HØGSKOLEN I AGDER
Agder University College

ECORN*

Wireless Short Range Communications & Applications for Higher Student Education and Common Work Places

1 Project Summary (2000 characters)

In three to five years the industry will turn to new applications that take advantage of "WiFi" (IEEE 802.11) short range communication links in mobile devices. Around that time we can expect WiFi to be a common feature in most mobile devices just as Bluetooth, cameras, and media-players are today. For the first time, technology will be mature enough to get us closer to a vision of "Ubiquitous Computing" where applications and services are supporting our daily lives in an easy and natural way. Devices will be aware of their immediate, local environment, and will be used in many innovative ways.

We foresee that wireless short range communications will turn our mobile devices into extremely useful tools supporting, e.g., education, industrial applications, entertainment, and our relations to people around us.

In this project we would like to learn how "Ubiquitous Computing" as described above can enhance student education and common work places. To ensure a successful project and meaningful, exploitable results we need to assemble a number of key competences allowing us to study our target area from a user, business, applied technology, and theoretical research point of view. An iterative research process requires access to representative target organizations and end-users.

The project combines the scientific expertise of three faculties at Høgskolen i Agder (HiA): Fakultet for Økonomi og Samfunnsfag, Fakultet for Teknologi, and Fakultet for Realfag. Thus we are able to study user needs and requirements, business aspects and opportunities, wireless applications, underlying service and communication platforms, context awareness, trust and security, as well as deployment and software development aspects.

HiA has an existing wireless infrastructure and testbeds that can be enhanced to fit our project. HiA's employees and students are representative for the target segment that will benefit from the proposed project.

* The acronym "ECORN" is recursive, and stands for "ECORN Communication Research Network".

2 Project Objectives and Sub-Goals (1000 characters)

The project will build up key competence in the thematic area of "Wireless Short Range Communications and Applications" for "Ubiquitous Computing".

The project will study how we can improve the quality of education and work environments, and how they benefit from future mobile devices and new applications. Special emphasis is put on enhancing participation in education within and outside the actual teaching situation.

The project results will address user needs and requirements, business aspects and opportunities, wireless applications, underlying service and communication platforms, context awareness, trust and security, as well as deployment and software development aspects. The process of organizing this will in itself be an invention and taken care of in this project.

The project will support HiA's strategy plan "Mot 2010 - Strategiplan for Høgskolen i Agder" by carrying out research that is (1) at a high scientific level, (2) relevant to society, (3) involving a wide spectrum of different scientific areas, and that (4) gives students knowledge and understanding that they can apply today and to future social and work challenges.

3 Overall Area Definition & Motivation & HiA Strategy

In three to five years the industry will turn to new applications that take advantage of "WiFi" short range communication links in mobile devices. Around that time we can expect WiFi to be a common feature in most mobile devices just as Bluetooth, cameras, and media-players are today. For the first time, technology will be mature enough to get us closer to a vision of "Ubiquitous Computing" [Wei93] where applications and services are supporting our daily lives in an easy and natural way.

Today more and more devices show the potential of using short range links. The Sony Playstation Portable allows kids to play games together, to share game software, to surf on the Internet, and to receive updates and news. Microsoft's Zune media-player links to other players for sharing music. New advanced mobile devices like the iPhone, QTEK 8300, Sony Ericsson P990i offer their owners access to broadband Internet services. Current experience shows that the possibilities of these new devices can be used in a broad range of application. The Nintendo DS, e.g., is used not only for group games but also for learning, e.g., English and Mathematics.

This is the start of a major evolution of mobile devices towards a device that is aware of its immediate, local environment, and that can be used in many innovative ways. Today its primary focus is however on reaching remote users (phone calls, SMS) or remote services (web, email).

We foresee that wireless short range communications will turn our mobile devices into extremely useful tools that, e.g., support education, industrial applications, entertainment, and our relations to people around us.

The EU has put significant resources in the 6th framework to start research on "Ambient Networks" and "Ambient Intelligence" which have similar ambitions. Much of that research has focused on new future networking architectures while activities at the application level are rare.

The project combines the competence of three faculties at Høgskolen i Agder. We bring together expertise in "User & Business Aspects" (Fakultet for Økonomi og Samfunnsfag), "Mobile System Design" (Fakultet for Teknologi), and "Mathematics" (Fakultet for Realfag).

This unique combination allows us to study our target area from an applied technology, theoretical research, user and business point of view.

As a result, the overall work plan is divided into four sub-areas: (1) Wireless Short Range Applications Design and Implementation Aspects, (2) Context Awareness and Reasoning in Ambient Space, (3) User Acceptance and Effective Utilization of Mobile Services, and (4) Innovation and Knowledge Development in a Multidisciplinary Environment.

This split allows us to start from our area of expertise and extend it in the other directions, which would have been difficult or impossible without such a project. Moreover, this division does also allow us to cover all important aspects of the area and to combine many related but currently unconnected research areas.

Finally, the project corresponds closely to the the strategy of HiA ("Mot 2010 - Strategiplan for Høgskolen i Agder") in four central areas: carrying out research (1) at a high scientific level, (2) being relevant to society, (3) involving a wide spectrum of different scientific areas, and (4) giving students knowledge and understanding that they can apply today and to future social and work challenges.

Research on the use of mobile short-range technology and services could focus on several application areas. For this project, we have chosen support for teaching. "Experiences with Interactive Lectures" [Sch05] have shown that mobile devices can contribute to strengthen the learning process in higher education essentially. The increased students' attention and motivation leads to better acquisition of knowledge. Teachers receive additional information about the students learning progress and feedback on improvements of their lectures.

We would like to focus on eLearning in terms of advanced wireless short range communications and services available on the whole campus and not only in the classroom. Once students leave their classroom environment, their mobile devices are rendered useless otherwise, and only the typical messaging and voice telephony applications remain.

HiA has wireless coverage of the whole campus, which allows us to seek for finding new usage areas for "Ubiquitous Applications" in this project. These applications will be targeting not only students, but also visitors, academic and administrative employees.

4 Wireless Short Range Applications Design & Implementation Aspects

We would like to understand how "Ubiquitous Computing" and mobile devices can enhance student education inside and outside the class room. Target users are students in higher education, their teachers, administrative staff, and visitors. Mobile devices can be WiFi enabled PDAs, phones, and TabletPCs. First we will focus on WiFi-enabled phones,e.g., HTC P3300.

This subproject will review existing applications, assess technology trends, and drive an overall application and service strategy for the project. The strategy will integrate results from similar research from other universities. The project will also identify new services within and outside the classroom. The theoretical work is combined with regular user consultations and field trials, thus involving the end-users and stake-holders in the research process.

Studies by the Centre for Excellence in Teaching and Learning (CETL) by London Metropolitan University, in partnership with the Universities of Cambridge and Nottingham have shown that students have a surprisingly positive attitude towards using mobile devices in education. Some of the questions were: How would you view the university contacting you via your mobile for learning purposes? (55% a positive aspect, 23% negative aspect). Is the ability to learn at any time and in any place important to you? (62% extremely important, 15% not at all important). "One essential motivation for the students in their use of mediaBoard was highlighted in the Learning Object, i.e. it would contribute to their future employability: "This is a useful piece of innovative internet technology to learn about, especially if you want to impress prospective employers with your cutting edge technology skills." [Co06]

The studies of University of Mannheim, Germany, have shown that mobile devices can significantly contribute to strengthen the learning process in higher education [Sch05]. Applications in interactive lecturing included quizzing, task distribution, feedback collection, post annotations on lecture slides, and "hand-raising". Even remotely located students could now participate actively in lectures.

In the UK the "Assessment and Learning in Practice Settings (ALPS)" comprises a partnership between the Universities of Bradford, Huddersfield, Leeds, Leeds Metropolitan and the York St John University College (http://www.alps-cetl.ac.uk/). The ALPS competence centre develops a virtual learning environment and authoring tools that allow to create services for mobile devices, e .g., to enhance communications between the assessor, student and personal tutor, to support students on external assignments (Moblog) .

The projects mentioned above are only a small selection of activities which will provide us with an excellent starting point and results that we can apply in our own research.

Because of the size of the project we cannot seek out too complex and equipment intensive applications such as "Augmented Reality" [Abow00] which is an intriguing example of a context-aware application that links a mobile device to its immediate environment, e.g., for field technicians. However, it requires significant remote computing resources and head-mounted displays.

Some of the applications outside the classroom will connect to activities from ongoing projects, e.g., HiA's cooperation with Ericsson in WiFi and remote access to multimedia content.

Typical examples of new applications are (1) wireless beacons that offer users dynamic information on today's events, workshop agendas, phone catalogs, floor plans, (2) meeting services to structure discussions, to distribute and hand-out materials, share whiteboards, voting

on questions, (3) basic reachability applications that find single persons, groups, or everyone within a certain area (emergencies), (4) people to people applications like presence, messaging, and positioning.

Many issues in wireless ad-hoc networks are still unresolved, e.g, trusted in peer-to-peer protocols, service discovery and power management, and location awareness [Want05], naming & addressing, auto-configuration, fast WiFi handover, ... For this project, however, we will focus on application and service related topics and pre-configure a working communication platform within one administrative domain.

We will provide a set of pre-configured devices to avoid the non-trivial set-up problems for differences in devices, operating systems, graphical environments, I/O features, libraries etc… The pre-configured devices will help student research activities on the master's and PhD level for distributed wireless system development.

In many cases we will find, that the underlying service infrastructure has to provide a set of common enablers, e.g., user and service management, trust and security handling. Some of which we will further develop in ECORN, e.g., Security, trust and context awareness (see next section).

5 Context Awareness and Reasoning in Ambient Space

In order for mobile devices to interact efficiently and smoothly with each other and with their environment, it is desirable that they be able to distinguish between benevolent and malicious peers, that they keep track of their changing environment as they enter and exit administrative domains, and that they be able, as far as is practical, to deal with unexpected circumstances in reasonable ways.

5.1 Trust among ambient processes.

Autonomous agents seeking to establish trusted communication in densely networked environments can face a multitude of difficulties, some of which have to do with incomplete information flow due to unreliable communication, barren environments with no trusted peers available, and outright malicious peers. Some efforts to remedy the situation are: the system of graded trust of Demolombe et al, which augments [Lia03] with an extra context-like index; the rôle-based trust model of Khambatti et al [KDR04], and several variants of reputation-based trust management, notably Ooi et al [OL03]. Much remains to be done, however.

Trust can depend on context. While it is clearly desirable to represent and reason about context-dependent trust, it is, unfortunately, not adequate to identify context with a proposition or set of propositions, cfr e.g. [MB98]. For this reason, approaches like that of Liau [Lia03] do not immediately lend themselves to contextual trust. However, Giunchiglia, Nossum, Serafini and others [GG01, NS02, GNW06] have developed systems for representing and reasoning about properties that vary with context, and which can be combined with systems like [Lia03] by dedicated deduction rules which bridge the gap between distinct contexts. Multi-context reasoning about trust by way of bridge rules seems to be a promising avenue towards increased expressivity and applicability of logics of trust.

5.2 Modelling ambient processes.

The Ambient Calculus with its associated Ambient Logic [Card00] enriches the π-calculus with an explicit notion of ambients, and provides a useful basic framework for representing and

reasoning about ambient processes. The language of ambients is quite rich, with a variety of interaction primitives. The relationship between ambient logic and other nonclassical branches of logic remains largely uncharted however, and a thorough investigation of its embeddability in modal logic seems timely. For example, in order to interpret terms denoting ambients, one would have to know which terms denote equal ambients, and a suitable quotient of the set of finite sequences of names would be a plausible candidate for the basis of a Kripke structure.

5.3 Reasoning about and within ambient processes.

Design of ambient processes poses significant new challenges which have to do with the heterogeneous and decentralized nature of the application environment. The mobility of ambients, and the unpredictability of their environment, means that the designer can not rely on a firm knowledge of the run-time conditions facing an ambient process. Traditional software design and development assumes that the interface between the environment and a running process is known at design time, and will remain unchanged for the operational life of the process. In an open system of autonomous mobile interacting peers, this assumption can no longer be made. Better tools for ambient software specification and development are needed. Some progress has been made in developing such tools on the π-calculus basis, e.g. in the EU Profundis project, but much still needs to be done here.

6 User acceptance and effective utilization of mobile services

Technological innovations in mobile information technology (IT) have the potential of creating business value by influencing individual customers and users in work related processes in organizations. However, for these IT enabled benefits to materialize, the new mobile services must be adopted and continuously used by individual customers or organizational users. The primary purpose of our proposed research is to investigate how these assumptions are met in the context of mobile services supporting education and coordination of students. Secondarily, we will investigate how user acceptance and use can be influenced in order to positively influence value creation from these services.

There has been extensive research on mobile services acceptance, focusing on intrinsic and extrinsic service attributes influencing acceptance and use of these services (e.g. enjoyment, expressiveness, and behavioral control) [Ny05, Ped04, Ped05]. In this sub-project, research on mobile services acceptance from various perspectives (domestication, gratification, adoption and diffusion) will be combined with the increasing research focus in information systems (IS) on determinants of user acceptance in contexts with varying degrees of external influence.

Value creation from mobile services can be understood as involving both a voluntary context and a mandated context. The proposed research program creates an interesting opportunity for studying how such processes evolve and influence value creation. If the usage decision is voluntary, value creation from innovations in mobile services assumes sufficient user acceptance both initially and over time. If the usage is mandatory either as a result of managerial directions or of lack of alternatives, the usage or utilization of new services must be appropriate and effective. If these assumptions are not met in these contexts, the services are either not sufficiently accepted or effectively utilized (see e.g. [Bro02]). Decades of research within the IS-field has described many of the intermediate processes between the innovation it self and value creation and empirically demonstrated that technological, individual, social and organizational processes can influence the utilization and value creation in many different ways (see e.g. [Amit01]). New research within the IS field points to the need for a reconceptualization of the usage construct [Bur06], and there is a need for a better understanding of the nature of use and its determinants in contexts with different degrees of external influence. Although recent studies

shed light on user acceptance in mandated environments [Adam03, Bro02, Raw98] and continued user acceptance in voluntary environments [Che05, Hsu04a, Hsu04b, Kim05], little effort has been made to examine continued user acceptance in mandated environments.

Our work aims to contribute to a better understanding of the antecedents to adoption and user acceptance of new mobile services in general and for educational applications in particular, as well as their continued and effective use:

- In mandated contexts defined in our testbeds we will contribute to a better theoretical understanding of user acceptance and appropriate and effective utilization of mobile services
- In voluntary contexts defined in our testbeds we will identify potential barriers to adoption and continued user acceptance
- For both contexts we will identify and test strategies to influence continued and effective use of mobile services in order to reduce potential barriers to value creation.

7 Innovation and knowledge development in a multidisciplinary environment

This project "Wireless Short Range Communications & Applications" involves researchers from different departments and with different disciplinary backgrounds. It aims at developing new understandings and applications of mobile communications and it will cooperate with external milieus, like research departments in industry. It is thus an interesting case of innovation and interdisciplinary knowledge development within and between university and industry.

There are few concrete studies of this type of innovation. *Centre for innovation and worklife* at HiA has for some years been engaged in innovation processes in the ICT industry at Agder among others through participation in the national research program Value Creation 2010 and through financing by Sørlandets kompetansefond, and one of our researchers is completing a PhD on HiA's role in the innovation system at Agder.

From an innovation-theory perspective, this SHP is interesting because there are few in-depth studies on how universities contribute to innovation. This is partly due to the fact that in order for university environments to be innovative, many different challenges have to be met. Examples are: individual based, free research have to be organised in collective processes, open, general knowledge generation (in universities) has to communicate with more closed innovation processes in industry, knowledge generation at universities has to be close to education needs, project leadership and coordination has to happen between departments, knowledge parts and knowledge types that go into the process are different discursively, disciplinary and methodologically, to mention some. We believe that this challenge will lead to innovations in organisation forms within the university college and between university and industry, and we also believe that the project will lead to new relationships and communication forms between researchers from different disciplines, and thereby to new forms of learning.

In this sub-theme we foresee that we follow the process in "Wireless Short Range Communications & Applications" in order to describe and understand how such a integrated, multi disciplinary learning process can be organized and how knowledge transfer and development happens in this process.

8 Academic & Industrial Network, Exploitation, Dissemination

8.1 Project Organization and Time plan

The ECORN project takes an iterative approach and executes five phases during 2007-2011:

8.1.1 Phase 1 - Initial Concept Phase (2007)

Refines common vision, specifies overall concept, test early visualized concepts
Milestones:
M1.1 - Month 1 – Project Kickoff
M1.2 - Month 6 – Early Overall Concepts, visualized, and iterated with users & local industry
M1.3 - Month 6 – Consolidation of State-of-the-Art (report)

8.1.2 Phase 2 - Early Selected Applications Design & Trial (2008)

Sets up trial infrastructure, prototypes and trials selected applications, analysis benefits & user acceptance
M2.1 - Month 15 - Trial of early selected user applications
M2.2 - Month 15 - Base logic and deductive system combining ambience and context
M2.3 - Month 18 - Analysis of user trials, update of project strategy
M2.4 - Month 18 - Workshop 1 with industrial & academic experts

8.1.3 Phase 3 - First Application Cluster Design & Trial (2009)

Creates a first, refined, holistic concept of wireless short range applications for higher education and common work places, executes trials, analysis benefits & user acceptance
M3.1 - Month 27 – Trial of First Application & Trusted Services Cluster
M3.2 - Month 30 – Analysis of first application cluster user trials, update of project strategy
M3.3 - Month 30 – Workshop 2 with industrial & academic experts

8.1.4 Phase 4 - Final Set of Applications & Major Trials (2009)

Prepares a major field trial involving several students classes, teachers, and supporting administrative personnel
M4.1 - Month 36 – Major Trial of Final Set of Applications & Trusted Services
M4.2 – Month 42 – Analysis of final user trials
M4.3 – Month 42 – Workshop 3 with industrial & academic experts

8.1.5 Phase 5 - Conclusion, Dissemination, and Exploitation Preparation Phase.

Documents project results and common conclusions, undertakes result dissemination
M5.1 - Month 48 – Final Project Report & Conclusions

8.2 Industrial & Academic Network

HiA is running several related projects with local and European industry in the area.

The project "ISIS" (2007-2011) with Telenor, Ericsson, TellU, NTNU where "the main objective is to create a service-driven development process with tools and service execution platforms that substantially improve industrial service engineering from requirements to execution on seamless infrastructures." Wireless Local and Remote Access to Shared Multimeda with Ericsson in the "ONE" project (2005-2008). We participate in the EU Future Internet Thinktank "Eiffel" that "was established in July 2006 as a group of individual researchers, upon an initiative of the EC DG Information Society, with the intention to address questions as to the how such an ambitious goal as defining the Future Internet can be achieved within the context of pan-European and global, research"

HiA is using "Fronter" which is "an open learning platform used by more than 2000 learning institutions across Europe (www.fronter.com)." Fronter is a Norwegian company in Oslo to which we therefore have close relationships.

In the NFR project MOVE, HiA collaborated with Telenor and other industrial and economic partners on developing and evaluating mobile services for tourists. HiA was here responsible for evaluating the value creation concerns in the project, related to customers and service providers, and the innovation project organization [Ped07, Ped06]. HiA is also currently involved in other research projects on adoption and use of mobile services that will complement the project outlined in this application, e.g. cooperation with the University of Oslo on the adoption and use of mobile services for alcohol control, and benefits realization in relation to the use of mobile handheld devices in health care in municipalities (in cooperation with the competence centre for e-government).

HiA has a PhD programme in Mathematics Education, and is host to the Nordic Graduate School in Mathematics Education. We anticipate that the present project will interact interestingly with ongoing research relating to the use of computer technology in mathematics education.

Marie Louise Mifsud at HiA conducts a PhD (together with University of Oslo) on the impact of mobile devices (Palm PDAs) in Norwegian schools ("ungdomsskole"). The SHP project will build on the methodology and insights developed in her project. However we target university students, teaching and administrative staff, and will investigate wireless services throughout the campus environment. HiA will here draw upon collaboration with University of Georgia, USA, where Prof. Robert P. Bostrom is conducting research on blended e-learning and new learning environments.

HiA and Aalborg University share several activities in the area, e.g., software development for mobile devices (Prof. F. Fitzek, AAU and Prof. F. Reichert, HiA). Together with University of Bonn (Prof. P. Martini) we cooperate in performance analysis of wireless networks.

HiA has decided to concentrate its activities on two campuses (Grimstad and Kristiansand), and this project will contribute significantly to the scientific cooperation between them. The Faculty of Mathematics and Science (Kristiansand) and the Faculty of Engineering (Grimstad) will merge in 2007, and the project contributes constructively to the merger. The Faculty of Economics and Social Science has an analogous structure, with activities on both campuses. This project joins forces across campus and faculty boundaries. It brings together scientists from basic research, systems development, and applications, from economy, mathematics and technology, and spans the entire life cycle from conceptual sketches to the realization of profits from a product deployed in the marketplace.

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