NTNU

Norwegian University of
Science and Technology

Student Centric Mobile Services

Design, Implementation and Evaluation

Muhammad Asif

Master in Information Systems

Submission date: June 2010

Supervisor: John Krogstie, IDI

Norwegian University of Science and Technology
Department of Computer and Information Science

Problem Description

Various student information sources are available at NTNU such as Innsida, It s Learning, Time Planner, student web, webmail and others. All these sources are playing important role in student s educational career. For every student it is important to have up to date information about current exercise assignments, lectures, upcoming appointments and other daily activities. In addition to these, different ways of communication and use of social networking tools can enhance the experience of students.

There is a great need to integrate all these sources in order to make existing information systems more valuable and productive for the students. By providing ubiquitous access to the information services on mobile devices will improve the utility of these sources. It will also help to reduce the time and effort required to access the student centric information.

Assignment given: 15. January 2010
Supervisor: John Krogstie, IDI

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Abstract

This project is a continuation of research work done by (Asif, 2009) which proposed an extended architecture of Mobile Student Information System (MSIS) to integrate the systems available for the students to provide student centric services on mobile devices. The architecture was developed by using Service Oriented Architecture (SOA) to provide services for collaboration and communication among the students or between students and the teachers. The mobile services are built by integrating MSIS to Twitter, Feed based systems and NTNU email system. The services have the potential to provide students an experience of a virtual environment of class, project work and discussion groups anytime-anywhere. The project has been carried out in accordance with design-science research model over a number of implementation and evaluation iterations.

A user-driven evaluation of the MSIS service has been conducted among a diverse group of NTNU students. The utility as well as the usability of the system were evaluated by applying observational and empirical evaluation methods in a real-world environment at the university. The usability test identified few issues with the initial design of services, and received feedback for enhancements. The Mobile Service Acceptance Model (MSAM) has been used to examine the factors that are influential for user adoption of mobile services in the light of this project. The MSAM instrument measures different facets of a mobile information service, such as the perceived usefulness, ease of use, and usage intention. Our findings confirm that the utility of the student centric mobile services are perceived as high, and students would likely benefit from such kind of services. There is no doubt about the great potential for a service like MSIS and it is believed to be a useful addition to the existing systems.

Preface

This report is a documentation of the project work performed as part of the Master's thesis in Information Systems spring 2010 by Muhammad Asif. The project work is carried out in the last semester of two years International Master Program in Information Systems at The Norwegian University of Science and Technology (NTNU). The scope of the project amounts to 30 units.

The project work has been defined in consultation with my supervisor, Professor John Krogstie at the department of Computer and Information Science (IDI). The project describes student centric mobile services based on integration architecture for Mobile Student Information System. The main focus of these mobile services was to enhance the collaboration and communication experience of students during the study at NTNU. In spite of much hard work, and a few intermediate challenges, it has been an extremely instructive and rewarding process, both academically and personally for me.

I would like to express my deepest gratitude to my supervisor, Professor John Krogstie, for invaluable feedback and guidance for the thesis work. I would also like to thank my family who encouraged and supported me throughout my life.

Trondheim, June 15, 2010

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Muhammad Asif

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Chapter 1: Introduction

This chapter gives an introduction of the overall project in the form of motivations, problem definition and the scope of the project. An outline of the overall report has also been presented.

1.1 Motivations

Mobile information system is extending the learning space and time for different communities particularly among the students. Mobile computing is changing the way of communication between teachers and students. Mobile computing is also used effectively to improve instructional quality and integrate information technologies into instruction to enhance teaching efficiency and effectiveness.

Various student information sources are available at NTNU such as Innsida, It's Learning, Time Planner, student web, webmail and others. All these sources are playing important role in student's educational career. For every student it is important to have up to date information about current exercise assignments, lectures, upcoming appointments and other daily activities. In addition to these, different ways of communication and use of social networking tools can enhance the experience of students.

There is a great need to integrate all these sources in order to make existing information systems more valuable and productive for the students. By providing ubiquitous access to the information services on mobile devices will improve the utility of these sources. It will also help to reduce the time and effort required to access the student centric information.

A preliminary study has been conducted in last autumn (Asif, 2009) which presented an overview for the possibilities of the integration of different sources of information. This study proposed integration architecture. There is a need of practical implementation of this architecture to provide some proof of concept. A new version of Mobile Student Information System (MSIS) with integration information services is required to be implemented.

1.2 Project Scope

In the last autumn project, an extensive pre study was conducted to explore the need of integration of MSIS to existing student information sources. It proposes integration architecture with some solution guidelines. The previous work gives an overview of the supporting integration technologies currently available. The work described in this project is based on the foundation of the earlier studies (Moe, Design and Evaluation of a User-Centric Information System, 2009) conducted in the context of MSIS.

The work in this project consists of two major tasks: 1) The development of integration architecture proposed in last autumn project and, 2) The evaluation of the prototype in accordance with a set of usability metrics, and finally applies the findings from the evaluation in order to improve the system.

We shall implement different information services which will extract relevant student information from various sources. We shall integrate some systems such as Web mail; It's Learning, a social networking tool Twitter and feeds based notifications and services. Other additional systems are included in future work.

1.3 Project description and context

The purpose of this project is to examine whether the assumptions made regarding the viability of proposed integration architecture for Mobile Student Information System are correct, by developing and testing the application. Some information services will be developed to extract the relevant information for the students depending on the real world scenarios and the student needs. An evaluation will be established whether or not our system is capable of fulfilling its intended purpose. The Mobile Services Acceptance Model (Gao et al, 2008) will be used to measure metrics such as perceived usefulness, perceived ease of use, and intention to use.

The results of earlier studies related to MSIS in order to implement the services will also be used. The possible challenges to integration and the related technologies proposed in last autumn project will also be considered.

1.4 Problem definition

The goal of this project is to design and develop mobile information systems by integrating it with existing information sources. It requires exploring how the integration with existing applications is possible and how it will enhance the experience with new user centric information services. How the services in integration architecture can be implemented with available technologies will be explored. The main idea is to provide a suitable integration architecture which can provide information services to the users depending on the user's interest and preferences.

1.5 Report Outline

Below is given a brief outline of the different chapters of the report.

Chapter 2 Background presents an overview of the technologies chosen for integration process and for the implementation of this project. It also presents the background of the project and the related studies.

Chapter 3 Research approach states the research questions that we seek to answer, and describes the research methods used in this study.

Chapter 4 Analysis, design and development presents the architecture of the systems such as Innsida, Time Planner, It's Learning, RSS or ATOM feeds and the possible ways to integrate them with MSIS. It describes the technical details of the implementation; how the various services operate and an overview of the technologies used for the system.

Chapter 5 Evaluation describes the usability test and user acceptance survey conducted as a part of evaluation of the system. The findings from the evaluation are presented, together with suggestions for improvements of the services.

Chapter 6 Results and Discussions describes the results of this project and discuss the results in the context of research questions. It gives an overview of the overall services

built and results gained from the evaluation of these services. It also contains description of the system implemented in MSIS, how they have been realized and to which extent the integration enhances the experience of students with MSIS.

Chapter 7 Conclusions and further work marks the end of the report by giving some concluding thoughts about the outcome of the project and the achievements made. It also discusses whether the work with this project has provided sufficient results in order to answer the research questions.

Chapter 2: Background

This chapter describes the theoretical foundation of the project. It provides insights of the state of arts technologies, theories, models and other related studies. It describes the suitable technologies available for the integration of heterogeneous systems with Mobile Student Information System.

2.1 Mobile Information System

Current information and communication technology (ICT) provides a variety of ways to access information systems and to use services made available on the Internet. On one hand, traditional personal computers are only one of the many ways to access information resources and services, since a variety of different interaction devices are available; on the other hand, traditional computing technology is becoming more and more mobile and ubiquitous.

It is common prediction that the way people use information resources will be radically transformed owing to the advent of new mobile infrastructures with the help of higher bandwidth and constant connection to the network from virtually anywhere. This will open the door to the provisioning of context-aware services. Anywhere, anytime, anyhow value-added services ("*3a*" services) can be defined: access to the system is possible from any location ("*anywhere*"), at any moment ("*anytime*"), and with personalized interaction in a multichannel modality ("*anyhow*") (Pernici, 2006).

"Mobile information systems can be defined as information systems in which access to information resources and services is gained through end-user terminals that are easily movable in space, operable no matter what the location, and, typically, provided with wireless connection" (Pernici, 2006).

2.2 The characteristics of mobile communication

The convergence of internet and wireless network has increased the potential of mobile communication. The potential applications for 'the Internet in your pocket' are many and varied, including shopping, banking, news feeds, email and Web surfing (Kim, Park, & Morrison, 2008).

Siau *et al.* (2001) identified four unique characteristics of mobile communication:

- *Ubiquity*: Through mobile devices, access to information is anywhere at any time. On the other hand, users can also get any information in which they are interested in, whenever they want the information regardless of where they are, through Internet-enabled mobile devices. In this sense, mobile computing makes a service or an application available wherever and whenever such a need arises.
- *Personalization*: An enormous quantity of information, services and applications are currently available on the Internet, and the relevance of the information users receive is of great importance. Since owners of mobile devices often require different sets of applications and services, mobile applications can customize information or services in ways appropriate to a specific user.
- *Flexibility*: Because mobile devices are inherently portable, users may be engaged in other activities, such as meeting people or travelling, while conducting transactions or receiving information through their Internet-enabled mobile devices.
- *Dissemination:* Some wireless infrastructures support simultaneous delivery of data to all mobile users within a specific geographical region. This functionality offers an efficient means to disseminate information to a large consumer population.

2.3 Campus Information System

Campus Information System for students is defined as "An interrelated group of information resources, accessible by computer through the campus institutional external and internal web environment, that a university places at the disposal of its users to enable them to consult it and/or provide a selection of significant and relevant data, in the wide

context of their university life in its academic, administrative and social senses, in order to improve student's knowledge base" (Josep Cobarsí, 2008).

Information resource is defined as: an element of infrastructure which enables the transaction of certain selected significant and relevant data, prepared in such a way that they provide content and information services to improve the user's knowledge base. It is necessary to establish some minimum socio-technical requirements for an element to be qualified as a resource. Examples of resources for students are course information prior to registration, course reading lists, and directories.

2.4 Mobile Services

In mobile information systems, a *service* is a set of functionalities to which at least one class of users assign some value. An *e-service* is a service that is supported by a mobile-information-system infrastructure. (Pernici, 2006)

Mobile services allow users to consume the services anytime, anyplace. There is a wide variety of mobile services exists in various domains such as business, tourism, banking, education and many more. Various types of services enabled by mobile technologies are discussed in (M. De Reuver, H. Bouwman, T. De Koning, 2008) are as follows:

- *Information Services*: Typical information services include search services, news and weather, transportation time tables and yellow pages. These services can be delivered through text messaging, emails, or some other ways. Location data also improves the quality of these information services.
- *Entertainment Services*: These include chatting, downloading music, sharing jokes, and horoscope. Now there is a growing trend of user generated contents which makes the users active contributors and content generators.
- *Transaction Services*: These types of services include shopping, purchasing tickets for movie shows and mobile banking.
- *Business Services*: Business services include mobile sales-force automation, mobile supply chain management, mobile access to email and emergency support services.

2.5 Mobile Web Services

Web services are becoming popular in the IT world. A further step has already been taken in applying the web services technology to mobile devices. This approach is known as Mobile Web Service (MWS) (M. De Reuver, 2008). There are many benefits associated with MWS as compared to the current way of using the web services. Because MWS uses open standards, it is easy to develop and reuse web services.

MWS is also expected to benefit end-users, as the ease of developing services will probably lead to a greater variety and number of services, a higher level of personalization, better and simpler user interfaces, and the provisioning of services over the most appropriate access technology (M. De Reuver, 2008). MWS can help to create generic service components such as geographical maps, authentication and billing services. Instead of having to develop these components for various service offerings, service providers can reuse and integrate them into their specific service offerings. Generic authentication and payment services are in fact the main services advocated in the MWS architecture proposed by Microsoft and Vodafone (*Microsoft*, 2003). In addition to requesting (generic) services from the outside world, MWS can also be used to enable external parties to request information from the mobile device. Although the benefits of MWS are clear in terms of flexibility, interoperability and reusability, there are also several challenges mentioned in the literature when it comes to applying web services in a mobile context.
Personalizing the MWS raises the issues of involving identity management and privacy that are more serious and in the mobile setting than they are in fixed web services. Another issue involved here is that the user interface with small screen and keyboard makes it more difficult to fill in forms, which has an impact on the usability of MWS (M. De Reuver, 2008).
Issues regarding bandwidth and processing power are especially challenging for MWS, as web services use XML and SOAP protocols to code the messages. Processing XML messages on mobile devices requires higher levels of processing power compared to HTML messages.

Although standardized MWS architectures have not yet been defined, industry parties like Microsoft and Vodafone (*Microsoft*, 2003) are working together in developing a MWS architecture, as well as Nokia and Sun (*Nokia & Sun*, 2004). The open Internet standardization body OMA (Open Mobile Alliance) is also working on a standardized MWS architecture. An important trade-off in these efforts involves the choice between using open protocols to implement MWS and using proprietary standards (M. De Reuver, 2008).

2.5.1 XML and Web Services

SOA is more like a design approach and a concept than a technology. To that extent, SOA could be implemented using any programming environment from a simple 3GL such as C or Java to established platforms such as JAVA EE and .NET, or the more contemporary Web Services.

A simple XML document describes the service/business function. The request is composed as an XML document (per the SOAP specification), and sent over HTTP to a web address. There is a SOAP processor on the other end that un-marshals the request in the XML document and executes the required service running on the other end. So the service developer needs to consider about the WS facade and the required access through whatever the APIs/mechanism available to access the system, just once. Once the service is available as a web service, then any application/solution which needs access to this application can access it as a simple web service.

A typical environment in which Web Service operate for systems running in heterogeneous environments is shown in fig 2.1

2.5.2 Service Execution and Communications

SOA at its core involves the services runtime, invocation, communications framework, services consumption and orchestration engines. Most of these have a strong technology and standards basis. For the integration architecture we select some SOA infrastructure elements which are most suitable for the architecture proposed are as follows:

- Service container—for executing the services
- Service implementation framework
- Adapters—to connect to legacy back-end applications
- Service discovery—registries
- Orchestration of Services (process engines)
- XML Handling
- Communication bus
- Web Service call outs—to enable accessing external services via HTTP as Web Services
- Security

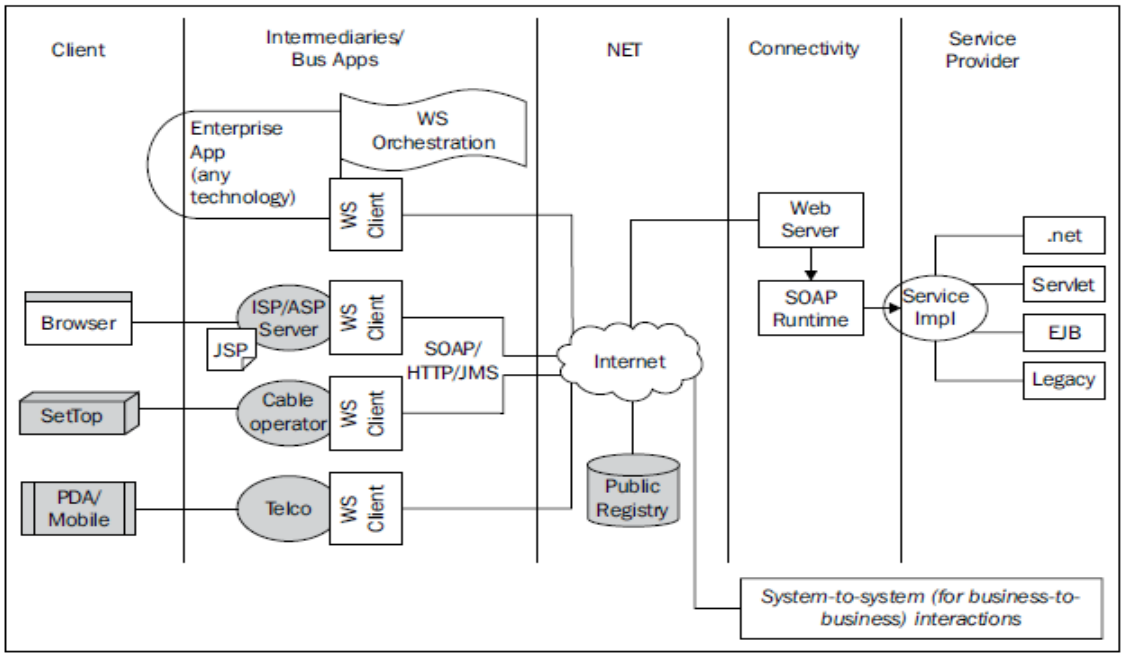


Fig 2.1 Heterogeneous environment (Juric et al, 2007)

2.6 Previous studies

This section describes the earlier studies and the development of the MSIS application. It also describes the proof of usability and survey results performed earlier. It contains some

basic information about the requirement specification of mobile student information system.

2.6.1 Mobile Student Information System

This study reviews the digital communication channels currently in use for the distribution of information at NTNU and proposes a service based on mobile computing and context-aware application concepts in order to provide more user-centric information services on mobile devices. Feedback gathered from the students through a survey has been guiding the directions and design of the final solution. The project work was carried out in accordance with the design-science research model (Moe, Design and Evaluation of a User-Centric Information System, 2009).

A fully functional prototype, named "MSIS", has been developed and successfully tested at the NTNU campus. The services offered by MSIS include a search tool for rooms and buildings around the campus, with integrated map and geographical positioning, a dynamic schedule service providing up-to-date information of weekly lectures and a news and announcements service.

Main findings

The project work of MSIS has two main contributions: (1) a survey conducted among NTNU students outlining flaws and shortcomings of the current information systems, and (2) a software system designed to assist students in their daily lives by utilizing context-awareness and location based services. A preliminary study has also been conducted, which reviews state-of-the-art technology within the field of mobile computing, geographical positioning services, and a survey of existing solutions. (Moe, Mobile Student Information System, 2008)

Architecture

The MSIS system's purposed architecture was based on a multi-tier architecture consisting of three disjunctive layers:

1. *Presentation Layer*: This layer provides the user interface that allows the user to interact with the application.

2. *Business Layer/Data Access Layer*: This layer includes the business logic and functions for storing and retrieving data from the database, and works as a mediator between the Presentation Layer and the Data Layer.
3. *Data Storage Layer*: This layer consists of the storage device/service, in this case a Microsoft SQL Server relational database management system (RDBMS) [6].

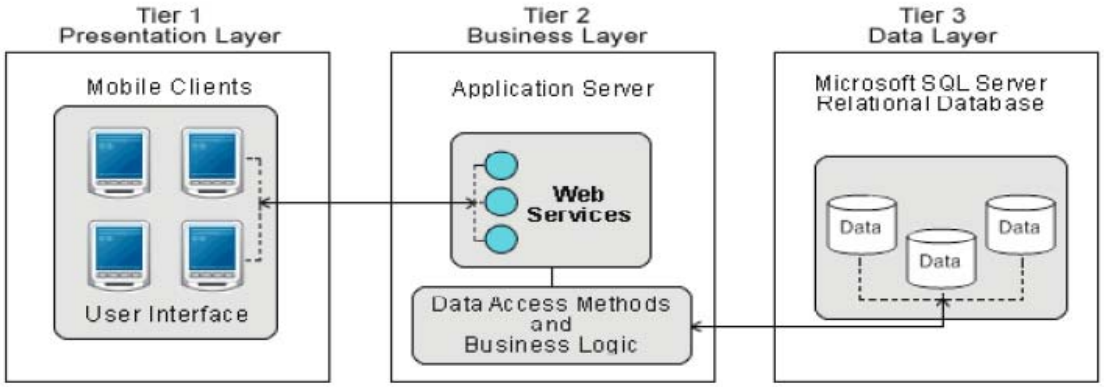


Fig 2.2 MSIS Architecture (Moe, 2009)

Figure 2.2 shows a graphical representation of the three-tier architecture of the MSIS system. All communication between the client application and the server is performed through remote invocation of a web service, which returns the results of the call back to the client. The web services are implemented in ASP.NET and use the SOAP protocol for exchange of XML messages between the server and the client. The web service writes and reads data from the database when needed. As a result of this, the client application never interacts directly with the database or the underlying data models. A Wi-Fi connection is used for communication between the client and the server. The database contains user information, and other data used by the application (Moe, 2009)

2.6.2 High level Integration Architecture of MSIS

A second study was conducted by (Asif, 2009) to provide integration architecture for MSIS. This research project explores the feasibility of the integration of the Mobile Student

Information System to existing student information sources such as Innsida, It's learning, student web and the student societies.

The architecture is presented in Fig 2.3 based on SOA infrastructure elements which are presented in the following section. It has four layers performing different functions.

- *Client Layer*: This layer only represents the client which will be mobile device upon which the client application runs. This client application will provide interface to the user to communicate and access the services. The client application should be light-weight to keep in mind the resource poverty of the device. To make it light-weight, an intermediary service layer has been provided which shifts computing to the server.
- *Intermediate Service Layer:* This layer manages all the communication and accessibility of the client to the available services. It will take the computation load of the client and perform it on the server side. This layer contains two basic modules of services. One module known as "Client Authentication Service module" will not only contain the services for login, client verification, but also verify the subscription detail of the client to various services offered by the system. The second module called "Service Coordinator" is the backbone for the service communication between client and the services offered. It will load, search, and execute all the services the client needs. It will also contain administrative services like subscription or un-subscription of services, managing different services for different clients.

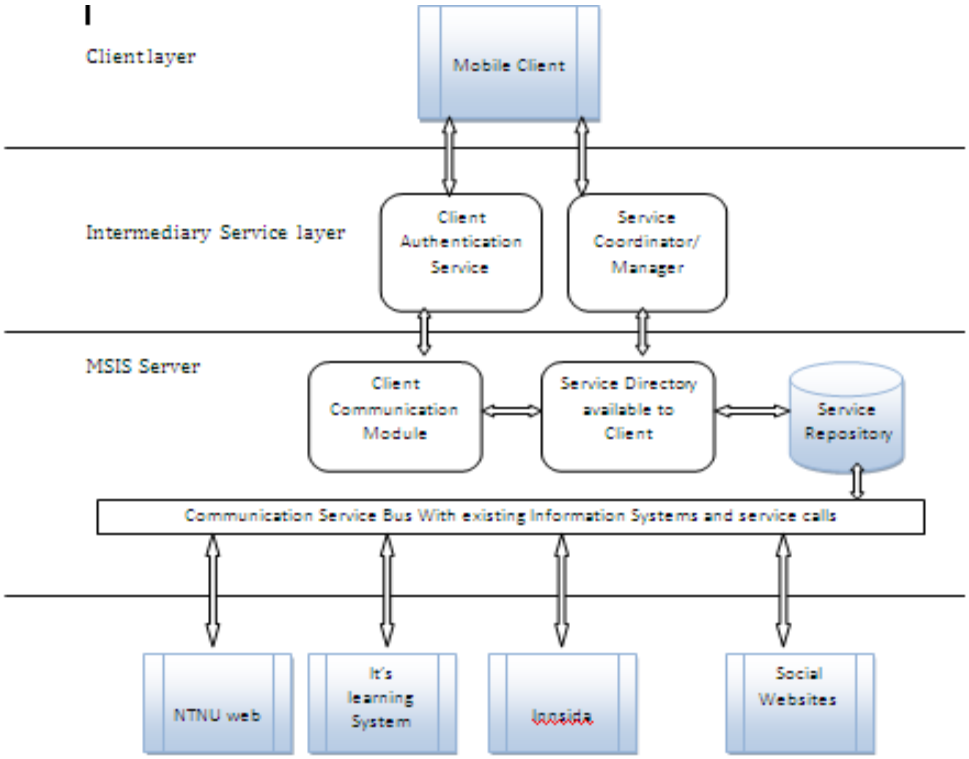


Fig 2.3 Integration architecture (Asif, 2009)

- *MSIS Server Layer* contains the whole business logic which is not transparent to the client. It will contain the services that will manage the whole service communication to executions process. It contains three modules, *Client Communication Module*, *Directory of services* and *service repository*. The client communication module has two way communications with the intermediary service layer in order to provide communication link to the subscribed services of the user. Directory of services contains services for the user and handles the communication between service coordinator and the service repository which holds the services offered by the external systems and the user can search for new services from this repository either manually or push information to the clients for new services. MSIS Server layer works like a kernel for this system contains core services.
- *Communication Service bus* is the layer which contains adapters to the external systems from which services can be accessed. This will contain different adapter services according to the architecture of each system to which we are going to link our

application. This gives us the flexibility to add as many systems as we want. The only thing is to create adapters for accessing and linking the application.

This study proposed different solution guidelines. Possible integration challenges which can be posed by different systems have also been discussed. A scenario and requirement analysis has been done to identify the requirements of users to provide the design guidelines for the architecture and the solution. Some design decisions made are as follows:

Design Decisions for Client Application and Development

The design choices for the client application were based on the analysis of survey results and the previous MSIS application. Further scenarios were developed which demonstrate the real situation of the students. These scenarios were analyzed to elicit the requirements of the integration architecture and the client application. The following are some decisions about the client application and the development framework.

- Profile creation and management should be the part of the client application.
- All communication between the client application and the server should be performed through remote invocation of a web service method.
- The web services should be implemented in ASP.NET and use the SOAP protocol for exchange of XML messages between the server and the client.
- A Wi-Fi connection should be used for communication between the client and the server.
- The designed application should be modular so that it can be extended easily in future. Each category of functionality should be in a separate module.
- Use third party components for the developments if required.

Chapter 3: Research Approach

This study is mainly concerned with the implementation of integration architecture proposed in study (Asif, 2009). It also focused on further development and addition of functionality to an already implemented system (Moe, 2009). Most of the functional and non-functional requirements have already been defined and described through use-cases. Thus the most central stages of the development model will be the design, implementation and integration phases, with minor alteration to the specified requirements and the integration architecture.

3.1 Research Questions

The followings are the research questions that need to be answered in this study:

1. To find out if it is appropriate to have a different level of integration with heterogeneous information systems.
2. What are the integration challenges posed by the systems under study?
3. How efficiently the students are able to interact, collaborate and exchange information by integrating different systems?

3.2 Research Method

This study consists of two major parts: one is to develop the prototype of MSIS which integrates it to different information sources and the second is to perform the usability test of the services built. This project employs the design science paradigm described as follows:

3.2.1 Design science paradigm

The design-science paradigm has its roots in engineering and the sciences of the artificial. It is fundamentally a problem-solving paradigm. It seeks to create innovations that define the

ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished (Walls et al, 1997).

To achieve a true understanding of and appreciation for design science as an IS research paradigm, an important dichotomy must be faced. Design is both a process (set of activities) and a product (artifact) – a verb and a noun (Walls et al, 1997). It describes the world as acted upon (*processes*) and the world as sensed (*artifacts*). This Platonic view of design supports a problem-solving paradigm that continuously shifts perspective between design processes and designed artifacts for the same complex problem. The design process is a sequence of expert activities that produces an innovative product (i.e., the design artifact). The evaluation of the artifact then provides feedback information and a better understanding of the problem in order to improve both the quality of the product and the design process. This build-and-evaluate loop is typically iterated a number of times before the final design artifact is generated (Markus et al. 2002). During this creative process, the design-science researcher must be cognizant of evolving both the design process and the design artifact as part of the research.

Design Cycle

(Takeda et al, 1990) has analyzed the reasoning that occurs in the course of a general design cycle illustrated in Figure 3.1.

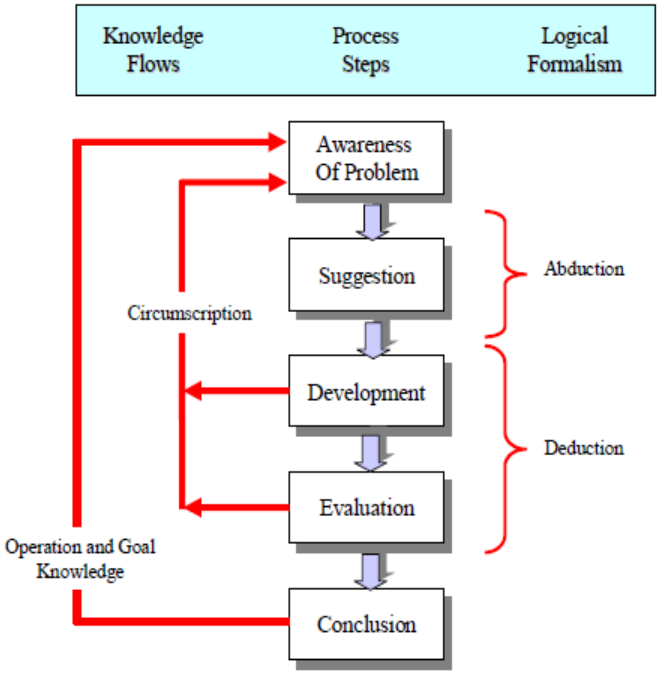


Fig 3.1 Design Cycle

According to this model all designs begin with *Awareness of a problem*. Design research is sometimes called "Improvement Research" and this designation emphasizes the problem-solving/performance-improving nature of the activity. *Suggestions* for the solution can be drawn from the existing knowledge/theory base for the problem area. An attempt at implementing an artifact according to the suggested solution is then performed. This stage has been shown as *Development* in the diagram. Partially or fully successful implementations are then *evaluated* (according to the functional specification implicit or explicit in the suggestion). *Development*, *Evaluation* and further *Suggestion* are frequently iteratively performed in the course of the research (design) effort. The basis of the iteration, the flow from partial completion of the cycle back to *Awareness of the Problem,* is indicated by the *Circumscription* arrow. *Conclusion* indicates termination of a specific design project (Vaishnavi, 2009).

The following table describes some potential output types of this approach.

	Output	Description
1	Constructs	The conceptual vocabulary of a domain
2	Models	A set of propositions or statements expressing relationships between constructs
3	Methods	A set of steps used to perform a task – how-to knowledge.
4	Instantiations	The operationalization of constructs, models and methods.
5	Better theories	Artifact construction as analogous to experimental natural science

Table 3.1 Design Science

The research process will follow the seven design science guidelines for information systems research as described by (Hevner et al, 2004). The guidelines and means to meet them are as follows:

Design as an artifact – The research must produce a viable artifact in the form of a construct, a model, a method or an instantiation. In the context of this guideline, our artifact will be an application which implements the integration architecture.

Problem relevance – The research has to develop technology-based solutions for important and relevant business problems. The application developed will provide help to enhance the student experience with the mobile student information system. The new information sources integrated to MSIS will provide better communication and collaboration tools between students and teachers.

Design evaluation - The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods. An analytical evaluation and usability testing will be done to verify the quality and utility of the application and the services provided to the students by using Mobile Service Acceptance Model.

Research Contributions – The research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies. In this context, this project will give new insights to provide provision to mobile information by integrating the different information systems to provide relevant real time information to the users. It will show how the students can collaborate and communicate by using different tools on mobile devices.

Research Rigor – The research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact. The developed application will follow the research methods for development and evaluation of the system. A usability test will be conducted with a group of students to evaluate the system.

Design as a search Process - Requires utilizing available means to reach desired ends while satisfying laws in the problem environment. Design as a search process motivates the use of iteration as a research methodology. Although this study is a continuation of existing studies yet it explores new possibilities to integrate different student relevant information sources. It will explore new ways of collaboration and communication by using services on mobile devices. The new service provide students an opportunity of informal communication which will give them a sense of presence and face to face communication.

Communication of research – The research must be presented effectively both to technology-oriented as well as management-oriented audiences. This report contains information from two perspectives, one is the technical detail of the development and integration process of the application and the other is the results of usability testing. The results and discussion chapter of this report will provide emphasis more on former perspectives.

3.3 Usability and user acceptance testing

In this project work, the first task is to integrate MSIS with different student information systems which provide services for collaboration and communication among the teachers

and the students. In addition to this, different mobile services are built which will help the users to access relevant information of their need any time anywhere.

The second part of this project is to test those services which are developed by integrating MSIS to different systems. There is a need to assess how well the system fulfills the purpose of integration and the services from different systems. This evaluation serves to find possible shortcomings with the initial design and potential areas for improvement both in integration architecture and the application. This section will establish a theoretical fundament for the methods and models that has been used in the evaluation phase. First the usability and why it is necessary is discussed in the following section.

3.3.1 Why usability evaluation

Usability evaluation is the second major part of this study. The mobile services build need of usability evaluation to verify the goals achieved and to know how much the students are satisfied with these services. Before going into the detail of usability evaluation and its methods let's find what the usability is.

"*Usability is the extent to which a computer system enables users, in a given context of use, to achieve specified goals effectively and efficiently while promoting feelings of satisfaction*." (Ivory & Hearst, 2001).

Usability evaluation may consist of various activities depending on the method employed. The common activities defined by (Ivory & Hearst, 2001) are as follows:

- *Capture*: collecting usability data, such as task completion time, errors, guideline violations, and subjective ratings;
- *Analysis:* interpreting usability data to identify usability problems in the interface; and
- *Critique*: suggesting solutions or improvements to mitigate problems.

Now a day's the dependence on the mobile device is growing and gradually positioning it as the key repository for core services. These include the news, travel, weather, sports updates that are becoming essential and "must-have" for many users. The increasing

number of mobile users significantly implies the importance of assuring that the application is useable by means of usability evaluation method (Hussain & Ferneley, 2008). Usability can bring many benefits such as users should be able and willing to use the various features of the phone and the services supplied by the operators, the need for customer support decreases and, above all, user satisfaction increases (Timo et al, 2006).

3.3.2 Usability evaluation of mobile services

Performing usability studies of mobile services can be a difficult task due to different form factors and technical specifications of the mobile devices. The user of desktop computer and applications has to deal with resource scarce mobile devices and services. The limitation of the resources in mobile devices poses different challenges to usability.
Some possible challenges are as follows:

- Screen size is an issue which limits the way to display the relevant information to the user. To manage the different menus used to control the information and the application is a challenge to due to limited screen size.
- Different resolutions and the form factors of the devices make it difficult for the application to work smoothly. Developing device aware applications is a big challenge. Common horizontal resolutions are 96, 128, 176, 240, and 320 pixels.
- Different mobile devices require different tools to interact with their interfaces. While each of these input tools accomplishes the essential task of selecting an object, each also presents us with limitations.
- Limited processing power and memory limits to develop complex and multithreading applications. It is a big challenge to develop energy aware applications to cope with the battery limitations.
- Mobile devices can be used in unpredictable situations; outdoors in very bright light, in the course of another activity (like driving), or while in constant motion which makes it difficult to operate the device and application.
- Network connectivity and latency can also pose some serious challenges to context aware applications.

(Timo et al, 2006) also describe that designing is becoming challenging with the increase of number of functions and reduction in size of the mobile devices. Another challenge is the ever shorting life of the mobile devices resulting in less time development.

3.3.3 Methods for evaluation of usability

Measuring the usability is very important to analyze and conclude the findings. Usability can be qualitative or quantitative depending on the context of evaluation. As (Good M et al, 1986) states the importance of measuring the usability. He states that

''*Without measurable usability specifications, there is no way to determine the usability needs of a product or to measure whether or not the finished product fulfils those needs. If we cannot measure usability, we cannot have usability engineering"*.

Different evaluation methods can be applied to different stages of the design and development cycle. Some methods are intended to assess certain usability characteristics early in the process by evaluating the product specification, while other methods are used to evaluate the final system. The evaluation methods can be classified into the following categories: (1) Cognitive modeling methods, (2) Inspection methods, (3) Inquiry methods, (4) Prototyping methods, (5) Testing methods, and (6) Other methods.

Evaluations can be done in the field in a real work situation or in laboratory settings in which the relevant aspects of the context of use are re-created in a representative and controlled way. (Wixon D, 2003) found that much of the literature on the evaluation of usability methods is ''unhelpful, or even irrelevant'' to the practitioner because the evaluations of the methods have been carried out in laboratory settings.

Performing usability studies for applications running on mobile devices can be a difficult task. Typical user study scenarios collect information by means of attaching an external camera to capture a view of the mobile screen (T. Kallio et al, 2005) or through logging (F.

Paterno et al, 2007). Using an external camera to view the mobile device's screen is quite challenging because of the fact that the screen is small and most of the time the user is occluding the screen (F. Balagtas-Fernandez et al, 2009). An alternative to this is to use screen capture software similar to the ones available for the desktop. However, because of limitations (D. Zhang et al, 2005) posed by mobile devices, it is quite a challenge to find such applications that can accurately and efficiently capture user interaction with the mobile applications being tested. Logging of events on the other hand can be an accurate source of usage information. The challenge in event logging though is in the whole process of preparing the system for data collection and the extraction and interpretation of the vast amount of logged data.

3.4 Technology acceptance model

It is very important to find the factors that can influence user centered information systems and services. Various technology acceptance models and theories have been suggested to assist developers in the evaluation of new software applications. As Theory of Reasoned Action (TRA) suggests the attitudes and norms are not weighted equally. Some people may care less for what people think and put more weight to their own attitudes, and vice versa.

The Technology Acceptance Model is an extension of the TRA which helps to model the user behavior towards new technology, information systems and services. The TAM suggests that a person's intention to use a system is determined by two main factors: perceived usefulness (PU) and perceived ease of use (PEoU).

TAM is one of the most widely accepted models, and has been successfully applied to predict user acceptance of various new information technologies (Davis, 1989). The correlation between the various factors of TAM is illustrated in following fig3.3.

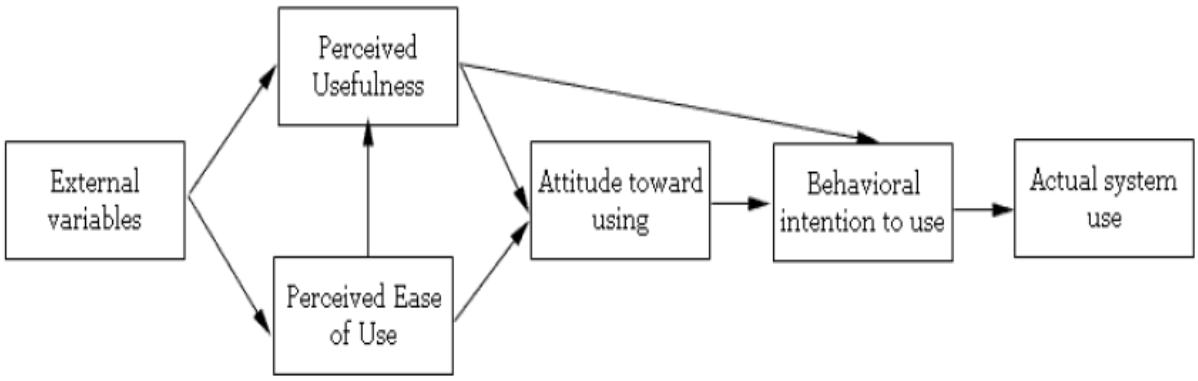


Fig. 3.3 The technology acceptance model (Davis, 1989)

It is found that TAM model and its extensions were developed and applied in various studies of mobile applications and services. In different studies such as (Mirella et al, 2004) explained the adoption of mobile gaming based on a refined TAM which considered context-specific factors and consumer traits. They found that perceived risk played a crucial role in the adoption process followed by complexity and compatibility. (Margherita et al, 2004) researched consumer's adoption of multimedia mobile services by adding price and speed of use to the TAM model. It is found that perceived usefulness, ease of use, price and speed of use are the most important determinants of adoption of multi-media mobile services. (Facer et al, 2004) studied how to use mobile technologies for learning, but they did not apply TAM model. (Yang, 2005) used TAM to explore factors affecting the adoption of mobile commerce in Singapore and found the importance of perceived usefulness. Hung and (Chang, 2005) used theory of planned behavior (TPB) to explain user's adoption of WAP. (Eija, 2005) proposed an extended TAM by concerning trust on the case studies (mobile Internet and mobile phones) to study user acceptance of mobile services.

3.4.1 Mobile Services Acceptance Model (MSAM)

Various extensions of TAM are developed and applied in different for assessing user acceptance in different contexts. (Gao et al, 2008) proposed an extended technology

acceptance model, called the Mobile Services Acceptance Model (MSAM). The model is based on TAM, but also considers the influence of trust, context, and personal initiatives and characteristics on user adoption of mobile information systems.

The constructs Perceived Usefulness and Perceived Ease of Use were adopted from TAM. As shown in fig 3.4 context (e.g. location, identity etc) has direct influence on Perceived Usefulness and Perceived Ease of Use.

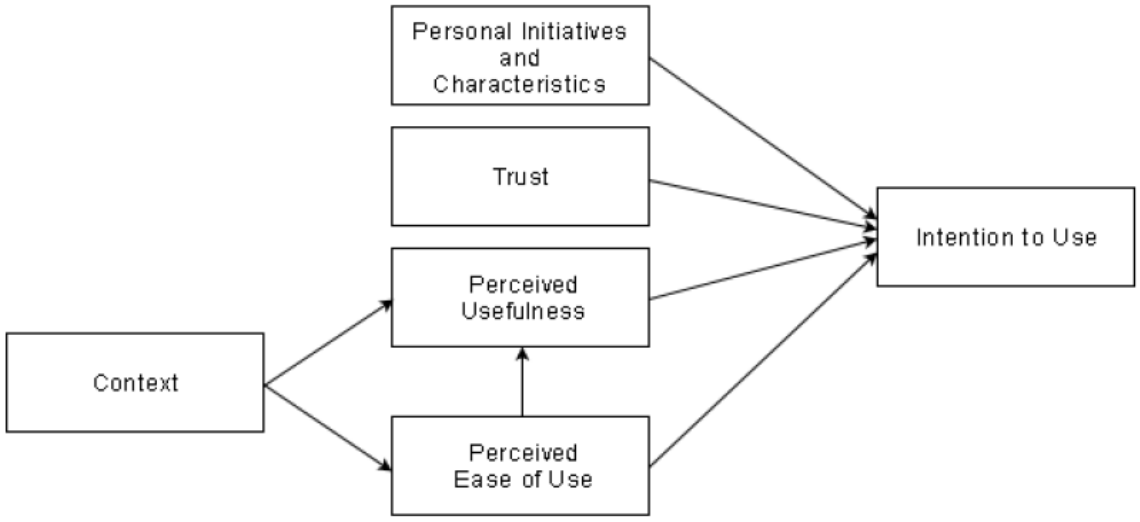


Fig 3.4 Mobile Services Acceptance Model (MSAM) (Gao et al, 2008)

For example, a mobile application may have higher perceived usefulness when no desktop computer is available or the user is away from the working place. The personal initiatives can be defined as the user's willingness to try out new applications. Some people are more interested to adopt new technology and innovations than others, which may be explained by the diffusion of innovations theory. The personal characteristics include the following elements: age, gender, educational background, knowledge and skills, culture and preference can highly influence the acceptance of technology. The Trust construct captures users' beliefs or faiths in a mobile system in terms of potential security and privacy threats. Trust is of concern in any software application but the heterogeneous, ubiquitous nature of mobile computing presents additional challenges to the developers of such systems.

According to (Gao et al, 2008), the perceived usefulness and perceived ease of use are positively correlated with usage intention.

In our study, we are using a revised version of the Mobile Services Acceptance Model to evaluate the MSIS system. We kept the six main constructs; PU, PEoU, Trust, Personal Initiatives and Characteristics, Context, and Intention to Use, but the model has been adapted in order to better capture the distinctive characteristics of the MSIS system. The MSAM was initially developed for mobile e-commerce applications, thus some of the measurement items were not relevant to our project.

3.4.2 Measuring system parameters

In a traditional usability study, the focus is mainly on the functional aspects of the system. Usability testing measures the ease of use of a particular system or part of a system and the aim is to discover errors and areas of improvements by observing people as they interact with the system. The new version of MSIS has been integrated with different student information sources and operates in real time. This new system requires various parameters to test such as connectivity, response time, security, latency and other related technical and operational factors. Usability testing generally involves measuring how well test subjects respond in four areas: efficiency, accuracy, recall, and emotional response, which relate to Nielsen and Shneiderman's principles of good system design.

- *Efficiency*: measures how much time is required by the people to complete a task using the system, e.g. the number of steps involved.
- *Accuracy*: how many mistakes did people make? Did the system provide useful error messages and information, or were the errors fatal and non-recoverable?
- *Recall*: how much does the person remember afterwards or after periods of non-use?
- *Emotional response*: what feelings does the person express towards the system? Is the person confident completing the task, or do they find the situation stressful?

The evaluation in this project has been conducted in accordance with these principles, but we have also considered some additional factors introduced by MSAM. Of particular interest are the impact of context, and the notion of trust on user adoption of mobile services. For each of the constructs defined by the MSAM, we composed a number of measurement items. A 7- point scale was used to measure the responses to each of the items. The usefulness and perceived ease of use measures up to what extent people will get benefit by using the system, in terms of increased task efficiency and lower error rate. The trust, personal initiatives and characteristics, and intention to use constructs concern the users' emotional response towards the system. Due to the nature of mobile services, the notion of context becomes an important factor. Context in this regard concerns characteristics about the user, such as their location, past experience/history, social factors, and so on. These are some of the factors that may influence how likely the user is to adopt the system.

Chapter 4: Analysis, design and development

The following section describes each system selected for integration with MSIS. It gives an overview of each system, architecture and the possible ways explored to integrate it. Since each system poses different challenges; it also describes the challenges faced, the tools and techniques used for the integration.

4.1 System analysis and design

Any system that we are going to develop or modify requires detailed analysis depending on the type of the system. System analysis helps us to understand and specify the detail of the system under study. And the design process helps us to specify how the components of the system will be implemented. For any successful system, it is required to apply proper analysis and design techniques to understand the system in detail.

System development can generally be thought of having two major components: systems analysis and systems design. In System Analysis more emphasis is given to understanding the details of an existing system or a proposed one and then deciding whether the proposed system is desirable or not and whether the existing system needs improvements. Thus, system analysis is the process of investigating a system, identifying problems, and using the information to recommend improvements to the system. As shown in following fig 4.1.

The analysis and requirement specification of the MSIS with few implementations has already been done (Moe, 2009). For further development, integration architecture was proposed in study (Asif, 2009). A detailed requirement analysis and specification for this integration architecture has already been done in this study. To implement this integration architecture further development and analysis was needed which is being performed in this study.

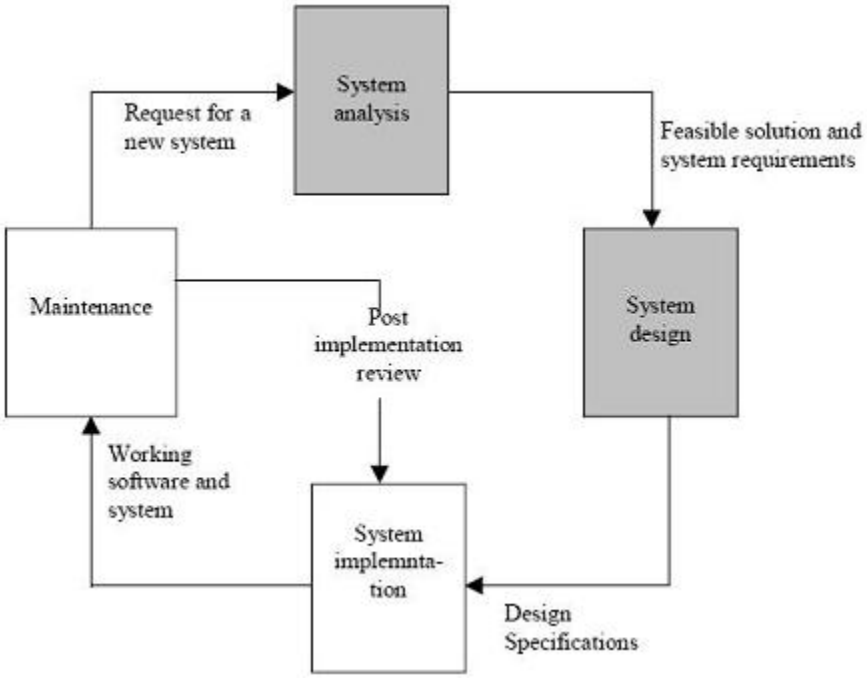


Fig 4.1 Analysis and Design stages (Free Tutes)

The purpose of the design phase in general is to plan a solution of the problem specified by the requirement document. This phase is the first step in moving from problem domain to the solution domain. The design of a system is perhaps the most critical factor affecting the quality of the software, and has a major impact on the later phases, particularly testing and maintenance. The output of this phase is the design document. This document is similar to a blue print or plan for the solution, and is used later during implementation, testing and maintenance.

4.2 Software architecture

Architecture is the crucial part of the design process. Software architecture encompasses the structures of large software systems. The architectural view of a system is abstract, distilling away details of implementation, algorithm, and data representation and concentrating on the behavior and interaction of "black box" elements. Software architecture is developed as the first step toward designing a system that has a collection of desired properties. Software architecture is defined in (Bass, Clements, & Kazman, 2003)as:

“The software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them.”

Software architecture can be important for the following reasons (Bass, Clements, & Kazman, 2003):

1. Communication among stakeholders. Software architecture represents a common abstraction of a system that most if not all of the system's stakeholders can use as a basis for mutual understanding, negotiation, consensus, and communication.
2. Early design decisions. Software architecture manifests the earliest design decisions about a system, and these early bindings carry weight far out of proportion to their individual gravity with respect to the system's remaining development, its deployment, and its maintenance life. It is also the earliest point at which design decisions governing the system to be built can be analyzed.
3. Transferable abstraction of a system. Software architecture constitutes a relatively small, intellectually graspable model for how a system is structured and how its elements work together, and this model is transferable across systems. In particular, it can be applied to other systems exhibiting similar quality attribute and functional requirements and can promote large-scale re-use.

4.3 Architecture Business Cycle

A system’s software architecture has a relationship with the environment in which it is created and exists. Software architecture is a result of technical, business, and social influences. Its existence in turn affects the technical, business, and social environments that subsequently influence future architectures.

Architects are influenced by the requirements for the product as derived from its stakeholders, the structure and goals of the developing organization, the available technical

environment, and their own background and experience. Similarly some of the feedback comes from the architecture itself, and some comes from the system built from it as shown in fig 4.2. (Bass, Clements, & Kazman, 2003)

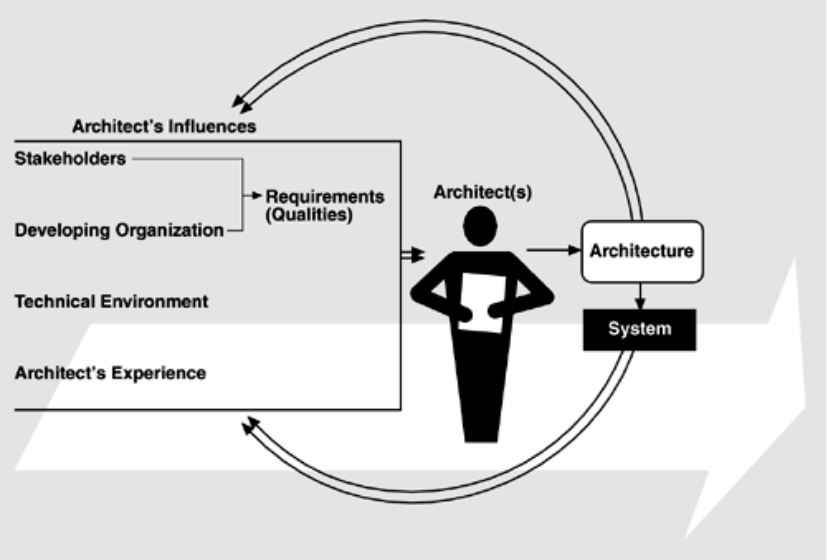


Fig 4.2 Architecture Business Cycle

4.3.1 Software Processes and the Architecture Business Cycle

Software process as described by (Bass, Clements, & Kazman, 2003) is the term given to the organization, reutilization, and management of software development activities. What activities are involved in creating software architecture, using that architecture to realize a design, and then implementing or managing the evolution of a target system or application? These activities include the following:

- Creating the business case for the system
- Understanding the requirements
- Creating or selecting the architecture
- Documenting and communicating the architecture
- Analyzing or evaluating the architecture

- Implementing the system based on the architecture
- Ensuring that the implementation conforms to the architecture

4.4 Mobile Student Information System (MSIS)

The integration architecture for MSIS was proposed in study (Asif, 2009) last autumn. The idea was to integrate MSIS with different systems to provide the ubiquitous access to the updated relevant information. To provide better information services and collaboration tools to the student community following systems were selected for integration.

- Twitter –A Social Networking Tool
- Mobile NTNU Student Email.
- It's Learning
- RSS feed based information services

An overview of the implementation of integration architecture is shown in following figure.

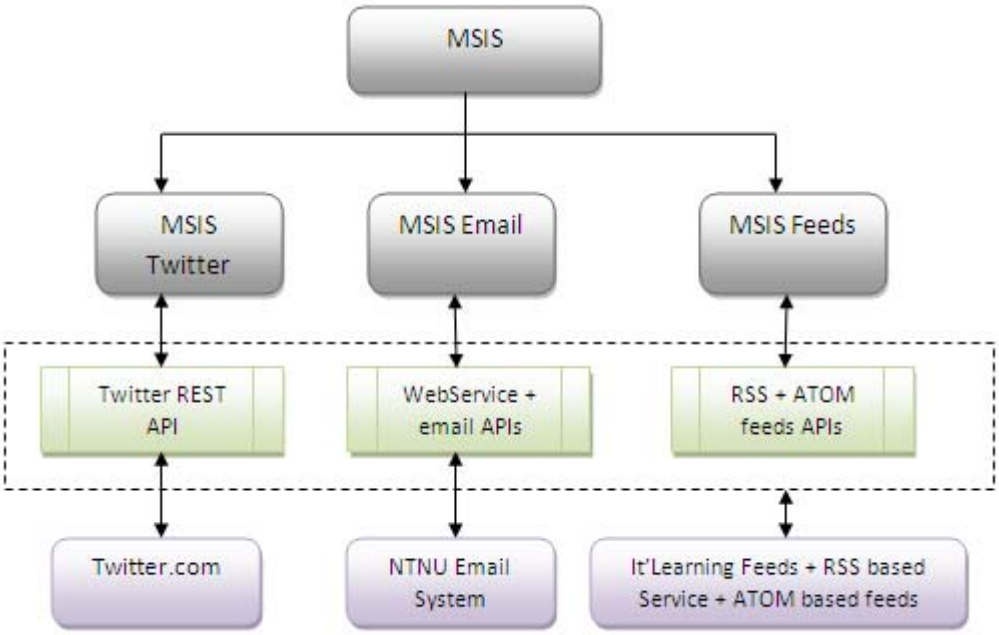


Fig 4.3 MSIS Integration overview

The following section describes the implementation detail with brief analysis of each system and its features.

4.5 It's Learning System

Its learning is a learning platforms designed specifically for the educational sector. This platform supports students and teachers in various aspects of the learning process. It consists of a series of tools to support teachers and students throughout the learning process. Some features provided by this system according to It's learning developers are:

- Personalized Learning for Students: It contains the features like personal dashboard, blog, ePortfolio, Task list and others. The blog feature gives the student an opportunity to have a discussion on the different topics of interest. It provides RSS feeds for subscription to which the users can subscribe and share their ideas.
- Collaboration Tools: It includes email, SMS, project tool, surveys, calendars and others. Emails and SMS are the common features of its learning for the collaboration.
- Course Management and Assessment: It includes the tools to manage the contents of courses, learning objectives, reports, assignments, grade books and may more.
- Customized Environment: It includes page layouts, custom skins, user profiles and preferences, languages and other related features.
- Content Flexibility: It provides various tools and plug-ins for customized contents.
- Integration services and support: It includes the features like Software as a service, export grade books and single sign on option.

4.5.1 It's Learning Platform

It's learning is a learning platform as defined by its developers:

"A learning platform is a framework of tools that work seamlessly together to deliver a student centric learning experience by unifying educational theory & practice, technology and content." (Its Learning Developers, 2010)

The main focus of this platform is to provide tools to schools and universities for planning, engaging, assessing, and reporting. It is also focusing the communication and the collaboration tools for students and teachers. It provides privilege to integrate third party contents from web 2.0 applications such as YouTube, Flickr, Google, RSS and others as shown in Fig 4.4.

Content can also be imported into it's learning from other sources through accepted standards such as SCORM or AICC. It's learning is also a personal learning environment with ePortfolios, blogs, and support for individual personalization.

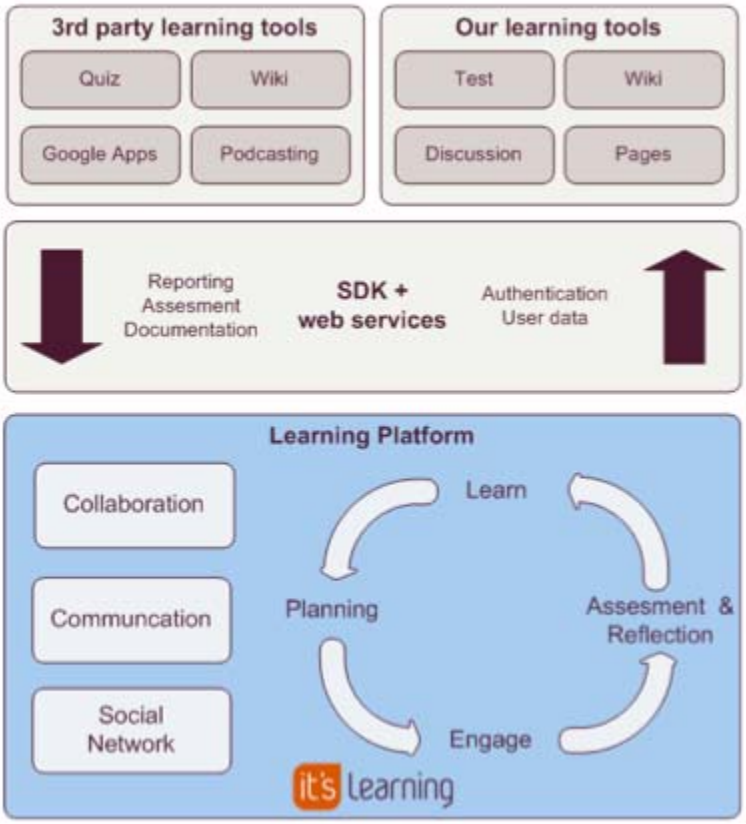


Fig 4.4 It's Learning Platform

4.5.2 Opportunities to interact with It's Learning System

It's learning platform provide the following features and support to interact with its environment. It provides help to create learning tools which are supposed to work inside it's learning environment. A learning tool or application in It's Learning is defined as (Its Learning Developers, 2010):

"*The application created by a developer that will run in a frame inside it's learning. A learning tool can create learning objects in a course in it's learning and will also let users view the created content*".

A few Terms defined by it's learning for the developers are:

- *Learning Object*: It represents the content. This is the common name that covers both Learning Resource and Learning Activity.
- *Learning Resource:* This is a content based learning object. Examples are document and podcast. Learning resources are not given assessments or deadlines, and is more like "one-way" communication. A learning resource only uses *read* and *modify* permissions.
- *Learning Activity*: A learning object that may have deadline and assessment. For a learning activity some kind of communication between teacher and learner(s) is expected. Examples of learning activities are discussions, tests and assignments. A learning activity uses the permissions *participate* and *evaluate* in addition to *read* and *modify.*

Support for the type of applications

It's learning platform provides the following four choices of assessment applications which can be developed to work within the it's learning environment.

- *Learning Resource*: This is the simple application which represents the learning contents. It's learning can track if a user has read a resource or not.

- *Learning activity without assessment***.** Sometimes you may not need assessment for learning activities, only the possibility to have the extra permissions *participate* and *evaluate*. it's learning will track if a user has accessed an activity

or not. The discussion tool in it's learning is an example of a learning activity that does not use assessment.

- *Learning activity with simple assessment***.** This will allow you as an application developer to set a percentile score, comment, simple status (not started, in progress, completed) and time spent. This is very much like the way SCORM and AICC content works.
- *Learning activity with advanced assessment***.** This will make use of the dynamically created assessments and assessment statuses users can find in it's learning. These will differ from site to site and are available to get and use via the rest API. This is how the test and assignment tools in it's learning work.

4.5.2.1 It's Learning REST API

It's learning provides APIs to develop the type of applications mentioned in the above section. As seen in the figure 4.4, it's learning has a core which gives the functionality that application developers can use via API or that is available for the users of applications in the it's learning user interface (Its Learning Developers, 2010).

There is no content inside the core, but the learning content is provided by a pluggable model. The core functionality is exposed to a REST API which is accessed through HTTPS (or HTTP). The plug-ins are called *Applications* or *Learning Tools.*

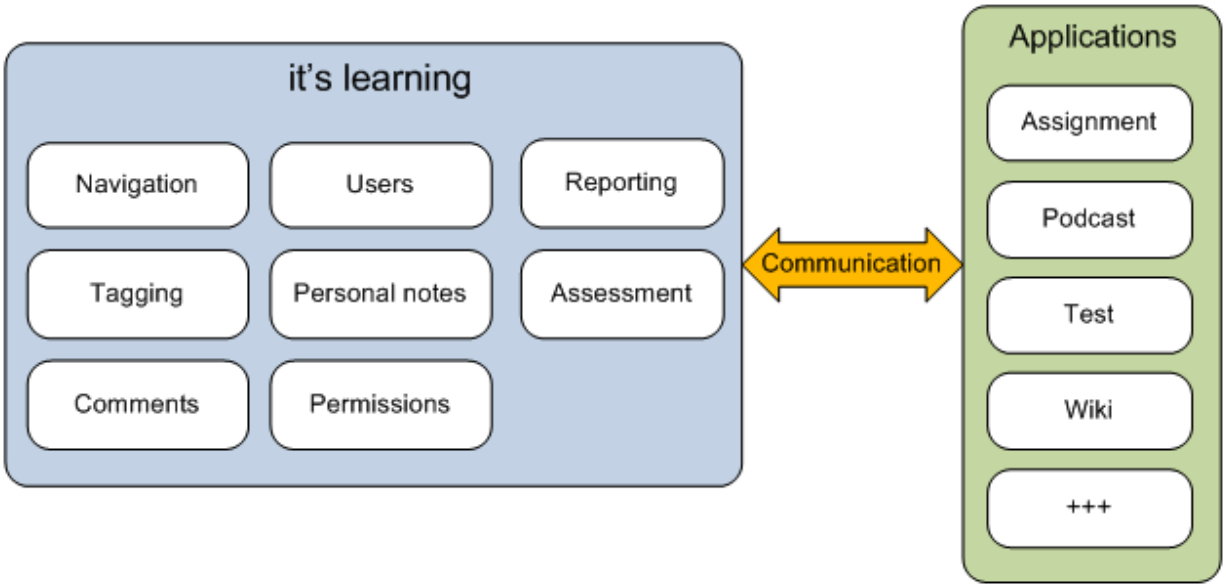


Fig 4.5 It's Learning APIs and Applications

Before the learning tools can be used in it's learning each tool has to be registered in the it's learning repository. During the registration the application developer get an *Application Key* and a *Shared Secret*. These keys identify the application from all the other applications already in it's learning. When learning Tools are hosted by the developer, it's learning interacts with the application using a simple query string interface.

The Learning Tool Applications are not tied to a specific platform or technology; developer can use any framework and programming language which supports creating web applications (.NET, Java, Perl, PHP, etc). A complete SDK for development is provided by it's learning. (Its Learning Developers, 2010)

A number of web services are provided by It's learning to communicate with the It's Learning tools with the help of REST API.

4.5.2.2 Challenges or Limitations of Integration

It's Learning is a rich environment for the development of learning tools or applications. A detailed REST API is provided to support the development of these learning tools. But the integration of MSIS with it's learning has faced some limitations or challenges. These

limitations are deduced after the detail analysis and testing of it's learning web services and REST APIs. Some questions related to this case were also posted on developer forum which helped to make the following conclusions:

- The It's Learning platform supports only those applications which can run inside the it's learning environment. Each application developed has to be registered at the developer's portal to get the application key and shared secret for further communication.
- The major limitation is that for each application developed with it's learning REST API can only run inside the it's learning environment. The application can only be initialized from it's learning environment which requires the application key to be verified, no external application can initialize communication with it's learning system.
- Currently the web services provided by it's learning system are only to support four type of applications learning resource, learning resource, learning activity without assessment, learning activity with simple assessment, learning activity with advanced assessment.
- Our focus was to access learning contents, course notifications, discussions, assignments deadlines and discussion threads. Currently the available REST API has no support to access these resources from external web services or applications.

Possibilities of integration

The REST API and web services of it's learning are in a continuous process of development. So it is the possibility that we may have some web services or APIs to access the environment of it's learning. Currently the blogs of the it's learning environment can be accessed via RSS support. It's learning newer version provides support of RSS blogs.

The only option available for MSIS to access it's learning blogs is via RSS application. A complete application is developed for MSIS which handles all RSS and ATOM based feeds.

4.6 Twitter-A Social Networking Tool

Twitter is a fast growing social networking tool which helps family members, friends, and co-workers to keep up to date with what an individual is doing. They can do this by using an instant messenger service, the web, as well as with mobile texting and other venues.

Twitter is an interesting concept that was created by Jack Dorsey and became an incorporated company in May of 2007. Since then, it has grown to be an Internet phenomenon, often featured on news channels on the web (Cherim, 2008).

"*It allows you to broadcast and receive messages from your computer or cell phone of 140 characters in length, all those who "subscribe" to your broadcast can see your message, called a "tweet," and you receive messages from all those to whom you subscribe. The key point to remember here is this can get sent to your phone, making it highly mobile*" (Cherim, 2008).

4.6.1 Academic use of Twitter

Since twitter is a social networking tool which attracts the large community from every field of life to share "What are you doing?". There are different ways and motivations for the people to use twitter. Different ways of accessing the twitter makes it more mobile and easy to use. This fast and easy access makes twitter more usable and interesting for the people.

Another important area where the use of twitter can be productive and interesting is "Academic use". Different ways to use twitter in academia are presented by (Cherim, 2008) are as follows:

1. *Class Chatter***:** Since the students have shared class room experience; they can continue the conversation outside of the class by twittering. When something came

up outside of class that reminded them of material from class time, it can be twittered. This can serve as a reinforcement or connection between the material and the "real world."

2. *Classroom Community*: By discussing and twittering lectures and other materials with each other can create a sense of class room community. Instead of keep the discussion for one lecture per week, students can continue to discuss and share ideas. It can give the students to ask questions to his fellows which were unclear during the lecture. It can change the classroom dynamics in a positive way.
3. *Get a sense of World*: Students can look at the 'Public Timeline' of Twitter. This is the place where all public messages get posted. The "noise" ratio here is pretty high, but one can get a sense of how varied are the things people are doing around the globe. Additionally the public timeline can serve as a sort of quick measure of what people are paying attention to.
4. *Track a Word*: Through Twitter students can "track" a word. This will subscribe then to any post which contains said word. So, for example a student could be interested in how a particular word is used. They can track the word, and see the varied phrases in which people use it. Or, they can track an event, a proper name, a movie title, a store name or something else.
5. *Track a Conference*: Now a day's various conferences have the opportunity to follow it on twitter. It can be easy and interesting for the research community to get instant updates about a conference.
6. *Instant feedback*: Because Twitter is always on, and gets pushed to your cell phone if you set it up this way, it is a good way to get instant feedback. It can be interesting to get instant feedback while you are arranging some event and want response from your coworkers.
7. *Follow a Professional*: Students can follow someone else who is on Twitter, who interests them. Various professionals have twitter accounts and they are regularly twittering. Students can follow the professionals of their interest or famous person of the world.
8. *Grammar*: Surprisingly Twitter is actually good for teaching grammar. Because of its short form those who tweet often abbreviate and abuse grammar rules, developing

their own unique "twitter rules." This helps to demonstrate, both how all communication needs rules/structure and how important something like a comma or a period can be.

9. *Rule Based Writing*: Rules rather than hindering communication can actually be really productive. Because Twitter is based on SMS technology it limits communication to 140 characters, it is surprising what develops out of this limit, and how quickly one starts to think in messages of 140 characters.
10. *Maximizing the Teachable Moment*: It is often hard to teach in context, Twitter allows you to do this, but better yet, allows your students to do it for you. It can be a unique experience to get the benefit of twittering.
11. *Public Notepad*: Twitter is really good for sharing short inspirations, thoughts that just popped into your head. Not only are they recorded, because you can go back and look at them, but you can also get inspiration from others. This is really useful for any "creative" based class.
12. *Writing Assignment*: It can be interesting to write a group assignment by twittering on twitter. Each student can write his own ideas and others can correct or suggest something different. It can create a sense of collaborative writing on a certain topic.

4.6.2 Twitter @Anywhere

Twitter is a micro-blogging service with an open API. It is providing a wide variety of APIs to integrate different types of applications. These APIs provides seamless connectivity to twitter different timelines. There are three different versions of twitter APIs exists. As stated below by its developers:

"Twitter maintains an open platform that supports the millions of people around the world who are sharing and discovering what's happening now. We want to empower our ecosystem partners to build valuable businesses around the information flowing through Twitter". (Twitter Developers, 2010).

The following section describes only the API version which is used in MSIS Twitter application.

4.6.2.1 The Twitter API

Twitter exposes its data via Application Programming Interface. The Twitter API consists of three parts: two REST (Representational State Transfer) APIs and a Streaming API. The Twitter REST API methods allow to access core Twitter data. This includes update timelines, status data, and user information. The API presently supports the following data formats: XML, JSON, and the RSS and Atom syndication formats, with some methods only accepting a subset of these formats.

For each feature twitter provides methods in its APIs. The communication between twitter and applications occured through HTTP protocol. The two main categories of REST APIs are (Twitter Developers, 2010):

- **Twitter REST API**: The Twitter REST API methods allow developers to access core Twitter data. This includes update timelines, status data, and user information.
- **Twitter Search API**: The Search API methods give developers methods to interact with Twitter Search and trends data.

The following example shows the structure of REST API methods.

> **Example: statuses/friends_timeline**: Returns the 20 most recent statuses posted by the authenticating user and that user's friends. This is the equivalent of /timeline/home on the Web.
>
> **URL:** http://api.twitter.com/1/statuses/friends_timeline.*format*
>
> **Formats:** xml, json, rss, atom
>
> **HTTP Method(s):** GET
>
> **Requires Authentication:** true
>
> **API rate limited :** 1 call per request

This is the basic structure of each method of REST APIs used to access twitter data.

Twitter API Console

Twitter provides a platform to test APIs calls called **API Console** as shown in Fig 4.6. The required API methods can be tested by using this console. Before implementing, the methods of API can be verified for errors and exceptions.

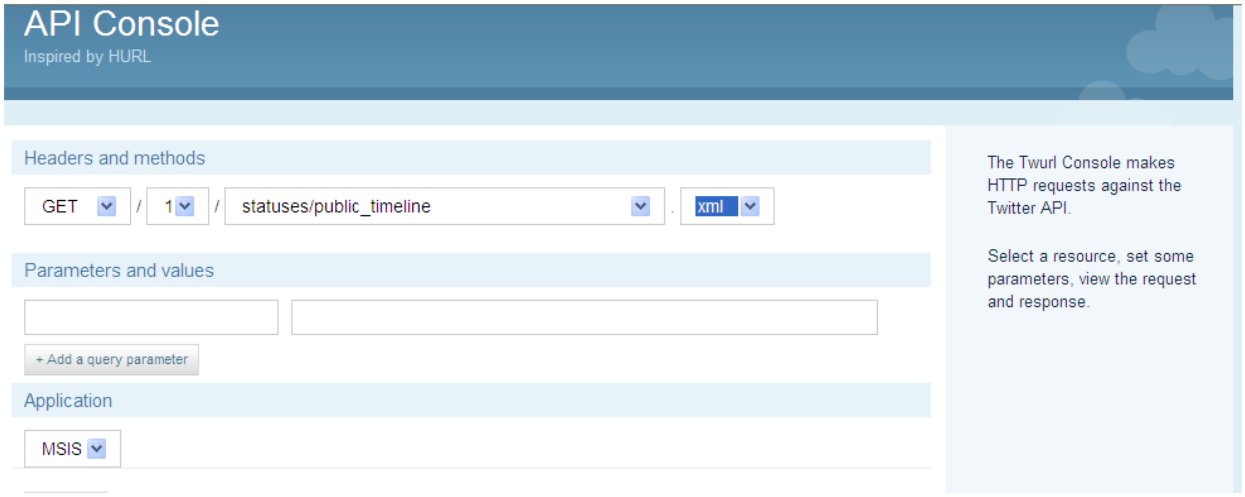


Fig 4.6 Twitter API Console

Twitter uses the open authentication standard **OAuth** for authentication. To use the Twitter API, the first thing you have to do is to register the client application. Each client application you register will be provisioned a consumer key and secret. This key and secret scheme is similar to the public and private keys used in protocols such as ssh for those who are familiar. This key and secret will be used, in conjunction with an OAuth library in your programming language of choice, to *sign* every request you make to the API. It is through this signing process that we trust that the traffic that identifies itself is you are in fact you (Twitter Developers, 2010).

4.7 MSIS Twitter

The popularity of twitter is rising due to various reasons in different communities. It provides a simple way to update friends about daily life has grown into a powerful tool for business, communication, and education. There is a plenty of room to create new and exciting ways to use Twitter on campus. The use of twitter on mobile devices will provide more benefits instead of using it on desktop computers. A twitter application is developed and integrated to MSIS which uses same twitter web account on the mobile application to access the different types of data from twitter. The developed application is general in nature and can be used in a variety of scenarios and collaboration purposes.

Twitter REST APIs are used to access the different time lines and updates. Each type of twitter updates has different URLs and parameters. The following use case diagram shows the functionalities implemented in MSIS Twitter.

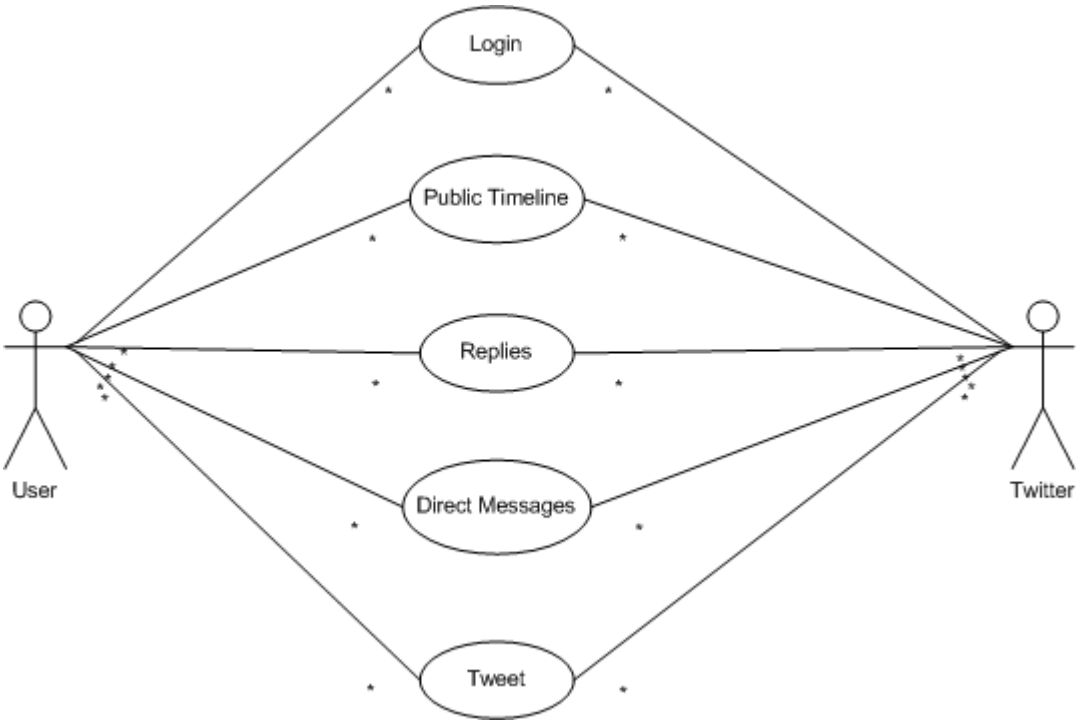


Fig 4.7 MSIS Twitter Use Case

4.7.1 MSIS Twitter Class Diagram

The following class diagram gives an overview of the implementation detail of MSIS Twitter application. It shows the major classes implemented in the solution. The major classes are **TimeLine, DirectMessages, Replies** and **Tweets** which are responsible to fetch the data from Twitter. **TwitterApi** class is responsible for providing connection to the Twitter REST API. Other classes are responsible for displaying the fetched data to the user. The **Configuration** class is used to store the configuration of the user to an XML file such as offline tweets, user id and password.

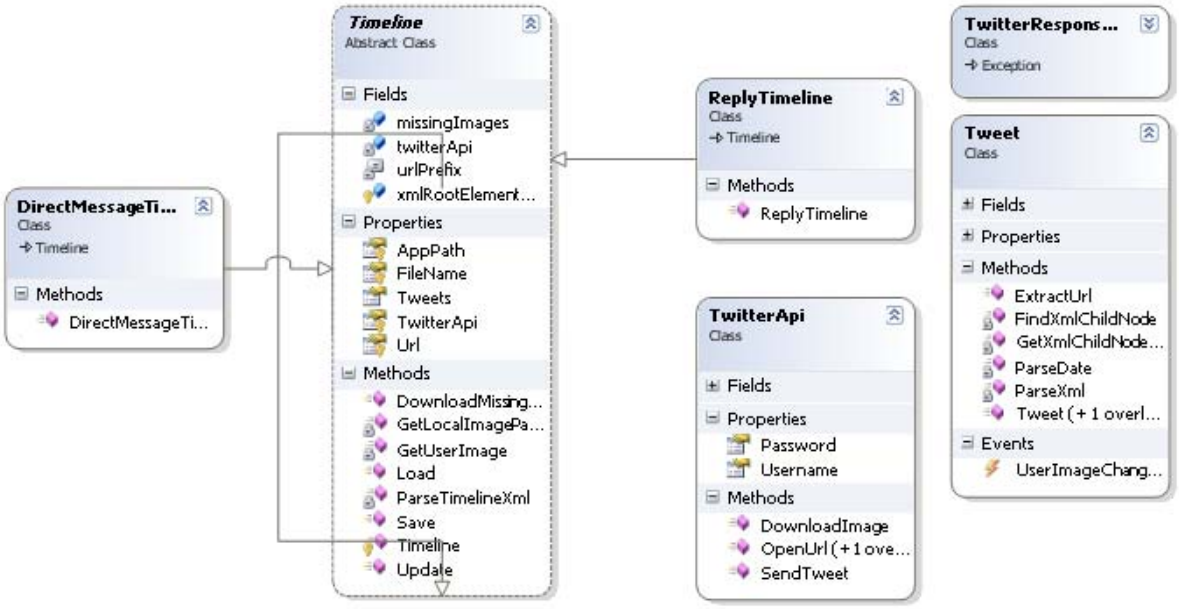


Fig 4.8 MSIS Twitter Class Diagram

4.8 NTNU Email System

A web email system for students, teachers and others is available at NTNU. This web email system works similar to ordinary email systems such as Yahoo, Gmail, Hotmail and others. The students have a web interface to access their email accounts with different language options available as shown in fig4.9 (NTNUWebmail, 2010).

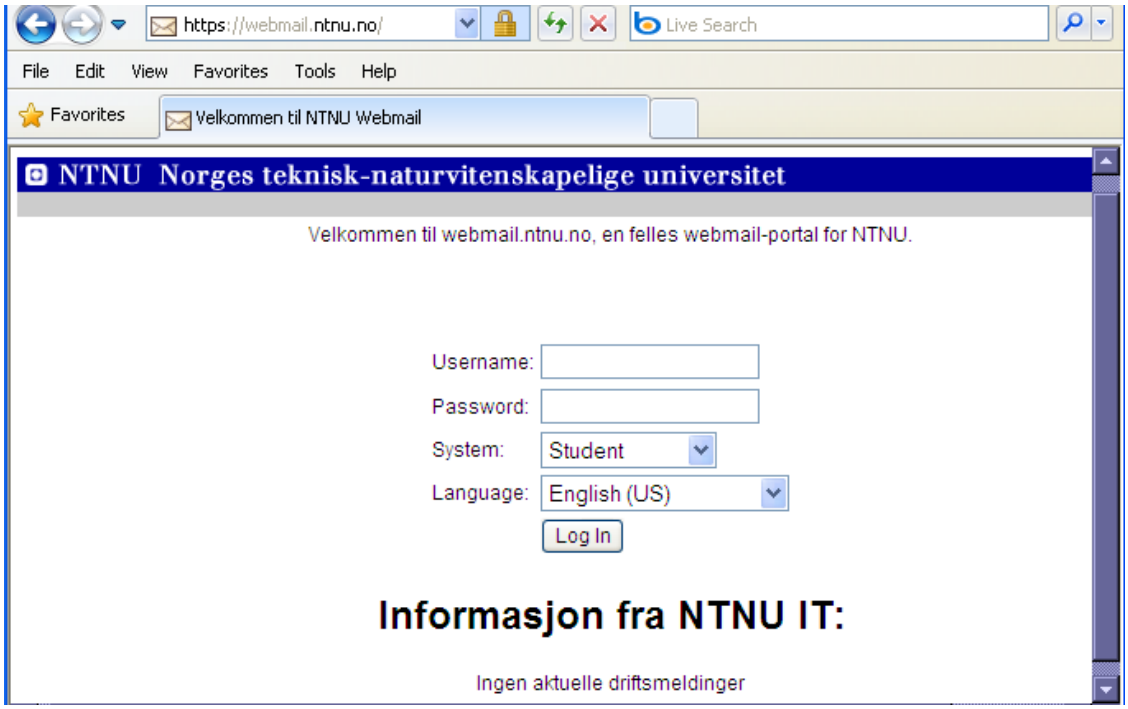


Fig 4.9 NTNU Web Email

This web interface is used by the students to access their email accounts. To make the email system more productive and ubiquitous it was necessary to develop mobile email version for students. The new mobile email client can help the students to access their accounts on the mobile devices. Keeping in view the benefits of mobile email a mobile client is developed for the students described in the following section.

4.8.1 MSIS Mobile Email

Traditional desktop email applications are used by the vast community. Always available access to the email can enhance the experience in much better way. To make it available anytime-anywhere it is important to provide it on handheld devices. The mobile email application can play a vital role for the student's collaboration and communication.

Email is the major communication channel used by the students. To provide the facility of mobile emails, an application is developed which communicates with NTNU email server.

4.8.2. Tools and Techniques used

The following section describes the tools and techniques used to develop MSIS email client application.

IMAP4 Protocol: NTNU Email Server is based on Internet Message Access Protocol (IMAP). The Internet Message Access Protocol, Version 4 (IMAP4) allows a client to access and manipulate electronic mail messages on a server. IMAP4 permits manipulation of remote message folders, called "mailboxes", in a way that is functionally equivalent to local mailboxes.IMAP4 also provides the capability for an offline client to resynchronize with the server. (Crispin, M., 1994).

IMAP4 provides operations for creating, deleting, and renaming mailboxes; checking for new messages; permanently removing messages setting and clearing flags; RFC 822 and MIME parsing; searching; and selective fetching of message attributes, texts, and portions thereof. Messages in IMAP4 are accessed by the use of numbers. These numbers are either message sequence numbers (relative position from 1 to the number of messages in the mailbox) or unique identifiers (which are not necessarily contiguous). (Crispin, M., 1994)

SMTP Protocol: Simple Mail Transfer Protocol is Internet's standard host-to-host mail transport protocol and traditionally operates over TCP, port 25. It is mainly used for outgoing emails. SMTP is a text-based protocol, in which a mail sender communicates with a mail receiver by issuing command strings and supplying necessary data over a reliable ordered data stream channel.

SMTP is a delivery protocol only. It cannot *pull* messages from a remote server on demand. Other protocols, such as the Post Office Protocol (POP) and the Internet Message Access Protocol (IMAP) are specifically designed for retrieving messages and managing mail boxes. An e-mail client requires the name or the IP address of an SMTP server as part of its configuration. The server will deliver messages on behalf of the user (Wiki, 2010).

The NTNU Email system is based on IMAP4 and SMTP protocols. To communicate with these protocols third party APIs are used. A brief overview of the APIs (Advanced Intellect, 2010)used is as follows:

- **aspNetIMAP**

  This library is used to access and communicate with IMAP servers. These APIs support Microsoft .NET Framework. aspNetIMAP consists of two libraries (aspNetIMAP and aspNetMime), that are used by software developers to create IMAP aware applications. These libraries, also commonly referred to as assemblies or dlls, are written in managed code, and do not have any COM dependencies. These APIs also provide SSL connection to communicate with IMAP servers. aspNetIMAP provides support such as connection management, folder management, message management and other message retrieval properties.

- **aspNetMime**

  This library helps to process and parse different type of email contents. It provides help to access email messages, or its attachments, embedded images, headers, or different parts of an email/MIME message. It provides functionality for accessing intricate parts of the MIME message, along with encoding and decoding methods. It is used with aspNetIMAP to process and retrieve emails.

- **aspNetEmail**

  This is a .NET assembly used for sending email messages. aspNetEmail is providing functionality such as DataSet MailMerges, emailing web forms, multi-part mime emails, attachment capabilities, along with embedding images. aspNetEmail allows to send email from any .NET application. This library can be used from ASP.NET web pages, to windows forms and to web services.

All the above assemblies are used to build NTNU mobile email client. These APIs does not provide direct help to mobile applications. Since these are specially designed for desktop and web applications. To use these assemblies to develop mobile email client web services are built which provide two way communications with mobile email application and mail server through these APIs. The following diagram shows how these assemblies are used in mobile email application.

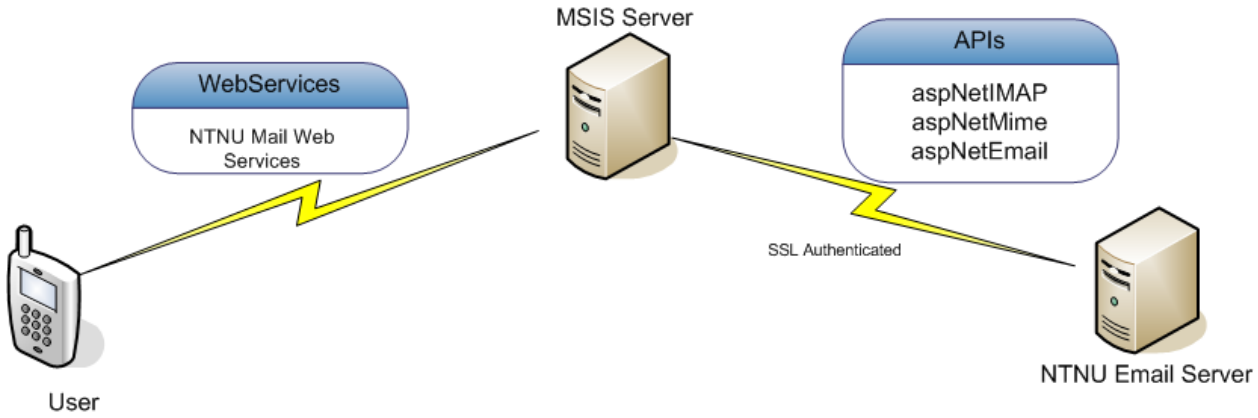


Fig 4.10 NTNU Mobile Email

The web services which are responsible for communication to the NTNU email server are deployed on the MSIS server. The client calls the web services on MSIS server which in turn uses the email APIs to communicate to the NTNU email server.

The following use case diagram shows the basic functionalities of the MSIS mobile application.

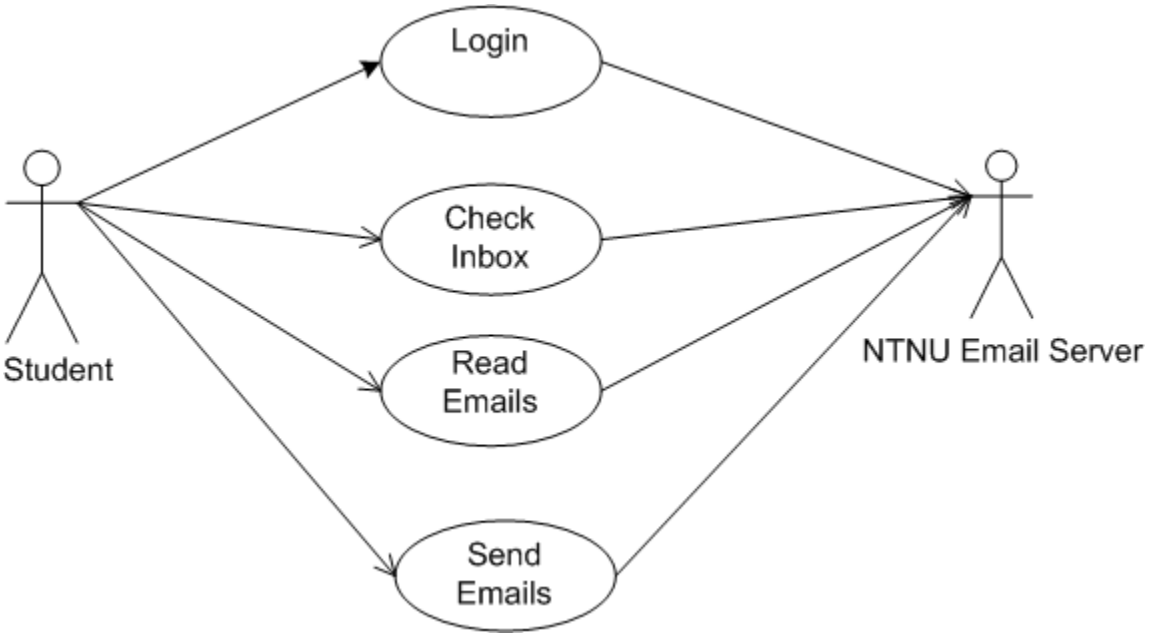


Fig 4.11 MSIS Email Use Case

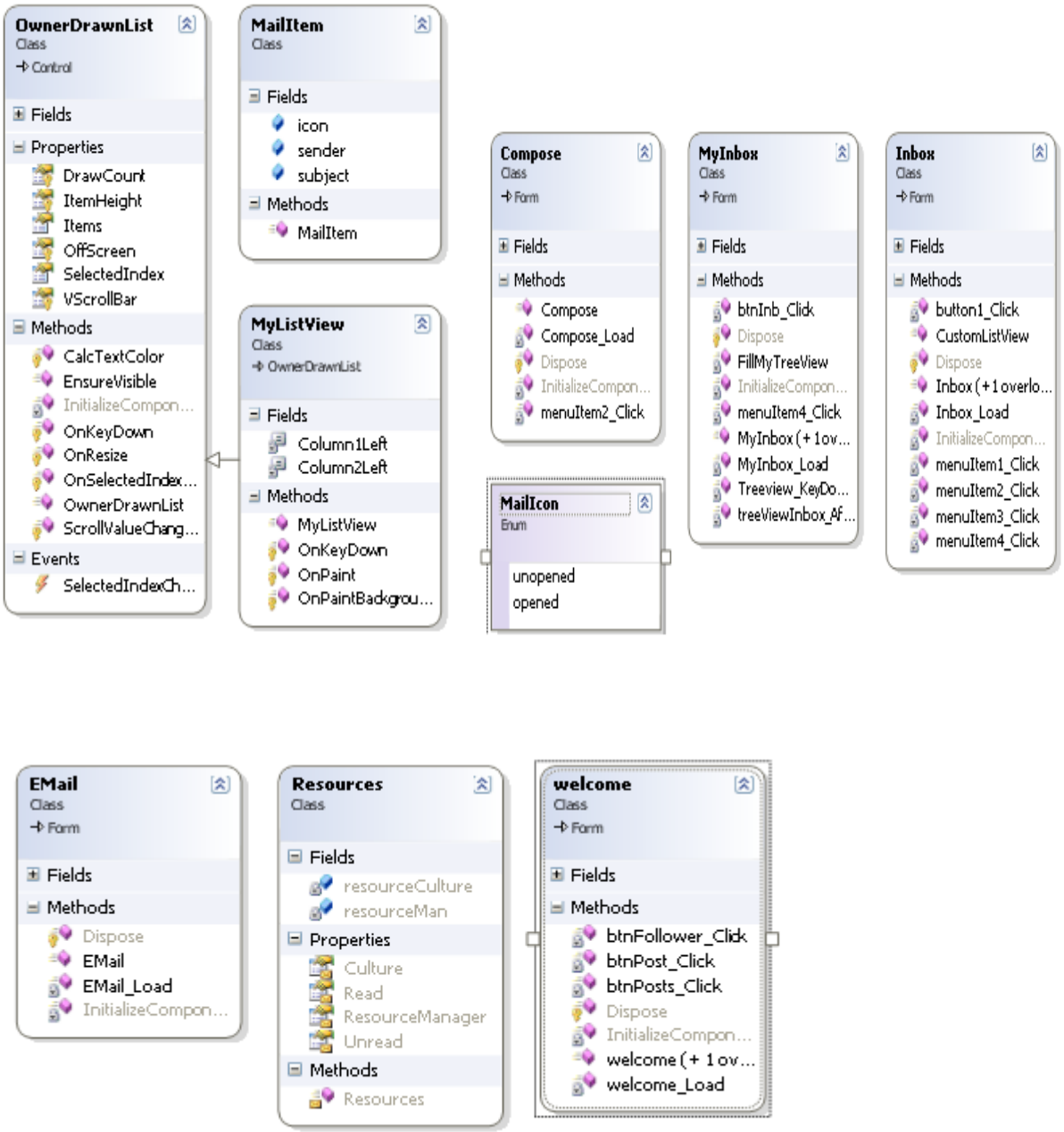


Fig 4.12 MSIS Email class diagram

4.9 MSIS Feeds

Most people are interested in many websites whose content changes on an unpredictable schedule. Examples of such websites are news sites, community and organization information pages, product information pages, medical websites, and weblogs. Repeatedly checking each website to see if there is any new content can be very tedious.

RSS and ATOM feed is a better way to be notified of new and changed contents. Notifications of changes to multiple websites can be handled easily, and the results can be presented in a well organized and distinct form.

The number of web sites that are RSS-enabled is increasing geometrically. According to feedster.com (a search and indexing engine for RSS feeds) more than sixteen million RSS feeds are available in the web including more than 75.000 professionally published sources such as the BBC, CNN and The New York Times. (Feedster, 2010)

RSS solves a problem for people who regularly use the web. It allows people to **stay informed easily** by retrieving the latest content from the sites. People can **save time** by not needing to visit each site individually.

4.9.1 RSS data structure

RSS is a dialect of XML. All RSS files must conform to XML 1.0 specification. The followings are mandatory elements of RSS file. (RSS Advisory Board, 2010):

RSS tag	Description
<rss>	Start RSS information
<item>	Chunks of summarized information
<ttl>	Time to live (in minutes). Denotes amount of time for which information is considered valid.
<title>	The title of the information presented.
<description>	A small description of the information.
<link>	A link to the actual information in the web page.

Table 4.1 RSS basic elements

Table 4.1 summarizes the functionality of the main RSS tags. Every RSS file has the root element <rss> where the version of the RSS file is defined. The only child of the <rss> element is the element <channel>. The element <channel> may contain any number of elements <item>, the main element in a RSS file. Every element <item> always contains the tags <title>, <link> and <description>. Beside the above tags, there are other tags supporting more functionality, depending on the RSS version.

4.9.2 ATOM data structure

Atom is the name of an XML-based Web content and metadata syndication format, and an application-level protocol for publishing and editing Web resources belonging to periodically updated websites.

The Atom syndication data format is a formalization of a variety of earlier RSS syndication data formats and addresses many of the shortcomings of those formats such as being able to handle arbitrary data in a blog and not just plain text or HTML. ATOM is a relatively recent spec and is much more robust and feature-rich than RSS.

ATOM feed is constructed of two major elements <feed> and <entry>. The following table gives an overview of some of the common tags used for ATOM feeds (Nottingham & Sayre, 2005).

ATOM tag	Description
Feed Element	
<id>	This identifies the feed using a universally unique and permanent URI.
<title>	This contains a human readable title for the feed.
<updated>	This indicates the last time the feed was modified in a significant way
<author>	This names one author of the feed. A feed may have multiple author elements.
<link>	This identifies a related Web page. The type of relation is defined by the rel attribute
<category>	This specifies a category that the feed belongs to. A feed may have multiple category elements.
Entry element	
<id>	This Identifies the entry using a universally unique and permanent URI.
<title>	This contains a human readable title for the entry. This value should not be blank.
<updated>	This indicates the last time the entry was modified in a significant way.
<author>	This names one author of the entry. An entry may have multiple author elements.
<content>	This contains or links to the complete content of the entry.

Table 4.2 ATOM tags

The architecture used to develop MSIS feeds application is shown in following figure. The basic idea is to load the feed categories and feed items from the user's compact database on the mobile device. This application uses SQL Compact database to store the feeds and user created categories according to the priorities of the users.

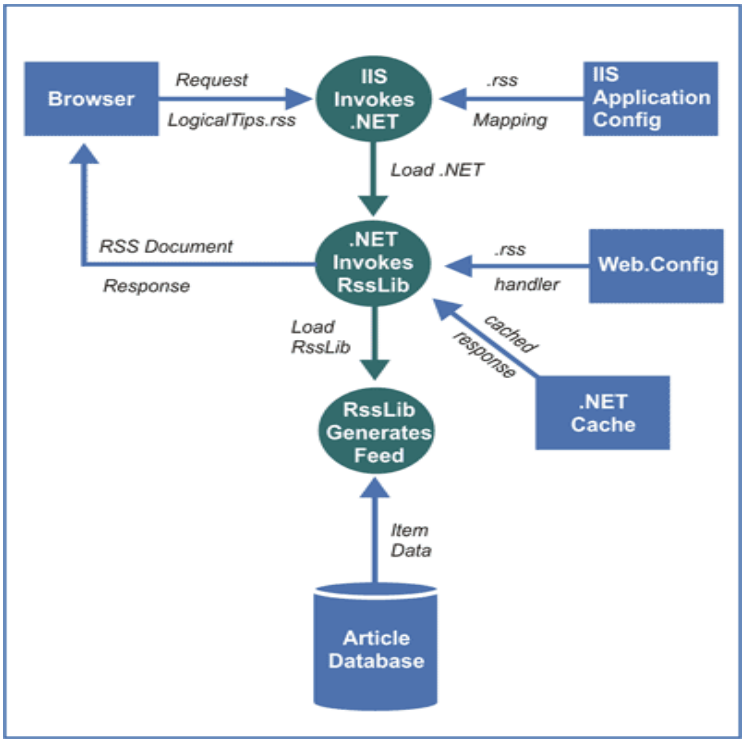


Fig 4.13 MSIS feeds architecture

4.9.3 MSIS Feeds database design

MSIS feeds application uses SQL compact database to store and manage the feeds. SQL Server CE is a lightweight relational database that supports data types that are compatible with full SQL Server 2008. It runs in-process in the application, meaning that it does not require a separate server process to operate. It can be used in Microsoft .NET Compact Framework applications running on Microsoft Windows CE or Windows Mobile, and also in .NET Framework applications running on Windows 2000, Windows XP, or Windows Vista. SQL Server CE also comes with application programming interfaces (APIs) that can be used in native applications (Andy & Daniel, 2007).

ER diagram of the database is as follows:

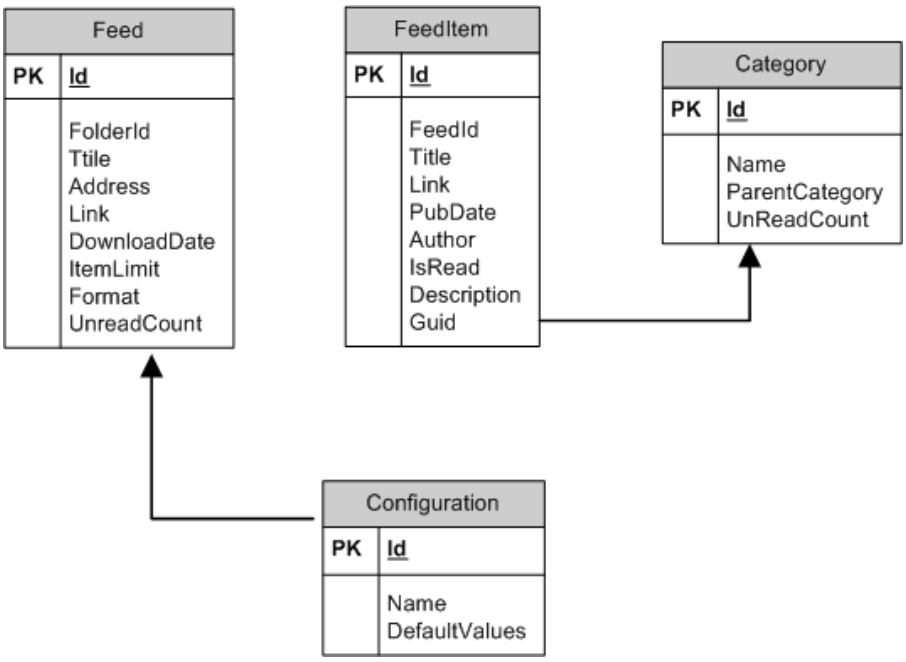


Fig 4.14 ER Diagram

4.9.4 MSIS Feeds Use Case

MSIS Feeds application provides various functionalities to the user. A brief overview of the system functionalities is shown in Fig 4.15

The feeds can be customized according to the user requirements. A complete overview of the application is presented in chapter 6.

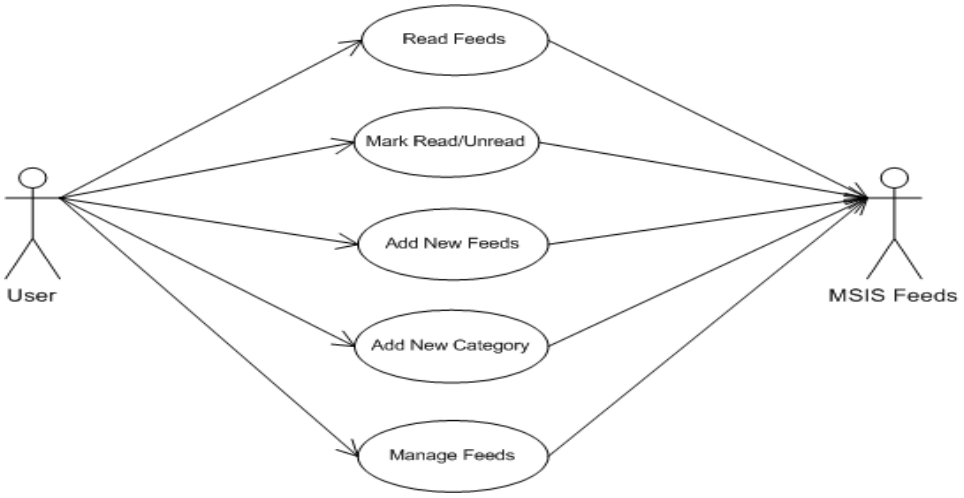


Fig 4.15 MSIS Feeds Use Case

4.9.4 MSIS Feeds Class Diagram

MSIS feeds application contains the following major classes as shown in fig 4.13. A detailed overview of these classes is shown in fig 4.16. **FeedBase** is a general class to represent any kind of feeds. There are three classes to represent different feeds such as RSS, ATOM and non recognized feeds which can use different XML specifications and formats. **FeedAtom, FeedRSS** and **FeedUnknown** are inherited from the abstract class **Feed**. **FeedItem** class is used to represents the retrieved feeds.

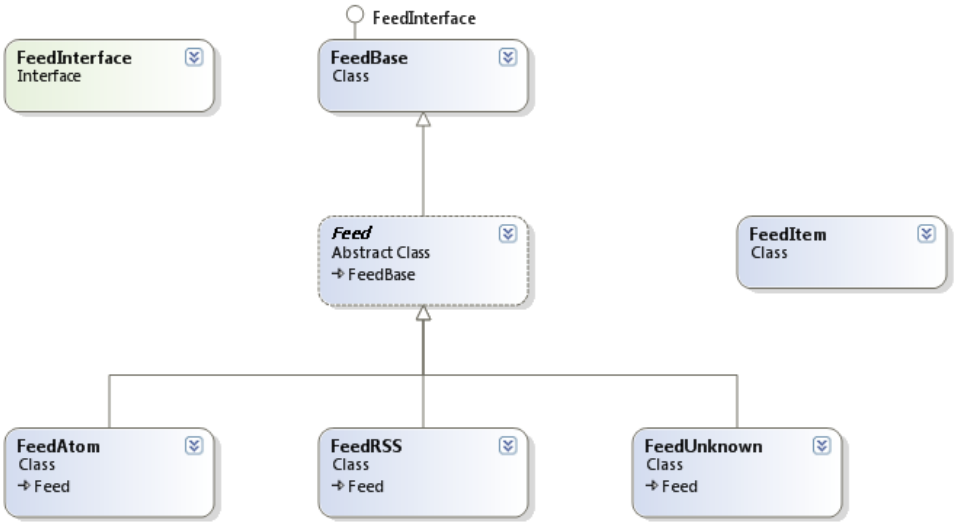


Fig 4.16 Class Summary

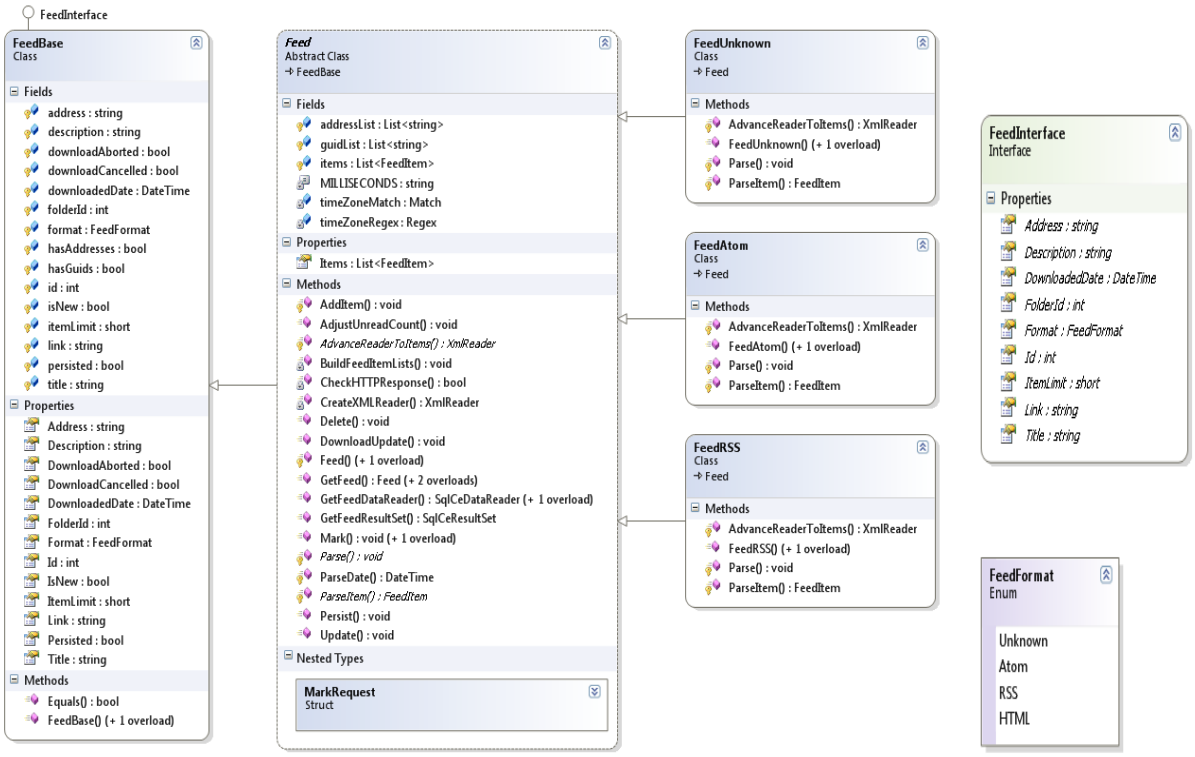


Fig 4.17 MSIS Feeds class diagram

Chapter 5: Evaluation

This chapter elaborates the evaluation process of MSIS. This evaluation consists of two major parts: usability test and user acceptance survey. The first section gives a brief introduction to evaluation process. The next section describes the usability test and overview of the user acceptance survey. Section 5.4 presents results of the evaluation.

5.1 Introduction

The Mobile student information system provides different mobile services to the students in order to enhance their experience in the study and about the campus. To verify that these services are working in real means, we carried out a usability test and user acceptance survey among our intended users from different disciplines. We wanted to test these services in the campus to get the real feelings and feedback of the users about these services.

A group of 20 students was invited to participate in the study. The test group consisted of students from various study programs, including people with both technical and non-technical background. Most of the survey participants had at least one mobile device and had some previous experience with mobile applications. Students ranging from master's students to post graduates participated in this evaluation. Our participants were from different cultures and educational backgrounds. This diversity among the test persons was expected to produce a more balanced view of the usability testing and the survey. The study constituted an important part of our final evaluation of this project. The results from the study will either confirm or reject our hypothesis that "*a system like MSIS is capable of enhancing experience of students at NTNU by providing mobile services from different sources of student information, and thus improve upon the current information services available*".

The evaluation process consisted of two major parts. One part involved a qualitative study, which in many ways was similar to a usability test, where the focus was on the usability of the system and its services, and how it could be perceived by its users. The other part of the study consisted of a quantitative survey based on an empirical model of (Gao et al, 2008)

for estimating user acceptance of mobile services. The purpose of the quantitative survey [1] was to investigate whether the target group intended to use the system and how it could fit their needs. The qualitative study made use of a number of scenarios[2] intended to illustrate the various range of uses. Feedback was gathered by observing the users during the test and the participants were asked to write down notes at the given papers while they carried out the tasks specified in the scenarios.

Before commencing the test, the participants were given a brief introduction to the MSIS system and the services it may provide. A mobile device with the application pre-installed was handed out. The participants were also informed that the data being collected would be the part of a research study.

5.2 Usability test and scenarios

The usability tests were carried out in accordance with the "*inspection evaluation method*" in an environment resembling a real-world situation for the students. The "*think-aloud protocol*" was applied to elicit cognitive feedback from the participants during the tests. Each test lasted for approximately 45 minutes. We prepared three scenarios for the test, but due to time constraints we tested only two of them to illustrate the use of the application. The scenarios consisted of a number of tasks that students would like to perform in their daily activities of study, collaboration, communication and other activities at campus. To help the users to perform scenarios we provided user guide[3] for each scenario to the users which consisted of snapshots of the application. The idea was to minimize the interaction of users with facilitators which helps us to observe the user's behavior and emotions. Another intension was to find out when and where the user will ask about help explicitly to perform different tasks of scenarios which helped us to identify the areas of improvements and user's behavior. We asked about the comments at the end of each scenario such as which part of the application work; which part did not work;

[1] See appendix for survey form and questionnaires.
[2] See appendix for test scenarios.
[3] See appendix for user guide.

response time; what was illogical or difficult in the application? Comments of users helped us to improve the solution and services.

5.2.1 Preparation for scenario 1

First scenario was to connect to social networking tool twitter which can be used in a variety of ways by different people and organizations for communication and collaboration. The idea was to follow NTNU's news and events[4] on twitter. Another intension was to follow course updates provided by the respective course teacher on twitter. To test this scenario we created test accounts on twitter for the users who did not have accounts. These accounts were configured to follow NTNU's news and events on twitter and one example of a course for updates to follow. We also configured these accounts to follow each other for collaboration and communication among a group of users.

The first task was to start and logon to MSIS application by using the provided username and password. After successful logon user could start twitter application which prompted for twitter login. Users could logon to twitter[5] by their own twitter id/password but we preferred to logon by using our provided test accounts which were specially configured for the scenarios. After the successful login each user could see the updates or tweets of his followers or friends. The next task was to check the replies and direct messages send by different followers or friends. All these updates were retrieved from twitter site in real time and displayed to the users. The last task was to send back tweets or replies to the friends. The message limit was applied to 140 characters as per policy of the twitter. After sending tweets or messages user could check their status updates on public timeline. Users were instructed to send messages and replies to each other to create a sense of collaboration among a group of students.

5.2.2 Preparation for scenario 2

In the second scenarios we put feeds service to the test. The idea was to subscribe feeds provided on NTNU website and get updates on regular basis anywhere – anytime. Another

[4] Visit http://www.ntnu.no/aktulet/blogger
[5] For more information visit http://twitter.com

intention was to get updates for a particular course if it has any. For the moment we didn't have any course webpage with feeds of any kind. To test this scenario we created some sample categories of feeds and subscribed few feeds under each category. We also subscribed IDI webpage which contained news and event feeds[6].

The first task of this scenario was to start the feed service from MSIS main application window. User could see a few categories of feeds which were already created for test. As the user started the feeds service new updates of the feeds downloaded. The next task was to read and navigate through new downloaded feeds. The users were also required to mark read or unread the feeds of their choice.

The second task of this scenario was to subscribe new feeds. Users were required to enter the URL of the feed of their choice. For the convenience of users a list of NTNU's feeds were provided in application if users did not want to type it manually. Users were also asked to customize their feeds such as storage limit, title and parent category of feeds. The next step was to check the updates of the newly subscribed feed.

The last task was to create new categories of feeds of the user's choice. Users were asked to create new categories and to subscribe new feeds under these categories in order to download the feed updates. The idea was to create the category of each course and subscribe the feeds for this particular course and other related feeds.

5.2.3 Few considerations for usability test

The first consideration was to plan and manage the usability test properly to facilitate maximum participation. We provided flexible time slots for the participants and offered some incentives while recruiting testers. We arranged a prize draw among the participants which helped us to have more participants. We provided a link for online registration for participation with suitable time slots and other relevant details with brief introduction of the research project.

[6] See http://www.idi.ntnu.no/ for news and event feeds

The second thing was to facilitate the participants during the test. We provided them printed copies of scenarios, survey form and user guide of the application. We gave brief introduction of the research project to the participants before the start of usability test.

Next was to observe how participants interact with the system during the usability test. To measure how intuitive and easy to learn the user interface is for new users, the participants were offered as little guidance as possible during the tests. We had 3-4 participants with one facilitator during the tests at one time which made it possible to observe the feelings of the participants.

Some of the participants were interviewed after completing the test, to elicit detailed feedback regarding particular parts of the scenarios. Observations, think aloud protocol, interviews and survey questionnaires were used to collect as much information as possible from the tests.

5.3 The user acceptance survey

The user acceptance survey is also an important part of this research project used to evolve the services developed for MSIS based on the Mobile Services Acceptance Model (MSAM) developed by (Gao et al, 2008).

The MSAM is an instrument which is used to estimate the usefulness and usability of mobile applications. It base its assumption on a set of quantifiable data gathered from a group of users, which are likely to be among the intended target group. The survey respondents were those who also participated in the usability test. The respondents were asked to evaluate the system according to a number of constructs which are described in section 3.3.7. To measure the impact of these constructs on mobile service adoption, the respondents were asked to specify their degree of agreement with a total of 33 statements (measurement items). A 7-point scale, with 1 being the negative end of the scale (Strongly Disagree) and 7 being the positive end of the scale (Strongly Agree), was used to measure participants' responses to items in the questionnaire. These ratings were then analyzed to estimate the individual's intention to use the application. The instrument also describes

how factors such as context, personal initiatives, and trust influence the user adoption of the mobile service. The survey seeks to address the behavioral aspects of information system research; human and organizational impacts of IS design and implementation.
The complete user acceptance survey is included in appendix B.

5.4 Presentation of test results

In this section we have presented results from usability test and user acceptance survey. The first part of this section is dedicated to the results of usability test performed with scenarios. For each scenario we also received additional comments which will be described in this part as well. The second part of this section describes the analysis of data collected from user acceptance survey.

5.4.1 Usability test

The following observations are based on comments obtained from the participants, as well as feedback collected during discussions with a selection of the test subjects. The results are presented in the same order as the tasks had been performed.

Observations and results of Scenario 1

Observations and results of scenarios task by task are described below. It also contains the analysis of comments written by the users at the end of each scenario.

Logging on to the system

The first step was logging to the MSIS application with the given username and password, start the twitter service which again required login of twitter. We wanted to give a flying start to the users to give them confidence and quick familiarity with small keyboard and small size of the screen. Secondly a sense of trust was provided for the users through these logins. On the first day of test some of the users had previous experience with touch devices. These simple tasks gave them confidence to handle the device.

Retrieving tweets, replies and direct messages

In the next task users were asked to read the tweets of their followers and friends retrieved from twitter. The task was quite simple and people felt comfortable to do this. Here we faced one issue regarding user interface with different resolutions of the devices. Anyhow it

did not affect the usability of services considerably. Since most of the users had never used a Windows Mobile handheld device previously, they felt some confusion and misunderstandings related to user interface and controls whether these were the part of our system or the operating system. Likewise, the on-screen keyboard was not user friendly compared to the keys on a traditional mobile phone. As almost no one had experience with Windows Mobile so it became a bit challenging for the users and they gone to comment on issues pertaining to the device or interface of operating system rather than our system. So we made some adjustments were to rule out any confusion.

Some other subtasks under this major task were to retrieve replies and direct messages from twitter. Users easily retrieved replies and direct messages. We observe that simple menu with few options was easy and quick to learn for the users.

Sending Tweets

The next task was to send tweets to friends and followers. We asked the users to send messages to each other being a part of a group working on an assignment and to use this as a collaboration tool. Users felt pleasure to send and receive tweets and replies on real time basis. Users liked this idea and showed willingness to use this kind of service.

The fig 5.1 gives an overview of the usability test results of scenario 1. These results are collected from the feedback of test persons. The results give the summary of success rate of each task of the scenario under test. Since our twitter service required real time connectivity and access to twitter website; there was a chance that people would not be able to access real time data from twitter. Since each scenario consisted of several tasks and subtasks, so we focused on major tasks as a whole. Different users were not able to fulfill different tasks due to different reasons, for example one task was to retrieve replies and direct messages of followers; three users were not able to access it.

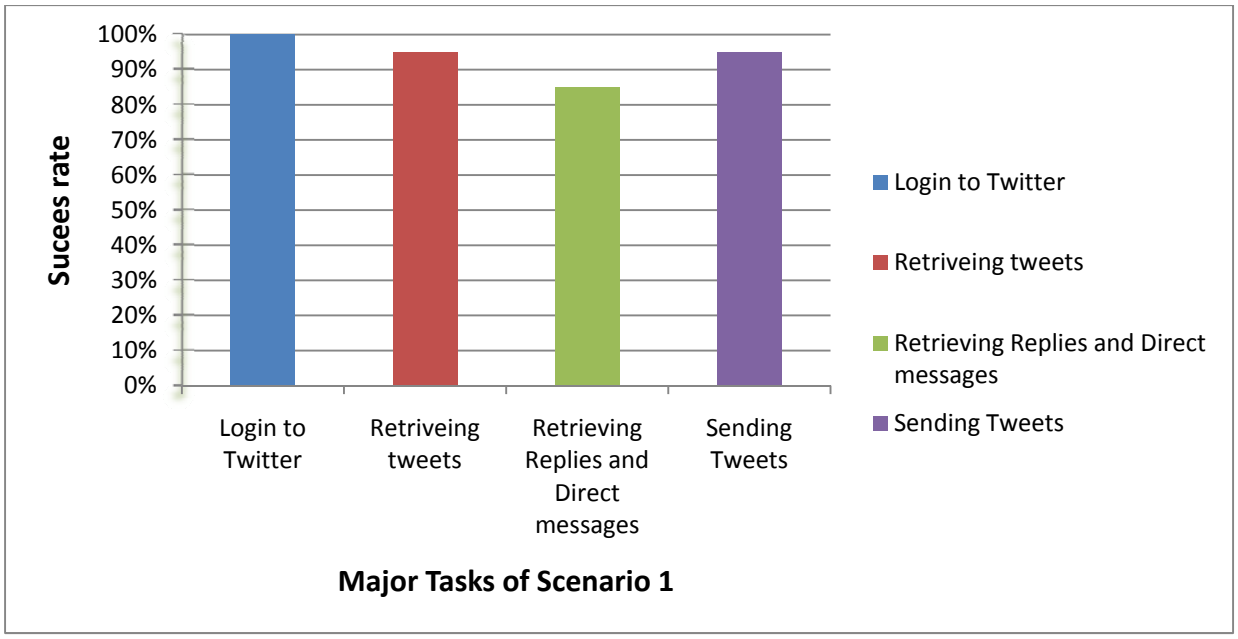


Fig 5.1 Usability test of scenario 1

A few suggestions were made by some computer science students to enhance the service of twitter. For example they suggested that there should be more options in order to deal with twitter such as creating groups, group tweets and finding friends. These were good options to implement, but due to the time constraints these functionalities were not possible to be implemented. This kind of suggestions and feedback regarding new functionalities has been included in future work.

Observations and results of Scenario 2

The second scenario was to test the feeds application; its observation and results are described task by task as follows:

Reading different feeds

The first task was to read the different feeds already subscribed for test. We provided client compact database for each device which could store all feeds and categories of the feeds generated by the users. When we start testing feeds application; two users received exception in the beginning. But it was recovered by restarting the application.

It was observed that people felt difficulty in navigating the feeds. One student felt difficulty to scroll down the whole feed as the contents of that feed were not specially designed for mobile devices. We subscribed different feeds from different sources which had different formats. The feeds application supported both major categories of RSS and ATOM feeds.

There were two ways for the people to navigate through feeds one was main menu and the other was through icons. We observed that people liked simple navigation through small icons instead of using navigations options in menu.

Adding new feeds

The second task was to subscribe new feeds of the user's choice. We provided few URLs as a list menu for users to select or they could enter the URL of their own choice as well. It was found that instead of entering the whole URL of the feed; people liked to select from available feeds in the list. It appeared to be bad idea to ask the users to enter the complete URL of the feeds.

We briefly explained the idea to retrieve updates of courses during the study through the feeds subscription of the course web page. One user suggested that to use this idea we should provide automatic subscription of the registered courses. This was a novel idea that when the user will register his course on time-planner, the feeds application should automatically configure all the feeds of the registered courses.

There were also few options to customize the feeds such as storage limit, renaming of title and parent category of the feeds. Few users asked the facilitator about how to use those options as it was bit complicated to operate. One user was not able to change the title of the feed and he wrote it in comments as well.

Adding or deleting categories of feeds

The last task of this scenario was to add new category of feeds through menu options. These were simple options to add new folder under any category. Users had done this in no time and they explored further to add feed under this new category. Sometimes due to bad URL feeds application was not being able to retrieve updates because feeds required exact URL to get the updates. Few users noted that the response time was more than 8 seconds. It was due to the weak strength of networks sometimes and also dependent upon the size of the content of the feeds.

Fig 5.2 gives a summary of test results of scenario 2. The task of this scenario was little bit complicated for ordinary users. Another issue with these tasks was to interact with different blogs and feeds in real time. This was a challenge to get 100 percent success.

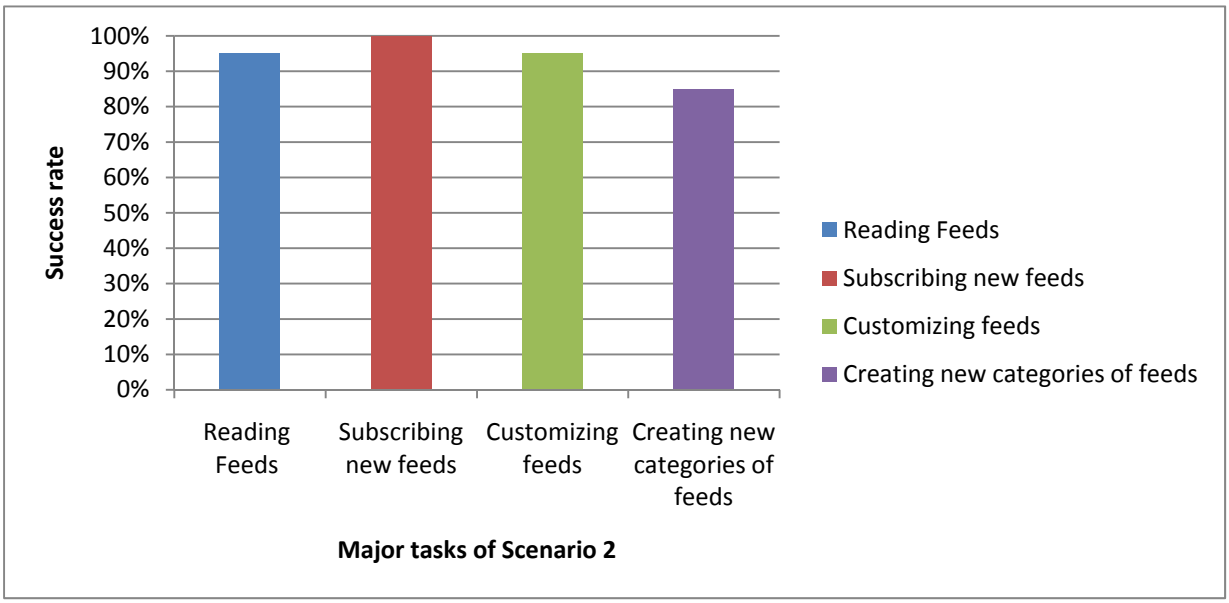


Fig 5.2 Usability test of scenario 2

We provided offline feeds for the users when one will not be able to download updates. User could download updates later on getting connectivity. Subscribing new feeds was also posing a challenge because it required complete and correct URL to RSS and ATOM feeds. To handle this challenge, we provided a list of URLs to the users to select from instead of typing the URL. Three users gave a feedback that they were not able to subscribe feeds under the new category. We provided a client database to store the feeds and categories; occasionally the database engine of device OS was not able to commit the changes of the database. Since this problem was due to device compatibility with the database; we left it to handle in further improvements of the service.

Discussion

The overall feedback of the usability test was very positive. Both twitter and feeds service worked well as this was the first test iteration of the services. The test participants could easily recognize the need for such services. As a collaboration tool, people liked twitter service and some of them who knew about twitter, liked the idea to use twitter service for academic purpose. A group of test persons used it as collaboration tool among the students of an assignment group and they really appreciated the real time collaboration like other

services such as IM. Most of the people wished to adopt it as this gives them the opportunity to use twitter for collaboration and communication on both mobile and desktop computers. A group of computer science students like the idea to follow the course during the semester on twitter. In a nutshell, the feedback about the technical and operational usability of twitter service was very positive.

For the second feeds service, people gave good response after using this service. As people found feeds on the web for different purposes; this service provided them the opportunity to have their customized tool for feed based services. Most of the persons liked it due to the fact that this service was multipurpose as it could provide them different or their favorite channels of information. A group of test persons liked the idea to receive updates for courses, assignments and other related news during the semester.

As mentioned initially, the test group included people with different backgrounds. We were curious to find out whether a mobile service like this would only appeal to technology savvy users, or if users with less computer skills would also adopt the service. Virtually all the participants were positive to the service regardless of their profession. What we did notice, however, was that the technology savvy users gave more comments regarding the technical aspects of the service. They were, for instance, more interested in the implementation and technical details behind the service than the rest of the test persons. They also paid more attention to small technical subtleties which, on the other hand were insignificant for the non-technical users. For example, one user admired the interface of twitter service and commented that it looked like iphone interface as this was not important for the users who were not iphone users.

5.5.2 Descriptive analysis of survey feedback

This section describes the analysis and results of the user acceptance survey. Some discussions are also made at the end of this section.

In the user acceptance survey we used scale of 1- 7 for response; hence one could not assume that respondents perceive the difference between adjacent levels as equidistant. The data had an inherent order or sequence, but one cannot assume that the respondent

means that the difference between agreeing and strongly agreeing is the same as between agreeing and being undecided. Because of this, many researchers dissuade from using the "mean" as a measure of item response. For example, it makes little sense to add a response of "Agree" (coded as 5) to a response of "Undecided/Neutral" (coded as 4) to get a mean of 4.5. A more appropriate measure is the median or mode, because they are less sensitive to extreme observations. On the other hand, researchers are sometimes inclined to interpret responses as interval (or "pseudo interval") data, which allows more powerful statistical methods to be used. (G. M. Breakwell et al, 2006). We believe that the computed mean can provide some more useful information, as it can give an indication of where the majority of the responses are centered.

In the following we will analyze the data obtained from the survey and discuss the results. The tables below use the same labeling for the measurement items as in the questionnaire (see Appendix B). The tables show the percentage distribution of the responses categorized by each construct. The last two rows show the summarized total of the measurement items. Total1 denotes the average response to that particular construct, based on the mode calculated from each participant's set of responses. To alleviate the impact of duplicate modes, the summarized mean is included as well (Total2). The last column denotes the average score (mean).

Perceived Usefulness

The following table 5.1 gives an overview of the results of the measurement items concerning the usefulness of MSIS application. The average score for the twitter service and the feeds application is 5.9 which is a good score for a small number of participants. As 95% people are in scale from 5-7 which is a good indicator of the usefulness of these services. The second highest average score, 5.6, is for PU-5 which is about the usefulness of these services for students.

The main reason for the people who remain neutral or did not perceive these services' usefulness was that they didn't know much about twitter and feeds. During the survey we encouraged people to use their own twitter accounts and we found that only one test person had a twitter account. Other persons used test accounts which were configured only for test and could not fulfill the requirements of individual interests. Similar case had been

seen with feeds service; as computer science students were more aware of the feeds compared to non computer science students.

Summing up, the majority of the users perceived the system as easy to learn and interact with. Based on the results, we concluded that the new users would easily be able to adopt the system. The findings from the user acceptance survey confirm the tendency of adopting these services when these will be in real settings such as when teachers will provide accounts on twitter for particular courses or feed based notifications of the courses. The few suggestions to use twitter and feeds application in academia are also presented in chapter: Results and discussions.

Response: (1)Strongly Disagree-----(7) Strongly Agree														
Item	**(1)**		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**	**Avg.**
PU1	0.0%	(0)	5.0%	(1)	5.0%	(1)	35.0%	(7)	35.0%	(7)	10.0%	(2)	10.0% (2)	4.7
PU2	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.0%	(1)	35.0%	(7)	25.0%	(5)	35.0% (7)	5.9
PU3	0.0%	(0)	0.0%	(0)	0.0%	(0)	20.0%	(4)	40.0%	(8)	40.0%	(8)	0.0% (0)	5.2
PU4	0.0%	(0)	0.0%	(0)	10.0%	(2)	15.0%	(3)	50.0%	(10)	10.0%	(2)	15.0% (3)	5.1
PU5	0.0%	(0)	0.0%	(0)	5.0%	(1)	10.0%	(2)	30.0%	(6)	35.0%	(7)	20.0% (4)	5.6
Total1	0.0%	(0)	0.0%	(0)	0.0%	(0)	10.0%	(2)	55.0%	(11)	15.0%	(3)	20.0% (4)	5.5
Total2	0.0%	(0)	1.0%	(1)	4.0%	(4)	17.0%	(17)	38.0%	(38)	24.0%	(24)	16.0% (16)	5.3

Table 5.1 Frequency Results- Perceived Usefulness

Perceived Ease of Use

The responses to the perceived ease of use of the services are presented in Table 5.2. The average score for EOU1: Learning to operate the system "*would easy for me*" gains highest score. 95% respondents agreed that the system was easy to learn and operate as most of our users were not technology aware. One user found it difficult to learn and operate because of unawareness with touch mobile services.

The second item that got a good average score of 5.6 is EOU2: which was about "*how easily the user found the required information"*? 85% users were agreed to this. Similarly EOU3 was about "*user interface that it was clear and intuitive*" and it got a response of 70% agreed. Few users found the interface difficult to handle. This was because of the fact that

our mobile devices had different resolutions and settings. Due to different resolutions few menus of our application did not display properly.

EOU4 receives lowest response which was about "*the flexible interaction to the system*". We also received feedback that it was difficult for few users to interact with. Few users asked about the limited message length in twitter service which is the length of the message posed by twitter itself. We received good response on average 5.4 in EOU5 which was about "*how much system was easy to use*".

Response: (1)Strongly Disagree-----(7) Strongly Agree															
Item	**(1)**		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**		**Avg.**
EOU1	0.0%	(0)	0.0%	(0)	5.0%	(1)	0.0%	(0)	20.0%	(4)	35.0%	(7)	40.0%	(8)	6.1
EOU2	0.0%	(0)	0.0%	(0)	0.0%	(0)	15.0%	(3)	30.0%	(6)	35.0%	(7)	20.0%	(4)	5.6
EOU3	5.0%	(1)	5.0%	(1)	5.0%	(1)	15.0%	(3)	30.0%	(6)	20.0%	(4)	20.0%	(4)	5.3
EOU4	5.0%	(1)	5.0%	(1)	5.0%	(1)	20.0%	(4)	15.0%	(3)	30.0%	(6)	20.0%	(4)	5.1
EOU5	0.0%	(0)	5.0%	(1)	10.0%	(2)	5.0%	(1)	25.0%	(5)	30.0%	(6)	35.0%	(5)	5.4
Total1	0.0%	(0)	5.0%	(1)	5.0%	(1)	5.0%	(1)	30.0%	(6)	25.0%	(5)	30.0%	(6)	5.6
Total2	2.0%	(0)	3.0%	(3)	5.0%	(5)	11.0%	(12)	24.0%	(23)	30.0%	(30)	27.0%	(25)	5.5

Table 5.2 Frequency Results- Perceived Ease of Use

Trust of Users

Trust of users is believed to be an important factor for the adoption of mobile services. We proposed six measurement items related to trust in our user acceptance survey. The results show that 95% people were concerned about the reliability of data. The second factor which got maximum score is the privacy of the users as shown in table 5.3.

TU4 received important response which is about "*to keep the system under control*". It shows that people were very concerned to have control of the system which they were using. Control over the system would give them more confidence to use and privacy.

There was response "important" on the average for TU1 which is "*about the clear conception of the functionality of the system*". But still this result argues that the users should have clear conception of the functionalities of the system.

Response: (1)Not Important-----(7) Very Important														
Item	(1)		(2)		(3)		(4)		(5)		(6)		(7)		Avg.
TU1	0.0%	(0)	0.0%	(0)	5.0%	(1)	15.0%	(3)	40.0%	(8)	35.0%	(7)	5.0%	(1)	5.2
TU2	0.0%	(0)	5.0%	(1)	5.0%	(1)	25.0%	(5)	15.0%	(3)	45.0%	(9)	5.0%	(1)	5.1
TU3	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.0%	(1)	25.0%	(5)	25.0%	(5)	45.0%	(9)	6.1
TU4	0.0%	(0)	0.0%	(0)	5.0%	(1)	5.0%	(1)	30.0%	(6)	35.0%	(7)	25.0%	(5)	5.7
TU5	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.0%	(1)	5.0%	(1)	40.0%	(8)	50.0%	(10)	6.4
TU6	0.0%	(0)	0.0%	(0)	5.0%	(1)	10.0%	(2)	30.0%	(6)	25.0%	(5)	30.0%	(6)	5.7
Total1	0.0%	(0)	0.0%	(0)	5.0%	(1)	0.0%	(0)	30.0%	(6)	40.0%	(8)	25.0%	(5)	5.8
Total2	0.0%	(0)	0.8%	(1)	3.3%	(4)	10.8%	(13)	24.2%	(29)	34.2%	(41)	26.7%	(32)	5.7

Table 5.3 Frequency Results- Trust

To sum up, our findings indicate that there is a strong relationship between trust and the individual's intention to use a mobile service, and thus it confirms the hypothesis proposed by the Mobile Services Acceptance Model. However, there are different aspects of trust which may apply to different type of applications. For example, in our study, the most important factor proved to be the reliability of data. This may have turned out differently if the application subject to evaluation was, for instance, a service for mobile commerce, for which vendor reputation and recognition is likely to be of greater concern (users are generally more cautious to adopt services which involve financial transactions).

Personal Initiatives and characteristics

Table 5.4 presents the findings from the construct Personal Initiatives and Characteristics. The response of PIC1 which is about "*using the system would be interesting*" showed good percentage 85% and average score of 5.7. We got some neutral responses from three persons but no response of disagreement was received which gave us the conclusion that the system will be interesting for the users.

We receive neutral response over PIC2 (fun to use the system), PIC3 (prefer to be the first user of the system) and PIC4 (system gives advantage over those who do not have). We found that the reason to have this neutral response was that very few people knew about the use of twitter and feeds services. Another reason is that these services are quite general and needs to provide real context in which we intend to use these services. Most probably

that people didn't understand the context of these services i.e; how the twitter and feeds services can be used in academia.

We received a strongly disagree response in PIC7 which was about that "*using this mobile system can be considered as a social status symbol among friends*". It shows that people will not adopt these services for social status instead they want real utilization of these services.

Response: (1)Strongly Disagree-----(7) Strongly Agree														
Item	**(1)**		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**	**Avg.**
PIC1	0.0%	(0)	0.0%	(0)	0.0%	(0)	15.0%	(3)	30.0%	(6)	25.0%	(5)	30.0% (6)	5.7
PIC2	0.0%	(0)	5.0%	(1)	0.0%	(0)	35.0%	(7)	25.0%	(5)	25.0%	(5)	10.0% (2)	5
PIC3	10.0%	(2)	0.0%	(0)	5.0%	(1)	35.0%	(7)	10.0%	(2)	20.0%	(4)	20.0% (4)	4.8
PIC4	0.0%	(0)	0.0%	(0)	10.0%	(2)	50.0%	(10)	10.0%	(2)	10.0%	(2)	20.0% (4)	4.8
PIC5	0.0%	(0)	0.0%	(0)	10.0%	(2)	15.0%	(3)	5.0%	(1)	30.0%	(6)	40.0% (8)	5.8
PIC6	0.0%	(0)	0.0%	(0)	0.0%	(0)	35.0%	(7)	35.0%	(7)	25.0%	(5)	5.0% (1)	5
PIC7	10.0%	(2)	5.0%	(1)	25.0%	(5)	35.0%	(7)	10.0%	(2)	15.0%	(3)	0.0% (0)	3.4
Total1	0.0%	(0)	0.0%	(0)	0.0%	(0)	40.0%	(8)	10.0%	(2)	20.0%	(4)	30.0% (6)	5.4
Total2	2.9%	(4)	1.4%	(2)	7.1%	(10)	31.4%	(44)	17.9%	(25)	21.4%	(34)	17.9% (25)	5.2

Table 5.4 Frequency Results- Personal Initiatives and Characteristics

Significance of Context

The adoption of mobile services is likely to be more affected by context than traditional desktop applications. The response of CT1 (use the system when out of home or office) is quite satisfactory people liked to use these services when they would be out of home or office. The response of CT2 didn't receive good response as people will not adopt the services based only because others are using the system and they should also use it.

People showed good response 75% on CT3 which is about the previous experience of using the mobile services. We didn't receive a strong response as most of our users had no previous experience of service like these.

People showed a good response 85% of acceptance for these services if the university or the organization will encourage them to use the system. It is important evidence that people needs encouragement to adopt new technology and services like these.

We received very good response on the relevancy of these services to the user's daily tasks (CT5). People found it meaningful in the context that it would help them in collaboration and communication of their daily life. There is also a strong response (95%) that people would use if they do not have access to desktop or laptop computers (CT6) as expected. Similarly the response on context based services shows the importance of location based services (CT7).

Response: (1)Strongly Disagree-----(7) Strongly Agree														
Item	**(1)**		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**	**Avg.**
CT1	0.0%	(0)	0.0%	(0)	5.0%	(1)	10.0%	(2)	15.0%	(3)	45.0%	(9)	25.0% (5)	5.8
CT2	0.0%	(0)	5.0%	(1)	20.0%	(4)	5.0%	(1)	25.0%	(5)	35.0%	(7)	10.0% (2)	5.1
CT3	0.0%	(0)	0.0%	(0)	5.0%	(1)	20.0%	(4)	25.0%	(5)	25.0%	(5)	25.0% (5)	5.4
CT4	0.0%	(0)	0.0%	(0)	5.0%	(1)	10.0%	(2)	10.0%	(2)	45.0%	(9)	30.0% (6)	5.9
CT5	0.0%	(0)	0.0%	(0)	0.0%	(0)	10.0%	(2)	10.0%	(2)	35.0%	(7)	45.0% (9)	6.2
CT6	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.0%	(1)	15.0%	(3)	35.0%	(7)	45.0% (9)	6.2
CT7	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.0%	(1)	20.0%	(4)	40.0%	(8)	35.0% (7)	6.1
Total1	0.0%	(0)	0.0%	(0)	0.0%	(0)	5.0%	(1)	15.0%	(3)	35.0%	(7)	45.0% (9)	6.2
Total2	0.0%	(0)	0.7%	(1)	5.0%	(8)	9.3%	(13)	17.1%	(24)	37.1%	(52)	30.7% (43)	5.9

Table 5.5 Frequency Results- Context

Intention to Use

Intention to use was the last construct of the user acceptance survey. Table 5.6 shows the response of the users. We have omitted the modular scores from this table as it makes no sense to use with two variables. The item IU1 shows the proportion of respondents that intended to use the system, assuming that they have access to it. We received 45% strong and 15% very strong response to use the system and it shows the positive intention to use

the system. 25% people thought that they might use this system. Other 15% people were either neutral or unlikely to use the system.

The last item (IU2) gives an indication of the proportion of users which predict that they would use the system provided they had access to it. The respondents gave the approximately same response to IU1. It shows that providing access to the system will motivate the users to use it.

To get an overview of the percentage of respondents that intended to use the system, we have taken the minimum value of the two responses from each respondent, and then computed the frequency distribution which is depicted in the row labeled Total3. Two respondents didn't intend to use the system, while four were undecided. We selected the minimum of the two item responses in order to get the most conservative estimate of user adoption as shown in following table 5.6.

Response: (1)Strongly Disagree-----(7) Strongly Agree														
Item	**(1)**		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**		**Avg.**
IU1	0.0%	(0)	5.0%	(1)	0.0%	(0)	10.0%	(2)	25.0%	(5)	45.0%	(9)	15.0%	(3)	5.5
IU2	0.0%	(0)	5.0%	(1)	0.0%	(0)	10.0%	(2)	20.0%	(4)	60.0%	(12)	5.0%	(1)	5.5
Total2	0.0%	(0)	5.0%	(2)	0.0%	(0)	10.0%	(4)	22.5%	(9)	52.5%	(21)	10.0%	(4)	5.5
Total3	0.0%	(0)	5.0%	(1)	0.0%	(0)	15.0%	(3)	30.0%	(6)	45.0%	(9)	5.0%	(1)	5.3

Table 5.6 Frequency Results- Intention to Use

Relationship between Perceived usefulness and Intention to Use

The following Fig5.3 shows how the perceived usefulness of the application relates to intension of use. The graph shows that it might not always be a positive correlation between the perceived usefulness and the intention to use a mobile device. It shows how the people might perceive the system and what their intention to use the system is.

Horizontal axis shows the number of respondents and vertical axis shows the scale used for user acceptance survey. The two lines of graph shows *perceived usefulness* and *intention to*

use the system. It provides an overview of the correlation between these two constructs which can play a vital role in adoption of mobile services.

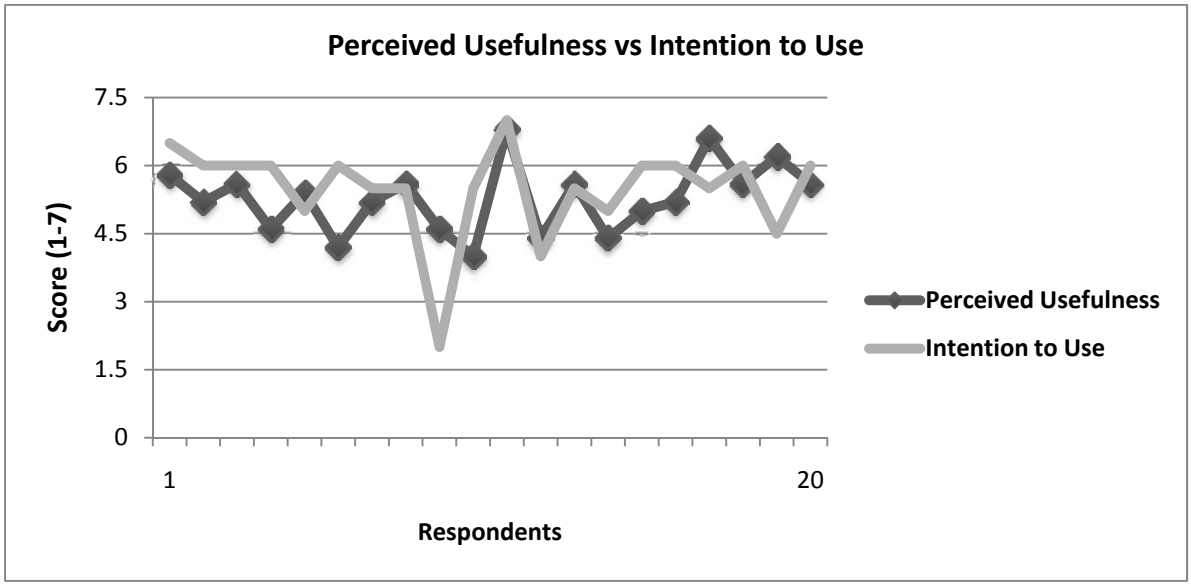


Fig 5.3 Perceived Usefulness vs Intention to Use

Relationship between Perceived Ease of use and Intention to Use

The following Fig 5.4 shows the relation between the *perceived ease of use* and *intention to use*. It is a clear indication that the ease of use of the application affects the intention to use. The respondents, who rate the ease of use low, do the same for the intention to use as well as it is clear from the following graph. Hence it is clearly evident that ease of use will affect the adoption of mobile services for the users.

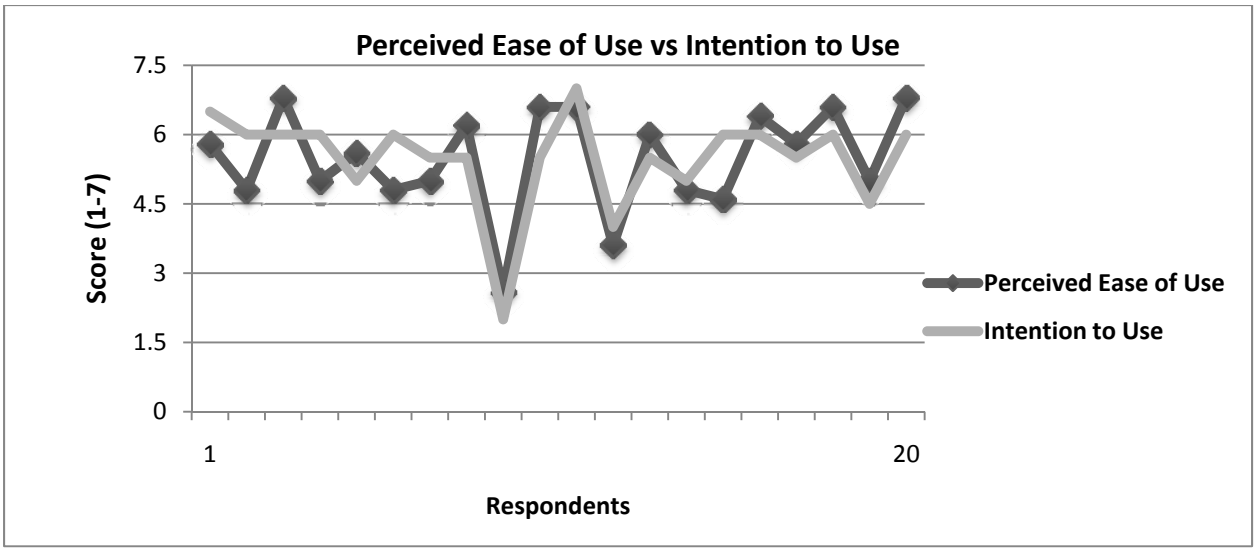


Fig 5.4 Perceived of Use vs Intention to Use

5.6 Validity of results

Performing usability studies for applications running on mobile devices can be a difficult task. Typical user study scenarios collect information by means of attaching an external camera to capture a view of the mobile screen (T. Kallio et al, 2005) or through logging (F. Paterno et al, 2007). Using an external camera to view the mobile device's screen is quite challenging because of the fact that the screen is small and most of the time the user is occluding the screen (F. Balagtas-Fernandez et al, 2009). Logging of events, on the other hand, can be an accurate source of usage information. The challenge in event logging though is in the whole process of preparing the system for data collection, the extraction and interpretation of the vast amount of logged data.

Despite of all these approaches we felt that this was not necessary in our study as such devices can also be an impediment on the use of the system. Instead we included a few control questions in our tasks for each scenario in order to measure the validity of the data returned from the system. We asked users to note down for each task whether it worked or not.

Although the sample size of 20 users might be bit small from statistical point of view, the main objective was to reveal the usability issues with the system and capture qualitative

feedback from potential users. According to (Faulker 2003), a sample size of 20 users was sufficient to find 95% of all usability problems. And in this usability study we tested the technical and operational factors of the services and got the positive feedback to improve these services.

Since we had respondents from different departments and with different backgrounds which means that results can represent the general view but still two factors are very important, such as "*limited period of time"* and "*lack of real context of services*". At least these services should be used during the whole semester due to their nature. A longitudinal study with larger sample size in real context may reveal the real strength of these services.

Source of distortion

Likert scales may be subject to distortion from several sources, which may influence the results of the study. Respondents may avoid using extreme response categories (central tendency bias); agree with statements as presented (acquiescence response bias); or try to portray themselves or their group in a more favorable light (social desirability bias). Designing a scale with balanced keying (an equal number of positive and negative statements) can obviate the problem of acquiescence bias, since acquiescence on positively keyed items will balance acquiescence on negatively keyed items, but central tendency and social desirability are somewhat more problematic. We did observe central tendency bias to some extent, but a remarkable large portion of the responses was to the right-most, i.e. a score of 7 (Strongly Agree). It is possible that this is a result of social desirability bias: the respondents wanted to agree with statements in order to please the developers. Or, in the case of the Ease of Use construct, they wanted to give the impression of being capable of using the system.

5.7 Summary

The evaluation was successful in identifying problems and issues with the newly built services. We received quite encouraging response regarding the services, and the general

perception is that the functionalities added to MSIS by integrating it to different student related information sources are of great value at NTNU.
We found that people will adopt as they find these services in real context. The services built are quite general in nature and it requires real context to use. But in this usability study we found some shortcomings with the services which can be improved easily. Since our services work in real time with other systems such as twitter and feed owners and it can affect the technical and operational factors of our services as well because twitter and feed based systems are in a continues process of development.

However the results of our evaluation suggest that a considerably higher portion of users are willing to adopt the system. The actual user adoption of the system might be higher or lower than what our measurements indicates. However, presented results should be regarded as a good indication of user's willingness to use the system.

Chapter 6: Results and Discussions

This chapter discusses the overall research work done in this study and the results obtained. It discusses the research questions and the achievements made regarding these research questions. It also contains a brief discussion on the evaluation of the services built. This chapter also evaluates the services that has been developed, and discusses its utility and possible shortcomings.

6.1 Services built for MSIS

In the study of last autumn (Asif, 2009), an integration architecture based on SOA was proposed with solution guidelines. The idea was to integrate MSIS with different information sources to provide different information services that can enhance the experience of student community.

In this study, three systems, twitter, feed based systems and NTNU email were selected to be integrated with MSIS based on the integration architecture proposed in previous study (Asif, 2009). A usability study was also performed on these services (See chapter 5) in order to evaluate these services. The following section describes these services in brief with some evaluation of results obtained.

6.1.1 Twitter Service

A twitter service is built for MSIS which is integrated with twitter system. To build this application, twitter APIs are used and users can use their existing twitter accounts on this application (See chapter 4 for detail). The idea was to provide a platform on mobile devices in the context of MSIS for students where they may collaborate and communicate.

This service contains several features which provide an opportunity to the students to communicate and collaborate with their fellows, teachers or they can also follow the course. Below are given a few screen shots of the services. The next section describes few suggestions to use the twitter service for academic purpose.

(a) Main Screen

(b) Twitter login

(c) Main timeline and menu options

Fig 6.1 An overview of MSIS twitter service

Usability and survey results

We performed a usability and user acceptance survey for this service among a group of 20 students (See chapter 5). As the result of technical usability, we did not find any problems with the service. All aspects of this service worked fine except the resolution problem with a couple of devices as it affected the visibility of messages. Results of technical usability are presented in chapter 5.

The acceptance of this service among the group of students was good and people liked the service and appreciated its good response. The detailed results of the acceptance of this service have already been presented in chapter 5. One issue with testing was that most of the users in the test group were not well aware of twitter itself. After a brief introduction of this service people found it interesting and showed willingness to use this service. But still this service was not tested in real settings. The lack of real settings and less awareness of the test group about the twitter itself reduce the acceptance of this service. The next section describes few scenarios to use this service in an effective way.

Few suggestions to use twitter service

Twitter itself is a social networking tool and it can be used in a variety of ways. This MSIS twitter service can also be utilized in a variety of ways for academic purpose. Below are given some suggestions divided into for specific groups and purposes.

Ideas for Instructors

Instructors can be benefited from these suggestions.

- *Notes after class***:** This MSIS twitter service can serve as a notepad to record thoughts or ideas from a lecture after the class.
- *Lesson plans*: Teachers can use MSIS twitter service to give lesson plans to their students, and even other teachers can also get the related information.
- *Collaborate*: Instructors can collaborate with each other using this service. Instructors can learn from and share with other instructors at one campus or at campuses around the world.
- *Instant feedback*. Especially in a large lecture class, this service can provide instructors opportunity for instant feedback about the class and the delivered lecture.
- *Increase class participation*. Having students use this service can help for more class participation, from acknowledging their attendance to finding a daily schedule.

Benefits for Students

These tips offer benefits for students, improving their learning environment.

- *Asynchronous class conversation*: Using MSIS twitter service students can discuss topics relevant to what is happening in the class as if something is going to happen away from traditional class time.
- *Create community*: Students who come together as a community are generally more open to communicate and learn from one another in the class. This MSIS

twitter service can promote a sense of community by sharing some personal information.

- *Create a greater depth of interpersonal understanding***:** Using this MSIS twitter service it can be easy to know small bits of someone over time provides a greater picture of that person, therefore developing a deeper sense of understanding that promotes more openness and sharing in the classroom.
- *Make better connections with professors*: Students and professors can communicate through this MSIS twitter service to open up better working relationships.
- *Post questions about assignments:* If during the study students get stumped, posting a question on this service can opens up opportunities for other students to help clarify or for the instructor to step in.
- *Ask questions without raising a hand*: Standing behind this service is sometimes less intimidating than raising a hand and having an entire class staring at you when asking a question. This service can encourage asking questions or finding clarification.

Tips for the Class

The following suggestions can improve the class experience for a new way of finding and sharing information.

- *Direct tweet or messages*: Professors and students can contact each other through direct messages without having to share cell phone numbers.
- *Collaborate on projects.* While working together on projects, set up a group using an application like "Tweet works[7]" to facilitate communication with everyone in the project.
- *Make announcements*: Professors can send out reminders about upcoming tests, project deadlines, or any other class news.

[7] Tweet works is a website (www.tweetworks.com) where groups can be created.

- *Brainstorm*: Brainstorming on class topics can be done by posting them using MSIS twitter service anytime-anywhere and can be seen who else is contributing.

6.1.2. Feeds Service

The second service built for MSIS is a feed service which is developed to work with different kinds of feeds such as RSS and ATOM. Each organization or institute is providing feed based news, announcements, updates and other notification services. This service provides different features to subscribe and manage different feeds from the sources of choice (for detail see Chapter 4). Each client has its own local database which is used to manage and store offline feeds when there is no connectivity.

This service is quite general in purpose; but the basic idea was to create feeds for the courses the students are taking during the semester. Based on the feeds provided for the course, students will be able to subscribe their courses to get updates or announcements. This service can be utilized in a variety of ways depending on the user's choice. The following fig 6.2 shows some snapshots of this service.

(a) List of feed categories (b)List of feeds (c) List of news

Fig 6.2 Feeds Service

Discussion of usability and survey results

A usability test was conducted with a group of users to find the technical issues with the service. A couple of problems pop up on the first day of testing and we modified the application based on the feedback. An overview of the success rate of the tasks performed in scenario has been presented in chapter 5.

User acceptance survey was also the part of this study and provided good results about the acceptance of this service. An analysis of the survey with this service has been presented in chapter 5. The acceptance of this service was quite good, but still some people were not well satisfied with the application. The basic reason was that people did not know much about feeds and its working. For this service, it was a challenging task for them to use and understand the usefulness of the service. Few users of computer science background were well satisfied as compared to the users who were not familiar with feeds.

Another reason for less satisfaction with the service was that it was not tested for real settings. For example there should be some feeds for courses and then user should use this service for a long period of time to get the real experience of this service.

Few usages and benefits

Here are few suggestions to use this service and its potential benefits:

This service can used to provide:-

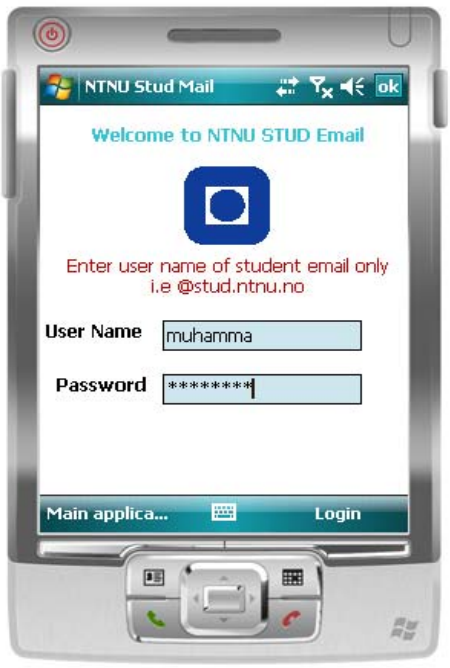
- Timely announcements without the need for reliable Internet service.
- Better connection with students, all of them having mobile phones.
- Substantial time savings for students, as they do not have to visit the blog on daily basis.
- It can be used to announce assignments, lecture schedules, cancellation of lectures, and any kind of quick updates about the subscribed courses.

- Listings of past or upcoming events, deadlines or holidays.
- Any updates made on Innsida and others similar systems can be provided on mobile devices immediately by this service.

6.1.3. NTNU Email Service

The third service built for MSIS is NTNU mobile email application. This service provides the students an opportunity to access email on the go. All most all the students at the university usually use web email application to send and receive emails. The main purpose of this application was to provide students a facility to use this communication tools at one place like MSIS.

Since this is the main channel of communication used by the student community, a mobile version of this service has been developed. The implementation detail of this service is presented in chapter 4. Here are few screen shots Fig 6.3 to give an overview of this service.



(a) Mail login

(b) Overview of Inbox

(c) List of emails

(d) Compose emails

Fig 6.3 NTNU Mobile email service

This service provides all the basic functionalities of an email application. But still it requires more features which can encourage the users to use this application. Scenario for this service had been prepared but due to the time constraints this service was not tested. The scenario is added in Appendix A so that it can be tested in future.

Few discussions

We did not perform any usability test and user acceptance survey for this service, but we performed some laboratory tests with friends and fellows to verify the functionality of this service. Since email service is a well known application; so we can assume that people will like to use this service on their mobile devices under MSIS platform. We tested this application to verify the technical and operational factors and found it to be successful.

This service has a number of limitations which were not focused due to time constraints such as, it is limited to work with only one email server i.e; stud email server[8]. Besides all, it is easy to extend the application to support other email servers at NTNU.

6.2. Research questions and results

This study consists of three layered process: First one is to explore the suitable technology that supports integration and help to cope up with the challenges posed by integration process. Second is to develop the integration architecture proposed in previous study. The third and the last one is to develop the services based on integration architecture and evaluate their usability in terms of technical and user acceptance as shown in following Fig 6.4.

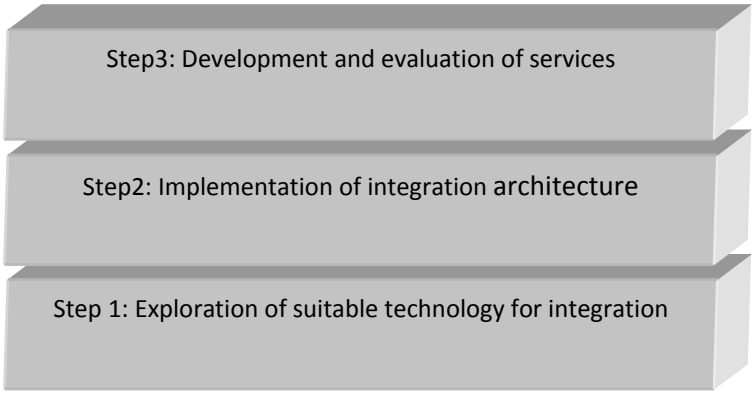


Fig 6.4 Layered process of this study

The following section describes the research questions and the results achieved. The above layered process also makes it easier to identify the relevant research questions for each step in this study and to seek the answers for those questions.

[8] There are different email servers for different users and departments at NTNU, we used only student email server to develop this application.

RQ1: *To find out if it is appropriate to have a different level of integration with heterogeneous information systems.*

This research question is related to step 1 in Fig 6.4 and addresses the issue that different systems cannot have the same level of integration depending on the architecture of each system. Since each system can be of different nature and may have different purposes, so it is difficult or impossible to find same level of integration. In this study we found that each system posed different challenges. The possible challenges were already explored in previous study (Asif, 2009).

In this study we decided to find different level of integration for each system selected for this study. We found that each system provides different level of accessibility to their services such as twitter provides web services and APIs to interact with their systems. There can be some possible threats for their system so they have also provide some authentication mechanisms to deal with (for detail see chapter 4). So we managed loose integration of MSIS with twitter on the behalf of their web services and APIs. The second feed service requires no authentication and no major accessibility issues due to its openness for all in nature. It requires only parsing of different format feeds and provides a loose level of integration. For the mobile email service, email servers require secure links to communicate with any client who can support their mail protocols (for detail see chapter 4).

RQ2: *What are the integration challenges posed by the systems under study?*

This research question overlapped both layer1 and layer2. Since each system has different architecture and security settings to protect their systems. In general we face different technical and operational challenges because of the dependency on those systems. We cannot change or modify the systems and we only have to manage our services to communicate with other systems. The major issue is that all these systems are in a continuous process of development and making changes on regular basis. Our services

need to be updated accordingly. Another issue is that all these systems are not developed to be integrated with other systems. The integration process can become easy if the systems are designed to provide support for integration such as twitter. We found that web services can be an easy tool to integrate with the systems if the systems provide their service in the form of web services. Web services can handle most of the issues regarding the integration.

RQ3: *How efficiently the students are able to interact, collaborate and exchange information by integrating different systems?*

This question relates to layer 3 of our study process and it is better answered in chapter 5 which contains the detail of the whole evaluation of the services and provides the results of user acceptance survey for the services developed. In this study we found that there is a need of comprehensive campus wide mobile information system which may provide purely student centric information services on the mobile devices of student's choice. In our evaluation we also found that solution can be really affected by the mobile devices as the students cannot be forced to use a particular type of device. Diversity in mobile devices can be a big challenge for the acceptance of the services. Since different people can have different level of needs and depending on their needs they can use mobile devices which they found useful, cheap and easy to use.

Chapter 7: Conclusions and further work

This chapter concludes the research work done, and presents a brief overview of contributions made. It describes the further work and the limitations of the services built in the context of MSIS together with the challenges faced.

7.1 Main Contributions

This work is a continuation process of the study (Asif, 2009) which proposed an integration architecture for MSIS. On the basis of the previous study the following is the contribution of this study:

- The first major contribution is the implementation of integration architecture. In this task we made a detailed analysis of the systems which we integrated with MSIS. Based on the different nature of the systems we had to choose different technological support such as web services, third party libraries and others. We successfully integrated the systems with MSIS see chapter 4 in detail about how we achieved this.
- The second contribution is that we have developed three major services MSIS Twitter, MSIS Feeds, and MSIS email by integrating to three different systems such as twitter, feed based systems and NTNU mail. Each system poses different challenges due to the different nature of each system. Since each system has different architecture, we had to adopt different level of integration for each system. Further we also made a detailed analysis of it's learning to find some way of integrating it (see chapter 4). But we did not find any suitable technological support to integrate it with MSIS as the REST APIs provided by it's learning developers have not this capability due to product commercialization. Systems like twitter can be integrated easily if they provide web services for other systems to communicate.
- We found that web services can be a great tool for the integration of systems as these are closely supported by Service Oriented Architecture. Web service has several other strong reasons to support mobile information systems and mobile

services. Another notion, MWS (mobile web services) has great potential for mobile information systems and related services (see chapter 2).

- For the integration of different systems, we found that the systems are in a continuous process of development and improvement. The developers of these systems are continuously changing the architecture which can be a big challenge for the systems like MSIS as they also need to be changes or modifications in their own architecture to communicate with other systems. For example, we integrated twitter with MSIS by using the web services and for secure authentication, twitter is going to change its authentication procedure in the near future. This change of twitter will also require modification of the MSIS twitter service to communicate with twitter which can be more expensive and challenging task.
- The services, we developed requires usability test and user acceptance. So we performed a complete usability test with a group of users and collected the feedback. Further we also performed a user acceptance survey based on Mobile Service Acceptance Model (Gao et al, 2008)[9]. The evaluation of the usability test and user acceptance survey has been presented in chapter 5.

7.2 Further work

During the evaluation of the services of MSIS we got some suggestions for improvements from the students. Some improvements and further work is as follows:

More features for the Twitter Service

From the evaluation we found that users demanded more features for this service. As they suggested that there is a need to add more features to the twitter service such as to create different groups and group messages. There is a need to create accounts for the courses of study and then users can subscribe to this course and perform usability study again.

[9] This user acceptance survey also serves to improve MSAM.

Improvements for Feeds Service

From the user feedback we found that the service was difficult to use. The reason we found that the user interface was less flexible and difficult to operate. The most difficult task was to add the URL of feed manually. There should be some browsing and auto subscription features present in the feeds application. There is a need to provide auto subscription for the courses when students get enrolled. Further it also requires usability evaluation by subscribing the users to different feeds of courses.

Usability evaluation of NTNU email service

Due to the time constraints, mobile email service is only tested in the lab. So it requires proper usability evaluation like other two services to find more about this service.

Feeds for the courses

Each course should have feeds which can be used to provide updates and other related news about the courses during the semester. Feeds based contents are light weight and can be utilized with mobile devices of different platforms. Feed based services can be an efficient way to provide student centric services on mobile devices.

Integration to other systems

There is a great need to integrate MSIS with Innsida, student web and others. There should be tight integration to Innsida as it provides news and announcements of events related to studies. Student web provides a platform for the students to register their courses and manage their study plans. There should be some mobile services which can provide students a facility to access student web.

Mobile based it's learning

During the study, students have to use it's learning for course contents, assignments, deadlines, and other study related updates (see chapter 5 for detail). There should be a

mobile based platform which can provide all these functionalities based on students' profiles.

7.3 Conclusions

Mobile information system is extending the learning space and time for different communities particularly the student community. There is a great potential of student centric mobile services which can increase the knowledge base of the students. There is a great need of campus wide mobile information system which can provide purely student centric information services based on the profiles of the students. The services we developed and evaluated showed great potential and need of such kind of services. In a nutshell, we are very pleased with the results of this research work and we believe that it will act as a solid foundation for future research.

Appendix A

Usability Scenarios and User Guide

Scenario 1: Follow NTNU and friends on Twitter

Bilal has a twitter account and he wants to follow NTNU updates and his fellows on twitter. There are other various possibilities for him to use twitter for institutional updates available at (http://www.ntnu.no/aktuelt/blogger). He also wants to tweet his friends and followers. He wants to keep in contact with his friends by following the replies and the direct messages of the followers or friends.

@NTNU

@NTNUstudier

@NTNUmedicine

@Vitenskapmuseet

@engineering

@imefakultetet

Task 1: (Pre conditions): You must have twitter account or can use test account (……). Go to http://www.ntnu.no/aktuelt/blogger and select the provided links to follow on twitter. Do the followings:

- Logon to MSIS with your login/password.
- Start the twitter application and logon with twitter Id/Password.
- Click the "update" button to refresh the updated tweets.

Task2: Check the replies and direct messages from your followers

- Go to **Menu->Timeline->Replies** (press "update" button if replies don't appear).
- Go to **Menu-> Timeline->Direct Messages** (press "update" button if messages don't appear).

Task3: Send tweets/messages

To send tweet/message performs the following steps:

- Go to **Menu->Tweet**
- Type your message (message limit is 140 characters) and press **Send** button.
- Check your tweet: Go to **Menu->Timeline.**

Comments: What worked? What didn't work? Response Time? What was illogical/difficult?

Scenario 2: Keep yourself update with your favorite RSS and Atom Feeds

Hassaan likes instant updates and wants to keep himself updated by subscribing to various news feeds and other favorite feeds such as educational news, weather, sports and blogs. He wants to get news feeds from his university site and on departmental events. He is very social and wants to remain active in the events of various student societies. He loves blogging and wants to follow the updates of his favorite blogs as well. He subscribes to all his favorite feeds and manages them according to his own priorities.

Some NTNU feeds available at (http://www.ntnu.no/aktuelt/blogger) are

- Generelle nyheter fra NTNU
- Forskning
- Næringsliv og nyskaping
- Studier
- Team NTNUs blogg
- News - forskningsnyheter på engelsk

Task 1: Read News feeds

To read the news feeds do the following steps

- Start the RSS application from MSIS main application container.
- Open the different news folders/categories.
- Select the news title to read the detail.
- Mark it as Read/Unread using the Menu options
- Navigate through all categories and news using options available in "Menu"

Task 2: Subscribe new feeds

To subscribe news feeds perform the following steps.

Pre Condition: The URL of the news feed to which you want to subscribe. For example the URL of NTNU IDI Events is: http://www.idi.ntnu.no/news/rss/events.xml. The feeds can be RSS and ATOM of any version.

- Select the desired category/folder to which you want to add feed.
- Go to **Menu->Add New->Feed**
- Enter the feed address/URL
- Change the settings such as "Storage Limit" and "Parent Category" by clicking the **Storage** and **Folder** button.
- Go back and check updates

Task 3: Add new Categories of feeds

To add or create new categories of news feeds do the following steps

- Go to **Menu->Add New->Folder** and enter the desired title.
- Select the newly created category and follow the steps of **Task 2** to add new feeds in this category.
- Go to **Menu->Edit Feed Details** to edit the detail such as title, URL, storage limit of any selected feed. You can enter the URL directly or select from the given list of RSS feeds.

Comments: What worked? What didn't work? Response Time? What was illogical/difficult?

Scenario 3: Mobile NTNU Student E-Mail

Talha is conscious about his emails and want to access his emails anytime, anywhere. He wants to access his NTNU email on his mobile device. He is away from his office and wants to send emails to his friends and colleagues on the move. He starts his email application on the mobile device and can send email quickly without going to any desktop computer. This can help him to send quick replies and keep himself in touch with his study environment.

Task 1: Open NTNU email inbox and read emails

(Pre Condition): To complete the task student must have stud email account such as "muhamma@stud.ntnu.no".

- Start MSIS application and login to application with your MSIS user id/password.
- Click "**email**" icon on the main application to start.
- Give your stud username/password i.e id: muhamma and password:*********
- Check your inbox detail.
- Click "**Open Inbox**" to open your emails.
- Select any email from the list and click "**Open**" to read its contents.
- Navigate through your emails using "**Next**" and "**Back**" buttons.

Task 2: **Compose and Send an email**

(Pre Condition**):** You can send emails only to student accounts of NTNU email server i.e "muhamma@stud.ntnu.no".

- Following the steps of task 1 if you are not logged in already.
- After log in click "**New Message**".
- Fill the fields "**To:forexample@stud.ntnu.no**" and **Subject: …….**
- Type your message and press the **Send** button to send an email.
- Press "**Log out**" to logout from email application.

Comments: What worked? What didn't work? Response Time? What was illogical/difficult?

User Guide for Scenario 1 (MSIS Twitter):

The following screen shots with brief description of each gives an introduction to the application and its usage.

This is the main application login form where the users can enter the main application by using given **user name** and

This is the main application form where user can start **Twitter**, **Feeds** and **Email** applications by clicking the given icons

This window appears when user starts **Twitter** application. It requires twitter login and password. It will also save your configurations for future login

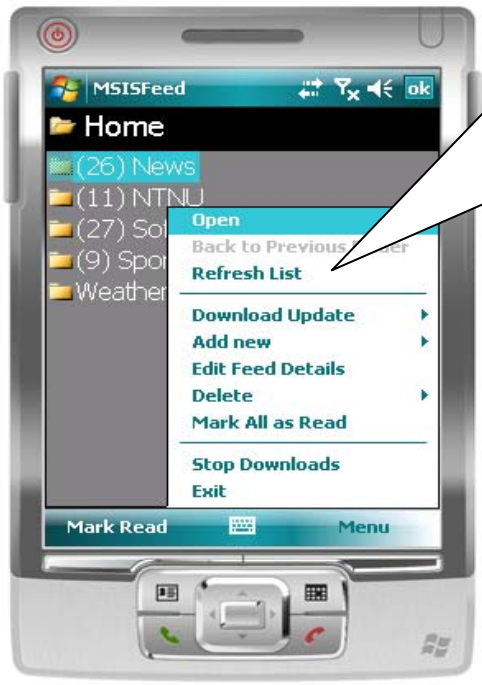
After successful login your public timeline of twitter will appear. Press **update** to refresh tweets.

By using these menu options user can check **Replies, Direct Messages** and **Main time line.** User can also send tweets by clicking **Tweet** option.

Here user can type his message up to 140 characters and press **Send** button to update his tweets.

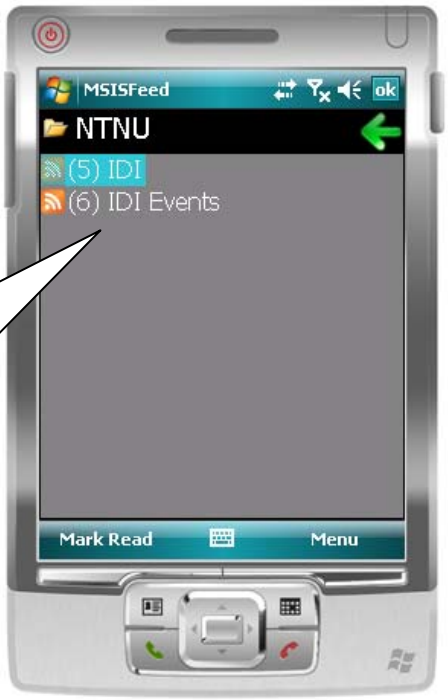
User Guide for Scenario 2(MSIS Feed):

The following screen shots with brief description of each gives an introduction to the application and its usage.



This form will appear when user clicks the **Feed** application from the main application. It will show the already available categories of feeds.

User can open any category of feeds e.g NTNU. It will show the unread feeds available.



This form shows the feeds from the subscribed URLs. User can use the different options as shown.

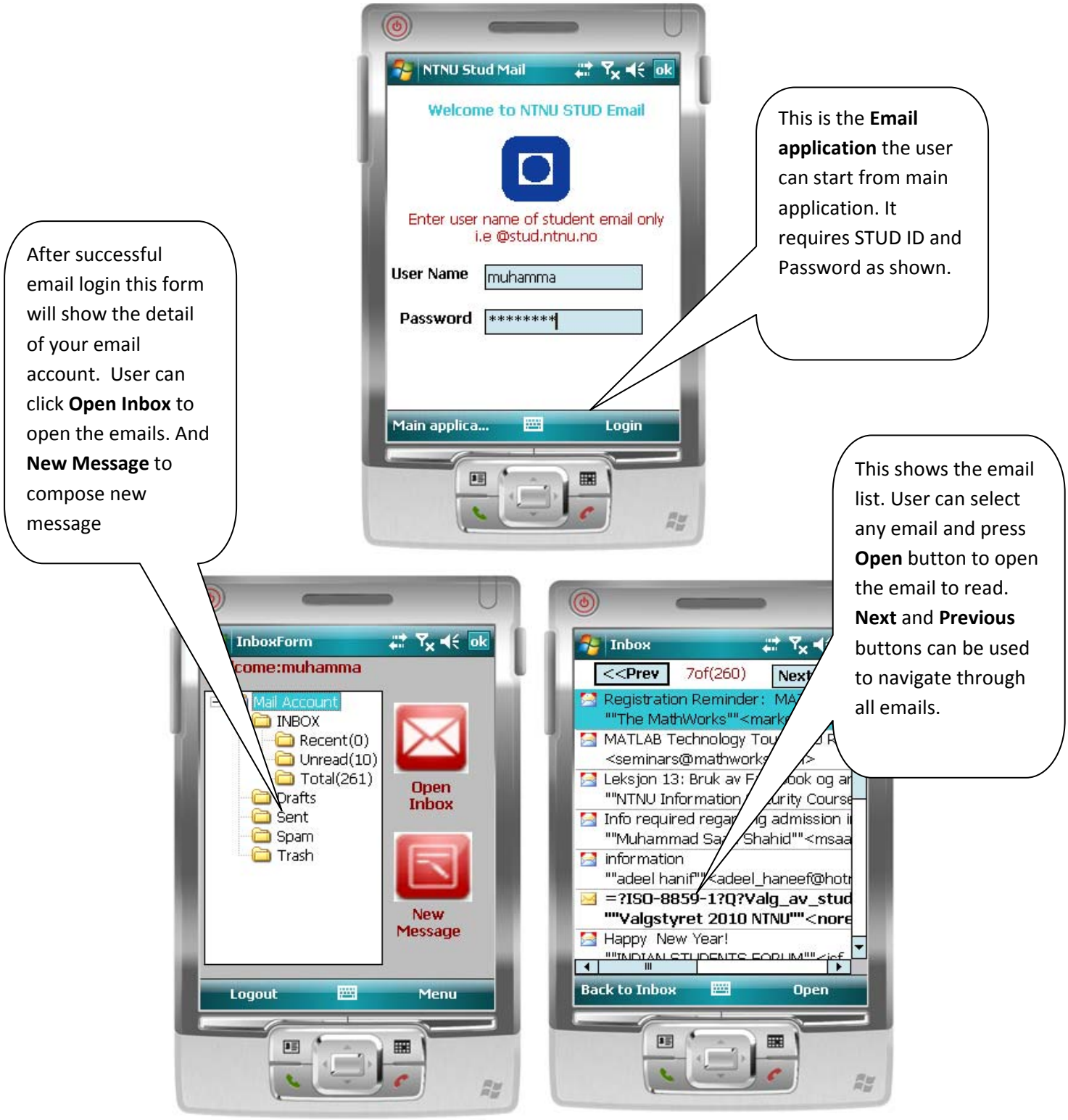
When the user will click any of the feeds it will open the feed detail in this form. User can use different options available.

This form will appear when user wants to add new category of feeds. Different options available can be used as

This form will appear when the user wants to add new feed under a particular category. User can add URL directly or can select from the list provided.

User can use these options to set the storage limit for offline feeds. And **Folder** option can be used to select the category of feed.

User Guide for Scenario 3 (NTNU Mobile Email)



This figure shows the contents of email when user will open the email to read.

This from will appear when user clicks **New Message**. User can compose email and press **Send** button to send an email.

Appendix B

User Acceptance Survey

Part 1: Personal information

1. Gender:
❑ Female ❑ Male

2. Age:
❑ Less than 20 years old ❑ 20–30 years old
❑ Larger than 30 years old

3. Department
❑ Science or Engineering Department ❑ Other Departments

4. Education Level
❑ Bachelor Student ❑ Master Student ❑ Doctoral Student

5. Experience in Mobile Services:
❑ 0-1 year ❑ 2-5 years ❑ more than 5 years

6. Nationality:

Part 2. Post-Experiment Questionnaire

Please use a few minutes to answer the following questions pertaining to the utility, perceived usefulness, usability and general impression of the MSIS service. All respondents remain anonymous.

Perceived Usefulness (PU)	**Strongly disagree**						**Strongly agree**
PU 1. Using the system would increase the efficiency of my daily work.	❑	❑	❑	❑	❑	❑	❑
PU 2. The system would allow me to find rooms and buildings at NTNU.	❑	❑	❑	❑	❑	❑	❑
PU 3. The system would make it easier to keep track of my weekly tasks.	❑	❑	❑	❑	❑	❑	❑
PU 4. The system would allow me to better schedule my time.	❑	❑	❑	❑	❑	❑	❑
PU 5. The system would be useful for me as a student.	❑	❑	❑	❑	❑	❑	❑

Perceived Ease of Use (EOU)	**Strongly disagree**						**Strongly agree**
EOU 1. Learning to operate the system would easy for me.	❑	❑	❑	❑	❑	❑	❑
EOU 2. I would easily find the information I am looking for using the system.	❑	❑	❑	❑	❑	❑	❑
EOU 3. I would find the user interface of the system clear and intuitive.	❑	❑	❑	❑	❑	❑	❑
EOU 4. I would find the system to be flexible to interact with.	❑	❑	❑	❑	❑	❑	❑
EOU 5. I would find the system to easy to use (user-friendly).	❑	❑	❑	❑	❑	❑	❑

Trust (TU) *I could use the system…*	**Not important**						**Very important**
TU 1. if I have a clear conception of the functionality of the system.	❑	❑	❑	❑	❑	❑	❑
TU 2. if the system provider is widely acknowledged (e.g. NTNU)	❑	❑	❑	❑	❑	❑	❑
TU 3. if the system protects the privacy of its users .	❑	❑	❑	❑	❑	❑	❑
TU 4. if I feel confident that I can keep the system under control.	❑	❑	❑	❑	❑	❑	❑
TU 5. if I feel confident that the data returned by the system is reliable.	❑	❑	❑	❑	❑	❑	❑
TU 6. If I believe it is risk-free to use the system.	❑	❑	❑	❑	❑	❑	❑

	Strongly disagree						Strongly agree
Personal Initiatives and Characteristics (PIC)							
* PIC 1. Using the system would be interesting.	❑	❑	❑	❑	❑	❑	❑
PIC 2. I have fun using the system.	❑	❑	❑	❑	❑	❑	❑
PIC 3. I prefer to be the first one using the system.	❑	❑	❑	❑	❑	❑	❑
PIC 4. Using the system gives me an advantage over those who don't.	❑	❑	❑	❑	❑	❑	❑
PIC 5. I would only use the system if it was available for free.	❑	❑	❑	❑	❑	❑	❑
PIC 6. I find it rewarding to use the system.	❑	❑	❑	❑	❑	❑	❑
*PIC 7. Using this mobile system can be considered as a social status symbol among my friends	❑	❑	❑	❑	❑	❑	❑

Context (CT) *I could use the system…*	Strongly disagree						Strongly agree
CT 1. if I am being out of home or the office.	❑	❑	❑	❑	❑	❑	❑
CT 2. if most people around me are using the system.	❑	❑	❑	❑	❑	❑	❑
CT 3. if I had nice experience in using mobile services before.	❑	❑	❑	❑	❑	❑	❑
CT 4. if the University encourage students to use the system.	❑	❑	❑	❑	❑	❑	❑
CT 5. if the system was easy to obtain and install.	❑	❑	❑	❑	❑	❑	❑
CT 6. if it is meaningful/relevant to my daily tasks.	❑	❑	❑	❑	❑	❑	❑
CT 7. if I did not have access to a desktop computer or laptop.	❑	❑	❑	❑	❑	❑	❑
*CT 8. if the system is offering services that is contextual relevant to me, based upon where I am and what I am interested in	❑	❑	❑	❑	❑	❑	❑

Intention to Use (IU)	Strongly disagree						Strongly agree
IU 1. Assuming I have access to the system, I intend to use it.	❑	❑	❑	❑	❑	❑	❑
IU 2. Given that I have access to the system, I predict that I would use it.	❑	❑	❑	❑	❑	❑	❑

Please comment on the scales above:

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