Challenges and Results of Establishing the Teleservice Laboratory at NTNU

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Abstract

In 2001 the Teleservice laboratory was established within the Avantel project, a co-operation project between Ericsson, Telenor, the Department of Telematics at NTNU, and SINTEF. Avantel aims at establishing a centre of excellence on rapid development of advanced telecom services.

The Teleservice laboratory provides state-of-the-art technology and infrastructures for service development and execution. Users of the lab are able to test the developed services on Telenor's fixed line and cellular networks.

Students form a major resource in the laboratory. They contribute to the development of services and to the assessment of new technologies.

In this paper we present the Teleservice laboratory facilities and activities. We show the relationship between the laboratory and the courses at the Department of Telematics at NTNU. We also discuss issues related to establishing and maintaining a laboratory in a pedagogical setting.

Keywords: Advanced teleservices, software laboratories, service creation environments, service execution environments

1 Introduction

The Teleservice laboratory [1] was established in September 2001 within the Avantel project [2], a co-operation between Ericsson, Telenor, SINTEF and the Department of Telematics at NTNU. The project is partially funded by the Norwegian Research Council [3].

The vision of the lab is to provide a setting in which students and researchers can experiment with the development of *advanced, hybrid* telecommunication services. By *advanced* we mean telecom services and features that combine traditional telecom services, multimedia, messaging, context awareness and information services. By *hybrid* we mean that telecom services can be offered over a combination of heterogeneous networks such as PSTN, GSM, and IP networks, and with different access types such as fixed line and wireless, the latter including Bluetooth or WLAN, and may involve several service providers.

The lab provides access to a wide range of facilities, and combines platforms from traditional telecommunications and information technology. Research in the lab is driven by the need for shorter time-to-market and controlled quality. Development methodologies are thus emphasised.

The lab is co-located at NTNU and Telenor R&D in Trondheim and connected by high capacity links to Ericsson NorARC in Asker. Additional links to other partner labs are possible, such as the one established to Agder University College in Grimstad, thereby creating a virtual centre of excellence.

The lab setting enables long-lived problems and research areas to be addressed, such as service development methodologies, feature interaction problems and dynamic service composition. It also provides the technological opportunities made available by the latest and greatest advances in mobile devices and software platforms (e.g. PDA, Smart phones, WLAN, Parlay, SIP, mobile media streaming). The lab is attractive to students keen on new technology, and interesting for research scientists, since the problems treated are substantial and long-lived. Hence it is used both long-term research and state-of-the-art experimentation.

2 The laboratory facilities

The Teleservice laboratory at NTNU facilities encompass dedicated physical equipment, software platforms and network interfaces, see Figure 1.

The physical equipment consists of:

- PCs for SW development, simulation, etc.,
- PDAs with add-ons for WLAN, GPS, GSM/GPRS, and Bluetooth,
- Mobile phones with camera, Java capabilities, GSM/GPRS and Bluetooth,
- A wireless local area network (WLAN),
- A wireless Bluetooth network.

A Trustix firewall server [4] controls the access to the service execution and network resources at Telenor. These include Parlay/OSA gateways to support call control, messaging and location services. The network interfaces provide access to Telenor's PSTN and GSM networks, and also other network resources such as location servers, streaming video servers (MPEG4) and map databases. Through the Parlay interface, calls to PSTN or GSM phones can be set up, SMS and MMS messages can be sent and received, and user's statuses can be obtained. The lab also has access to the Bravida Geomatikk map server [15].

The software platforms include standard components from the information technology and traditional telecommunication domains:

- Development and execution platforms such as Telelogic Tau Generation 2 for UML modelling [5], the Java development environment and CORBA middleware (Orbacus [6]).
- Client-server service platforms for the development of servlets (Apache Tomcat [7]) and web services (Apache AXIS [8], JBOSS [9]).

More specific telecom platforms are also included:

- Incomit OSA Gateway [10], a gateway for exposing network capabilities to developers according to the OSA/Parlay standard [11]
- JavaFrame [12] and ActorFrame [13], which are two frameworks supplied by Ericsson NorARC, supporting the modelling concepts from SDL and UML 2.0.

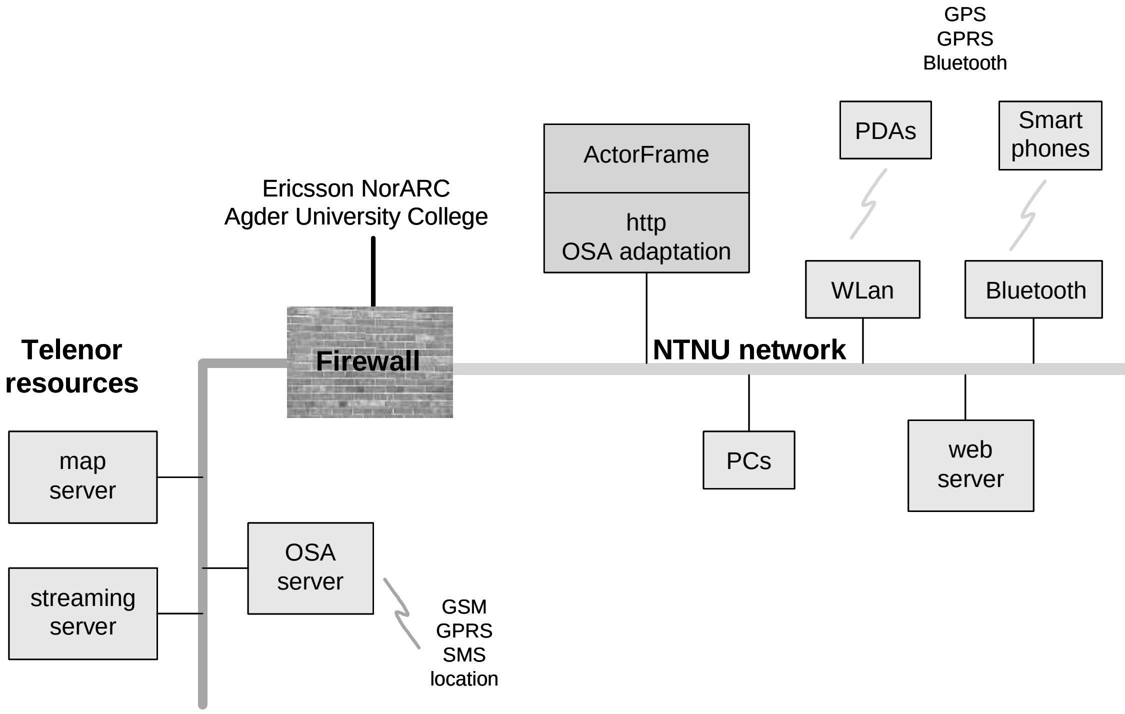

Figure 1: Some elements of the lab at NTNU

JavaFrame and ActorFrame are central execution frameworks in the lab. They combine mechanisms that are needed to support telecom services, such as state machines and asynchronous communication, with mechanisms commonly used in information systems such as synchronous communication and object oriented programming. The frameworks also enforce a set of software structuring principles and methodological rules. In that way the lab does not only address systems and technologies, but also methodologies.

A flexible code generator from UML 2.0 to ActorFrame [14] has been specified and implemented. This will help reach one goal of the lab, which is to let the students perform model driven development, making models and system architectures supported by automatic code generation, rather than only producing code.

3 The laboratory users

The Teleservice laboratory is used by researchers, Ph.D. students and master students. The lab represents a resource centre for the final years of study at the Department of Telematics at NTNU, where it is currently employed in the following courses:

- TTM4130 Teleservice ("*Nettintelligens og Mobilitet*"). The course provides an introduction to various service architectures and frameworks. A practical project using the lab is assigned as part of the course.
- TDT4735 System Development, Advanced Course ("*Systemutvikling fordypning*"). This course covers the topics of requirement analysis, specification, design and implementation of services and functional components in communication systems. Teaching is enforced through individual project assignments in the lab.
- TTM3 Self Configuring Systems Lab ("*Selvkonfigurerende systemer lab*"). This course deals with techniques for the rapid construction of distributed adaptable and context-aware systems. Teaching encompasses lab exercises and colloquia.

TTM4130 is offered in the spring of the 4th academic year, while TDT4735 and TTM3 are offered in the autumn of the 5th academic year. The lab is also available to M.Sc. students working on their thesis in the spring of the 5th academic year.

The students are able to test their services in real networks, which is more motivating than simulations or theoretical studies. While the lab provides modern tools and an exciting experimentation environment to the students, the students also contribute to the laboratory by development software components and assessing new technology.

In the near future, access to the lab will also be offered to companies and third party service providers in the context of the ARTS project [19]. In that way, we aim to provide 3rd parties an environment where they can validate their ideas and development projects.

4 The laboratory activities

Two approaches have been adopted with respect to organising the activities:

- Grouping a number of activities aimed at becoming part of a complex service. To this end, the *AMIGOS* (*Advanced Multimedia In Group Organised Services*) service has been specified and is in the process of being realised [16]. AMIGOS is a complex generic service where the users can create so-called *Meeting Places* with customised access management and miscellaneous functionality (e.g. chat, voice conferencing, and media object sharing). AMIGOS enables us to experiment with dynamic service composition. It is implemented using ActorFrame, and serves as proof of concept for the framework. Student assignments have proposed solutions for AMIGOS components such as PDA interface, customised service portal, location server, buddy list management with location, and synthetic voice chat.
- Stand-alone service experiments. For instance a set of simple services has been implemented with the aim of gaining experience on competing technologies:
  - *Intelligent Traffic System* supports communication between travellers within a geographical area, and demonstrated some of the features of J2ME MIDP and JXTA for J2ME.
  - *Geo MMS* supports finding a point of interest in the vicinity. It is based on WAP and MMS, and demonstrated a map engine and route calculator [15].

  Other examples are presented in the Hall of Fame [17].

The first approach is motivated by the goal of establishing a platform for studying long-lived research problems, and also to use the lab in a pedagogical setting to let students apply methods taught in university courses.

The second approach is favoured to test trial services at low cost, to assess them and the technology supporting them, before developing and deploying them more widely.

5 Alternatives to a laboratory

Before we discuss the pros and cons of investing in a laboratory, let us briefly list what alternatives that exist.

- University or research staff can propose and mentor academic exercises that do not rely on any shared platform. The assignments can build cases for research hypothesis, and/or they can seek to exemplify or verify issues taught in courses.

- Industry R&D staff can propose and mentor development projects combined with technology assessments.
- Students can suggest their own assignments and seek researchers and/or companies that can mentor them.

A common denominator of these approaches is that they do not easily become part of anything greater than themselves, as they typically do not rely on or build on other assignments or results other than those presented by available technology and by the parties involved. A laboratory contains shared resources, which individual work in general does not, apart from software resources available to anyone. In a telecom setting, these approached typically do not have access to expensive equipment, special software, or network access, unless provided by an industry partner.

6 Lessons learned

Although several experiments have been successfully conducted in the Teleservice Laboratory, and new service examples are continuously added [17], the establishment and maintenance of the laboratory poses several challenges.

Several classes of actors are involved in the laboratory: industry, researchers, teachers and students. Each has different goals and expectations from the laboratory, and each expectation should be understood and managed in order to achieve a productive co-operation. Conflicts can arise as each actor gives priority to its own goals, leading to diverging and sometimes conflicting activities, and unsatisfactory results.

Experimentation and research goals are important in all laboratories, but not the only goals. For example, from the student viewpoint, a laboratory should offer an environment where they can acquire skills that will be of interest for the industry.

In the following we present an evaluation of the results with respect to different actor viewpoints and goals. To do this, we have fetched inspiration from field studies from a slightly different setting [18]. Although [18] is dedicated to issues concerned with using students in *empirical studies*, we find it a good starting point to analyse the challenges in making the co-operation in the laboratory fruitful.

The authors of [18] identify the benefits and costs from the viewpoints of the involved actors. Some of these benefits and costs are also relevant a laboratory environment. In the following tables, we have presented what we view as relevant benefits and costs. We present an evaluation of the results achieved in the laboratory with respect to these benefits, along with an assessment of the costs.

We believe that the analysis as shown in these tables is a useful approach to analysing and discussing any problems encountered. In the context of the Teleservice Lab, we are aware that more work remains to accommodate the divergent goals of the actors, and to improve our ability to achieve results. Some of this is indicated in the tables.

In our presentation we mention the role of the research scientist. Note that we include both personnel from university, research institute and industry in this role, since a person often has several roles and subsequent motivations.

6.1 Benefit analysis

The analysis of benefits of the lab is presented below, first presenting common goals, then for each role (industry, researcher, teacher and students).

Potential benefit	Achieved results	Issues
Early experiences with heterogeneous platforms and services	Common service platform with open interfaces and access to a heterogeneous set of access and core networks established	The diversity makes for a complexity that requires the production of lab-specific documentation
Increased pace of innovation through service experiments	A portfolio of differentiated services (“Hall of fame”)	Some services are implemented on technology that since has be replaced
Mutual understanding of problems and solutions	A methodology for rapid service creation sketched.	The methodology has to be refined and validated in doctoral thesis.

Table 1: Benefits for all stakeholders

Potential benefit	Achieved results	Issues
Competitive advantages	Rapid development and modular deployment / withdrawal of reliable heterogeneous services	Hard to prove, but informal comparisons indicate success.
Gain experience with new technology, methods and tools.	Telenor has gained much experience by mentoring student work.	The results could be better documented for later use.
Improved recruiting base through better education.	Achieved: the students get known with the techniques and problems of interest in the industry.	The industry influence the contents of the study. The just balance between basic knowledge in the studies and industry priorities is needed.

Table 2: Benefits for industry

Potential benefit	Achieved results	Issues
Better standards	Contributions to OSA and Parlay standards.	
Develop prototypes as proofs of concept.	Several prototypes have been developed.	Research goals and their assessment could be more precisely defined.

Table 3: Benefits for researchers

Potential benefit	Achieved results	Issues
Demonstration of Development Methods	The services are often built from composing existing components.	Students tend to skip modelling. Code generator should improve this.
Demonstration of System Engineering	The project assignments and the courses are well integrated.	More focus on software architecture could be incorporated in courses.
Adopt new ways of teaching.	Lab provides a good basis for problem based learning.	Problem definition process could be improved.
Motivated students.	The students are generally enthusiastic, creative, and show initiative.	Systematic feedback from students could be implemented.
Critical attitude among students.	Some technologies are judged as uninteresting or unpopular by students.	Criteria could be defined in order to identify the exact reasons.

Table 4: Benefits for teachers

Potential benefit	Achieved results	Issues
Work on realistic cases.	Achieved.	
Work on state-of-the-art topics.	Achieved. For instance, mobility and context-awareness are important issues in the lab.	"Latest and greatest" is constantly changing.
Learn to work in teams.	Grading poses a challenge: each student is required to document individual achievements.	More effort could be invested to co-ordinate team work.
Learn how to research.	Students get some insight in research.	Research methodology is out of scope of the lab.

Table 5: Benefits for students

6.2 Cost analysis

The additional costs of adopting a lab setting instead of individual work are analysed. They are presented as common issues and for the various roles in the tables below.

Added cost due to lab	Achieved results	Issues
Establishment of the lab	External funding has been obtained from NFR for equipment and for compiling documentation.	It is easy to underestimate the resources needed for a lab to function well over time.
Maintenance of the lab	Some students have been assigned assistant work. Using motivated students can be very cost efficient	Student assistants can lead to unstable support conditions and lack of continuity. ARTS [19] will address this.

Table 6: Costs for all stakeholders

Added cost due to lab	Achieved results	Issues
Extra effort required for mentoring.	Satisfactory with respect to results achieved.	
Extra effort for providing network access and software packages	Costs and effort lower than the benefits achieved.	Co-operation in the project is firmly established in management.

Table 7: Costs for industry

Added cost due to lab	Achieved results	Issues
Effort to document lab platform, including provided technology and recommended combinations.	Substantial "added cost" has been necessary in order to document the laboratory and provide an overview of components.	More work may still be needed. But is may never be possible to win the "info war", since the problem area is large and complex.

Table 8: Costs for researchers

Added cost due to lab	Achieved results	Issues
Cost of co-operation with many partners	Costs have been moderate.	Results could possibly have been better with additional co-ordination.

Table 9: Costs for teachers

Added cost due to lab	Achieved results	Issues
Cost of choosing a “loosing horse”, i.e. a technology that is discontinued or does not prove adequate to solve the problem.	No complete “failures” have been reported, although porting between platforms has been necessary.	The duration of the project assignments limits the risk. Also, students can correct their course when starting M.Sc. thesis.
Complexity of the platforms leading to extra time when solving problems.	The available platforms are complex and of varying quality. Documentation now includes guidelines for the developer explaining how to install and use the platforms.	Some students have spent considerable time understanding the platforms instead of solving their assignments. Developing small example cases may be of additional help.

Table 10: Costs for students

7 Conclusion

The Teleservice laboratory provides a rich set of facilities for the development of advanced telecommunication services. During the first two years of operation, the lab has produced interesting examples of new services, and has shown the potential for work carried out in such in environment. Substantial results have been achieved from the student assignments, and which would not have been achieved without the lab setting.

The operation of a comprehensive lab in a pedagogical setting poses several challenges. One is to strike a balance between industry goals, research goals and educational goals. We have also learned that substantial effort is required to achieve an efficient learning environment for the students, and to incorporate achieved progress in future work.

The overall judgement is that the benefits of the laboratory are well worth the effort. Therefore the laboratory will be continued, and measures are now being taken to improve the learning environment according to lessons learned.

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