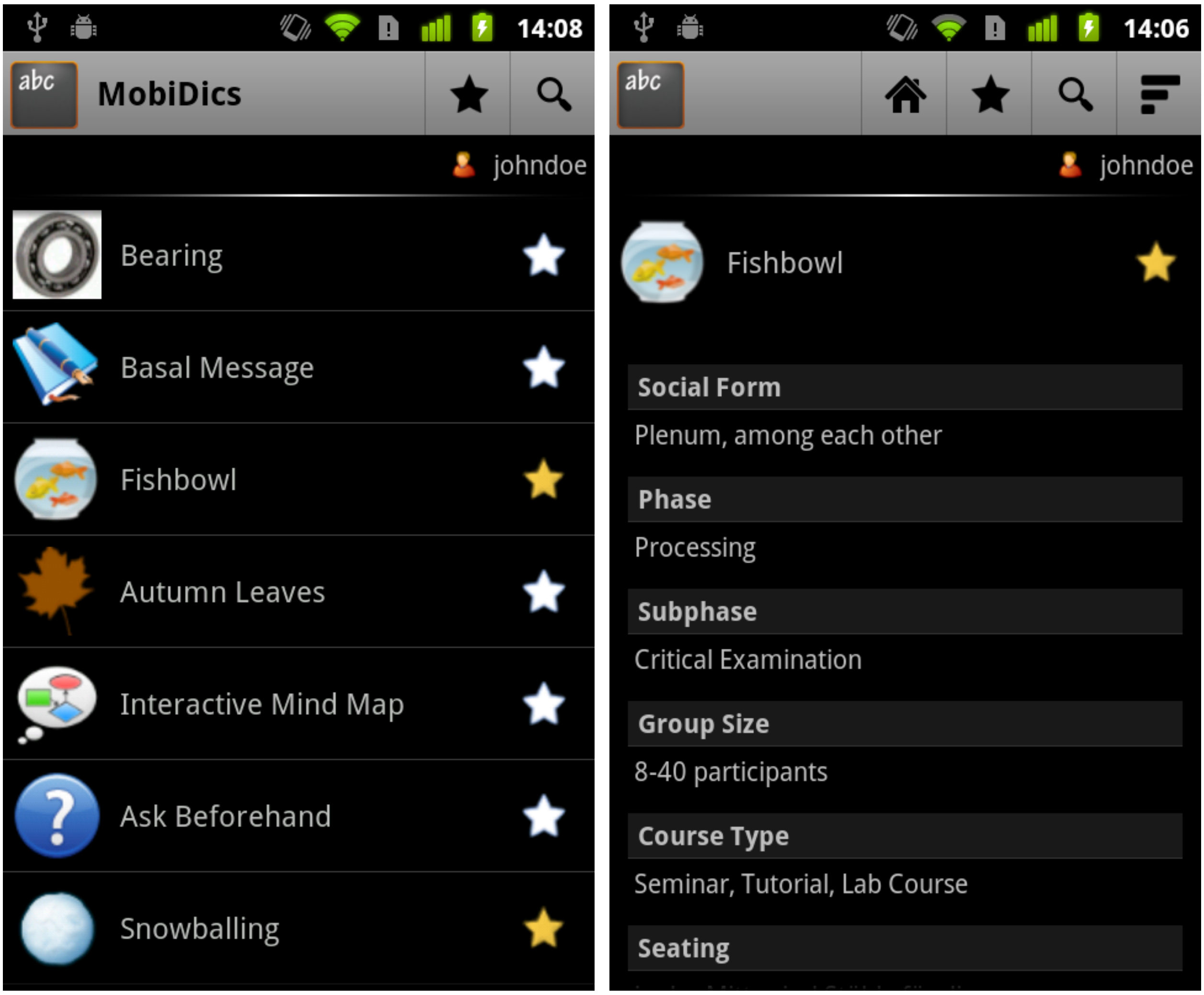

Figure 1.9: Left: The catalog of didactic methods in the main screen of the MobiDics application (here running on a Nexus S smartphone). Frequently used methods can be starred and viewed in a favorite list. Right: Techniques are categorized by application criteria and can accordingly be searched.

1.5.4 Survey on Mobile Didactics

In order to lay the basis for target-oriented development of mobile learning applications, we conducted an online survey. The first goal was the assessment of demand for mobile didactic support among people involved in university teaching – professors, lecturers, PhD students, etc. We evaluated general smartphone usage in the target group to find out whether a mobile application has the potential of being applied. Data on that specific group has so far not been available. Furthermore, we asked for lecture preparation habits, in particular for information sources on didactics and course structure, and whether people are satisfied with their current lecture preparation from a didactic point of view.

We also gathered feedback for the development of the MobiDics system. Subjects were presented a video of an initial prototype and its potential functionality. They were asked whether they would use it and which features they consider most important. We report on this study in detail later in the case study.

Method

The survey was conducted as online questionnaire consisting of seven questions, distributed over five screen pages. The possible response options were to be selected via checkboxes (multiple choice possible). For questions where further options were possible, we added an optional free text field. The MobiDics prototype was demonstrated in an embedded video in the survey website. The users' dwell time on the screen page was recorded, in order to drop out responses of participants who obviously did not take the time to watch the video.

On the last page of the questionnaire, we asked for statistical information (age, gender, university, profession, and department). All data was recorded anonymously. Participation in the study was voluntary.

Participants

In order to address the target group, we invited former participants of didactics courses at the Centre for Higher Education associated with our university. In an email, we exposed our plan of extending didactics support to mobile platforms and asked for their help by answering some questions.

From 135 course participants who clicked the link to the survey, 103 filled out the questionnaire completely and produced valid data records. These subjects were considered for the evaluation (n = 103). 53 participants were female, 50 were male; the average age was 32.9 years (SD = 8.8).

Professions The largest part of subjects were PhD students (43%), followed by postdocs (15%). These groups seem to have a high interest in didactics, as they are involved in teaching but have little experience yet. Assistant professors were represented with 12%, new or junior professors with 3%, and experienced professors with 6%. 15% belonged to other groups, such as lecturers, trainers or faculty administratives.

Departments 28% of participants come from technical departments (electrical and informational engineering, mechanical engineering and similar), 17% from natural sciences (physics, chemistry, medical science bioscience and related), 16% are computer scientists. These high numbers are due to our university being a university of technology. Furthermore, 12% of survey participants are members of social science departments, 8% belong to the educational area and 7% to the department of economics. The remaining 14% were members of various other institutions, faculties, and other universities.

Results and Discussion of the Survey on MobiDics

The survey produced interesting insights. We present the findings on the demand of mobile didactics support, as well as the evaluation results of our first prototype.

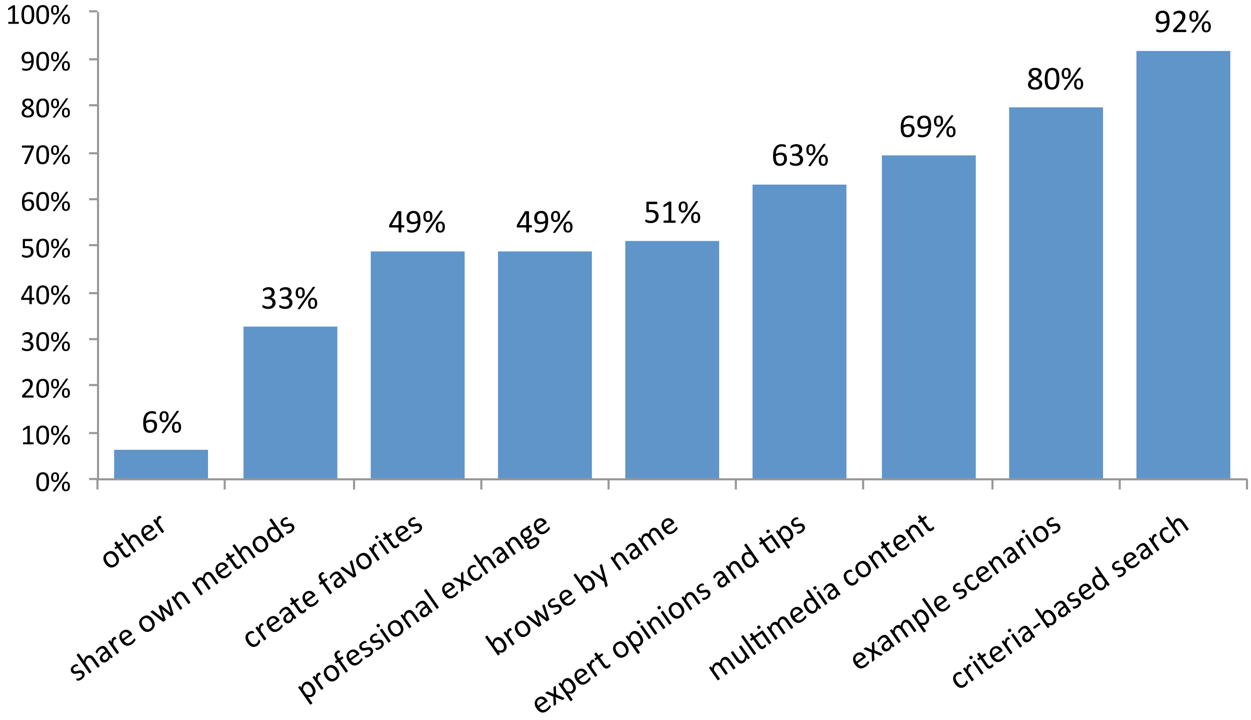

Figure 1.10: Popularity of potential features in a mobile didactics toolbox with professors, lecturers, PhD students and teaching assistants. The target group is particularly interested in functionality that is not available through conventional information sources.

Assessment of Demand 92% of the survey participants are smartphone owners and use it regularly. After email (92%), information search was the second most widely performed activity on the smartphone (79% of smartphone users). These numbers show that the technical basis for mobile didactics (smartphone coverage) is available in the target group. They also indicate that the smartphone usage for information research and consumption, and thereby also potential content on didactics, seems adequate for the target group.

Asked for the satisfaction with their course and lecture organization, 22% were 'very satisfied', 68% 'satisfied' and 10% 'rather not satisfied'. No subject answered to be 'not satisfied at all'. Interestingly, despite these positive results, a considerable number of subjects stated in the free text answer field that their use of didactic methods was low. From the subjects' answers, we were able to identify the following main reasons for their spare didactic method usage:

- They miss substantiated knowledge about which didactic methods *exist*
- Subjects have too little experience in teaching and the appropriate *use* of didactic methods
- The preparation time for courses and lectures is limited, especially for active researchers
- They lack feedback on the success of didactic methods; course preparation becomes a cost-benefit calculation (how much time to elaborate a new concept is it worth, if the benefit is unknown?)

Currently, teachers gather information about didactic methods through the internet, books, colleagues and advanced training courses. MobiDics addresses the problems identified in the survey, as it provides the educational background of didactic methods, suggestions tailored to personal teaching needs, and feedback about successful methods usage from other lecturers, as well as from professionals.

Feedback on Prototype After watching the prototype demo video, 25% of smartphone users stated they would 'very likely' use the presented application, another 25% would use it 'likely'. This is in total 51% who answered in favor of MobiDics. 35% considered the usage rather unlikely, and 14% would definitely not use it.

The most popular features were criteria-based search (92% would use this), followed by examples (80%), multimedia explanations (69%) and expert knowledge (63%). For the full feature list, see Figure 1.10. These are particularly the features that are unique to a mobile didactics solution as MobiDics. Subjects are especially interested in functionality that goes beyond just a digitized version of a printed method catalog.

1.5.5 Summary and Discussion

We presented in this case study MobiDics, a mobile didactics toolbox for professors, lecturers, PhD students, and teaching assistants. In a comprehensive study in this target group, we identified little experience in applying didactic techniques and resulting effects, as well as sparse lecture preparation time as challenges. Our presented system addresses these problems by providing professional didactic information tailored to specific teaching situations. The mobile platform enables flexible use of time, while a desktop interface supports extension by own methods and sharing personal experience. Expert exchange and tips from didactic trainers make MobiDics a valuable resource for course preparation and an instrument for professional further education.

A first survey about a prototype of MobiDics has shown that more than half of the target group would use the system for lecture and course preparation. Subjects particularly liked the possibility to be supported by appropriate didactic methods fitting their specific needs, multimedia examples illustrating method usage, and expert feedback. We believe therefore that MobiDics has the potential to increase satisfaction with teachers, and to improve university teaching.

1.6 Summary and Discussion

We have presented four different case studies from a university context, analyzing selected important aspects of context-based systems in smart environments. First, we have addressed the need for simple and secure interaction with public systems, which could be realized using Single Sign-On (SSO) authentication, which does not require to enter personal credentials at public terminals any more and provides a convenient way to use the personal smartphone as authentication proxy for context-based services. We have investigated the demand for context-based systems and services at the university and found that students and staff wish for comfortable service usage, especially on personal portable devices, going beyond conventional browser-based systems, and are interested in novel services like indoor navigation or mobile payment. Technologies like NFC or visual recognition facilitate new ways of interacting with an (intelligent) environment. With UbiVersity, we have discussed the social implications of context-based services at the example of a location-based social network. Finally, MobiDics, a context-based didactics toolbox has been presented, a system enabling docents to improve on course preparation.

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