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# Evaluating the quality of a software application for web services integration

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## **Evaluating the quality of a software application for web services integration**

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# Evaluating the quality of a software application for integrating web services

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## ABSTRACT

Due to the fast growth of web services integration, presenting a high quality integration solution has attracted considerable attention. Thus, the quality evaluation of these solutions has been actively investigated. On that basis a research topic was defined in collaboration with a small sized software company; Netoptions AB, to investigate the quality of the developed prototype in this study in which some web services were integrated.

The present study started with a review of relevant literature on web services integration, service oriented architecture and software product quality. This step focused mainly to find the best solutions for: defining the proper solution for integrating the web services that currently are used at Netoptions AB and investigating its quality assessment. Among them ISO/IEC 9126 standard was selected for assessing the quality of the prototype in which existing web services at Netoptions AB were integrated. Finally an experiment was conducted to evaluate the prioritized attributes in the defined quality model of the prototype.

The results of this study are the developed web application in which web services at Netoptions AB are integrated and also the measurement of the accuracy of the implemented integration and the defined comparison operation in the prototype. The result of the performed experiment demonstrates to what extent the developed prototype is operated accurately associated with the prioritized defined attributes.

## Keywords

Web Service, web services integration, ISO/IEC 9126, Software Quality evaluation

## 1. INTRODUCTION

A software product is ready to be delivered when it fulfills its defined requirements. In order to evaluate how much the software product can provide its defined functionalities, certain standards have been defined. Following these standards increases the chance of meeting the defined requirements for the software product.

One of the published standards for software product quality evaluation is ISO 9126. ISO 9126 quality model has the most complete quality characteristics for software product evaluation.[7]

Quality in all software products is important and its investigation is more considerable when the software product has a rapid progress. One of the categories in fast growing software products is the web service. World Wide Web (WWW) has become the storage of services which basically are distributed. These services present several functionalities that are distributed. Today, these distributed functionalities bring many benefits to software companies all over the world. Instead of developing a lot of functionalities, these companies take advantage of the web services in which requested functionalities were implemented. In addition to this considerable benefit, software companies have tried to integrate

these web services to create new functionalities which are based on existing methods in those services. In order to integrate these services different techniques are used. While these functionalities are growing and in some cases becoming critical, then their quality needs more investigation and attention. So, this is highly relevant to software development companies and increases their demands in order to find a good quality solution. Netoptions AB is an example of those companies. Netoptions AB develops and implements the BizWizard eMarketing Suite on the Scandinavian market, partly via its own sales and consultancy organisation, and partly via the company's network of partners, consisting of communication and advertising agencies, direct marketing consultants, CRM companies and IT companies. BizWizard eMarketing Suite is a modular software package which can provide support for marketing by e-mail, the Internet and mobile telephony.

There are some web services that are used internally at Netoptions AB in order to control their daily business and customers' activities. Netoptions AB had a demand for a high quality solution for integrating these web services and creating new functionalities. This request was addressed in this study in three steps: 1) Implementing a web application called NAS "Netoptions Administration System" in which the web services were integrated, 2) Identifying the quality characteristics of this product and prioritizing them, based on the defined quality model in ISO/IEC 9126. 3) Measuring the high prioritized characteristic.

All companies with the aim of developing an application to integrate web services and generate new functionalities can potentially benefit from the findings of this study. They also can find this study useful for investigating the quality of their new functionalities.

## 1.1 Report Outline

This report starts with the presentation of the problem in section 2. Section 3 mentions the delimitation. Section 4 presents a background of this study. Section 5 discusses about the research methodology used in this study and how it was conducted. In section 6 the prototype specifications are described. Section 7 contains the quality model of the prototype. Section 8 includes the analysis of the experiment result and a discussion around it. Section 9 provides the conclusion of this study. Finally section 10 presents a recommendation and future work.

## 2. Problem Definition

This study mainly focuses on identifying and prioritizing the quality characteristics/attributes of the prototype for integrating web services, that is based on the quality model defined in ISO/IEC 9126 standard and finally measuring the prioritized attributes in that model. The prototype is a web application which aims to integrate the web services that are used at Netoptions AB. There are four web services which are used internally at Netoptions AB to control customers' activities. By the help of this prototype daily business at Netoptions AB is managed more precisely. This prototype mainly focuses on managing the customers' invoices. Each invoice contains the

modules that one customer orders. These are the goals that the prototype should address:

- Comparing ordered modules in customer's invoice with the modules that customer really uses. Such a comparison can help Netoptions AB to find out whether customers pay the right bill or not.
- Managing support activities for customers.

When the implementation of this prototype was completed the next step that this study has considerably concentrated on, was started. In that challenging step, the right quality characteristics/attributes were chosen and prioritized. These characteristics/attributes were selected based on the quality model defined in standard ISO/IEC 9126. For evaluating the high prioritized attribute an experiment was designed and run.

The research question that is addressed in this study is:

How to identify the quality characteristics/attributes and prioritize them for investigating the quality of the prototype in which web services are integrated?

### 3. Delimitation

The scope of this study is limited to identification of quality attributes and prioritization and evaluation of them.

These quality attributes are investigated from external perspective and can be measured only at the runtime. In this study the quality attributes which are related to internal quality investigation of software product, are not studied. Internal quality attributes are those which refer to the construction of the software and are measured during the development process before the software is released. [19]

Internal and external characteristics are different views of the software. For example portability is an external characteristic and it can be evaluated by testing the software on different platforms of end-users. [23] But complexity is an internal characteristic since it is important during the development and it impacts the testing, development and maintenance. [26]

In order to measure the internal and external characteristics of the software, ISO/IEC 9126 standard provides a quality model and quality attributes. ISO/IEC 9126 standard has two parts for measuring the internal and external characteristics. In ISO/IEC 9126-2 part, it presents the internal characteristics which are measured when the software product is released. In ISO/IEC 9126-3 part, it presents the external characteristics which are measured during the development. [20]

In this study within the interview sessions at Netoptions AB it was clear that, the quality evaluation was needed from the point of view of the end-users. So the focus in this study is just on external characteristics.

Those readers, interested in the use of ISO 9126 in the context of requirements elicitation phase and software development phase are directed to ISO/IEC 9126-3 [19].

### 4. Background

In current section the basic concepts related to this study are described.

#### 4.1 Web Service

Web service is a software application. It provides a method for integrating heterogeneous applications over the internet. [1] Heterogeneity includes various platforms, programming languages and operating systems. [27]

Before defining web service, the two basic definitions such as XML and URI are explained.

Uniform resource identification (URI) is a compact string of characters which is used to identify a resource. URI is the most fundamental specification of Web architecture. [29]

Extensible Markup Language (XML) is a standard for transporting data across heterogeneous systems. XML is used to describe data. XML consists of user-defined tags which means the desired tags can be defined in an XML document. [28]

The Web Services Architecture Working Group of World Wide Web Consortium has defined a web service as: "A Web service is a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A Web service supports direct interactions with other software agents using XML-based messages exchanged via Internet-based protocols. [1]"

Web services are flexible and interoperable, so they are regarded as the most appropriate technology for exposing the functions of an application as services. Web services present important changes in comparison with previous distributed architectures like DCE (Distributed Computing Environment), RPC (Remote Procedure Call), and messaging systems. Some of these changes are as following: [25]

- Web services support asynchronous interaction as well as synchronous interaction.
- Web services utilize the standard internet protocol like Hypertext Transfer Protocol (HTTP), which causes fewer problems in connectivity. HTTP is a communication protocol for data transfer on the World Wide Web [29]. HTTP is supported by most web browsers [1].
- Operations in web services, exchange XML-formatted payloads.

Web services provide access to business functions over the web by combining the XML and HTTP technologies which are the foundation of web services. Service provider and service consumer communicate by XML documents. [1]

Web service technology is based on open standards such as XML, Simple Object Access Protocol (SOAP), Universal Description, Discovery and Integration (UDDI) and Web Services Description Language (WSDL). These technologies are built on the basis of XML and provide interoperability between several products of different vendors. [1]

All these mentioned standards together are referred to web services. These standards have been developed to address the following needs: [24]

- How to describe the service interface?
- Where and how to look up for available services?
- Providing data exchange between applications that is language independent and follows a common message format.
- How to specify several communication protocols?

These standards are explained in the following paragraphs:

WSDL: This XML-based language is used to describe the service and declare the interface, since the service provider and requester are neither aware of the language that the other is using nor its platform. [1]

In WSDL document there are two parts. The first part contains a description of the service operations and their input and output parameters. The second part consists of the transport protocol, message format and service end point network address. WSDL explains how to map the data types and structures to the exchanging message between the service provider and consumer. [24]

SOAP: Service consumer and service provider can communicate efficiently when they exchange messages based on an agreed format. This agreement is provided by SOAP protocol that is independent of programming language and the platform. A SOAP message can be carried with any transport protocol. [24]

SOAP provides an enveloping mechanism. A SOAP message consists of zero or more headers but only one body. The body contains the actual message but the header carries the information such as security, transactional information, service addressing, message reliability and so on. [30]

UDDI: UDDI plays the role of a search engine. When service provider and service consumer are far apart, service provider should publish its services and service consumer should discover them. In order to implement such environment a central place is needed which is called registry. The service provider records its service in this UDDI registry. A service consumer tries to find the services in the UDDI and use them. UDDI is a standard for implementing such environment and in the other word it gives a way to register, unregister and search for services. Figure 1 shows the working process of a UDDI registry. [24]

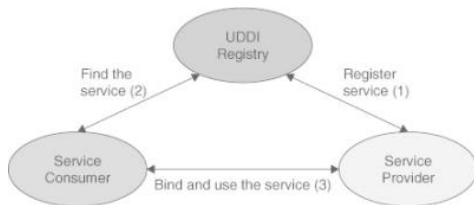


Figure 1: Working process of UDDI registry [24]

When the service consumer finds the required service in the UDDI, the service consumer directly binds with the provider in order to use that service.

For all these defined standards on which web services are based, there are some specifications that are called WS-Specifications. These specifications help having secure, reliable, composable and interoperable web services. [13]

Following is a list of the most important WS-Specifications and their purpose: [13]

WS-Security: Includes a set of security technologies like digital signing and encryption based on security tokens, including X.509 certificates.

WS-Policy: This specification allows web services to document their requirements and it is mostly focused on security. For example including web service security requirements, such as encryption and digital signing based on an X.509 certificate.

WS-Addressing: "Identifies service endpoints in a message and allows for these endpoints to remain updated as the message is passed along through two or more services. [13]"

WS-Messaging: By this specification group, some supports are provided which make it easier to develop the messaging application.

WS-Secure Conversation: By using security tokens, this specification group provides trusted communication sessions.

WS-Reliable Messaging: This specification provides some mechanisms which make the communication more reliable. So the sender will be aware that the receiver received its message successfully.

Transactions: When multiple business operations should be failed or succeeded together then transaction processing becomes important. As web services are disconnected components, so inherently they cannot participate in distributed transaction. "WS-Coordination", "WS-Atomic Transaction" and "WS-Business Activity" specifications are related to provide transaction management across distributed Web services.

WS-Interoperability:

In order to have the web services which are interoperable across different platforms, some specifications should be defined for web services standards. The Web Services Interoperability (WS-I) organization establishes these standard specifications. [13] This organization provides guidance, recommendation and supporting resources which leads to have interoperable web services that are able to communicate with each other with no knowledge of their platform. [24]

These specifications are grouped together as the WS-I Basic Profile and belong to a wide domain e.g. transport protocols, security etc [13]. The WS-I Basic Profile establishes some constraints to the defined specifications in XML, SOAP, WSDL and UDDI. As an example WS-I Basic Profile limits the transport protocol to HTTP and HTTPS (HyperText Transfer Protocol Secure). [24]

In order to reflect a clear image of web services standards and specifications, figure 2 shows the architecture of a web service and its standards and some of the specifications which have been defined for each standard.

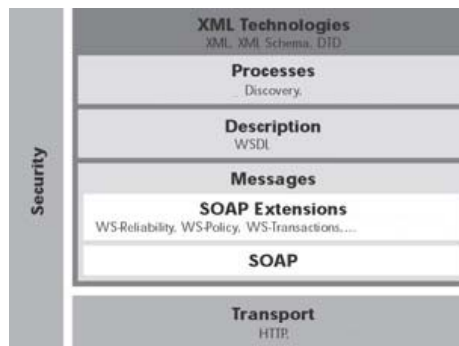


Figure 2: web service architecture [30]

As it is shown in this figure the web service architecture is based on XML. The web service is independent of the transport mechanism. The "Messages" level in this figure forms the base layer of this architecture includes the messages that are exchanged between the provider and consumer. These messages include the SOAP message with its extension which provides a number of SOAP header messages for message transactional capabilities, message reliability, and service addressing. [30]

The level on top of the messages is for describing the messages in a higher level. This description can be given by any description language e.g. WSDL. The highest level in this architecture refers to the discovery process which was

discussed in details. The vertical layer shows the security layer that provides a trusted communication session. [30]

Now by presenting the web services definition generally the next section investigates the web services that are used internally at Netoptions AB.

## 4.2 Web services at Netoptions AB

There are four web services that are used internally at Netoptions AB: OnTime, SuperOffice, E-economic and Bizwizard.

The developed prototype in this study intends to integrate these web services. The general definition of these web services is explained in following:

### 4.2.1 “OnTime” web service

OnTime is an application developed by Axosoft. This application has been developed for defect tracking. There is also a web service for OnTime application which integrates OnTime services to other applications.

### 4.2.2 “SuperOffice” web service

SuperOffice has CRM products for supporting business processes. SuperOffice web service has been presented for integration on the Superoffice CRM platform.

Customer relationship management (CRM) is the process of forming the interactions between a company and customers. CRM's goal is to optimize the value of the customers for the company. [31]

### 4.2.3 “E-economic” web service

E-economic is accounting software and can be integrated with nearly all types of systems that need data from accounting software. This integration is provided by e-economic web service.

### 4.2.4 “Bizwizard” web service

Netoptions AB has developed the application “BizWizard”. Bizwizard web service makes it possible for other systems to be integrated with the Bizwizard application and use some of its functionalities. Following section explains more about Bizwizard application.

### 4.2.5 Bizwizard application

“BizWizard” is a modular software package which can provide support for marketing, sales and other customers’ relations by e-mail, internet and short message service (SMS).

In other words, the BizWizard application which is used for message marketing, includes generating marketing messages and sending to thousands of customers and tracing recipients’ activities e.g. checking whether customers have received the emails and read them or not, checking clicked links (in received message), etc. In addition, BizWizard is a Web-based system which can be used either entirely independently or integrated with other company's information systems (CRM, ERP, etc.).

Enterprise resource planning (ERP) is a software solution that integrates business functions of an organization and helps managers to make better decisions. [32]

“BizWizard” has different modules. Each module is related to special aim, e.g. “Sending SMS” module, “Social media connection” module, etc. Each customer requests the desired modules and based on them a license key is generated. Selected modules are activated for customers, so the license key provides the modules that have been bought by customer. There is a definition as “installation” which refers to the selected modules and one license key for one customer. BizWizard is hosted for several customers in the hosting center of Netoptions AB but there are some customers who have hosted it on their own environment.

## 4.3 Software Product Quality

A software product has high quality when customer expectations are met. When a user expectation is not met then it will be considered as defect and defects count has close relation to software quality level. To improve the software product quality, standards are used which increase understanding and introduce several definitions [4]. For example International Standards Organization (ISO) and IEEE introduce quality in different ways. ISO defines quality as: “the totality of features and characteristics of a product or service that bear on its ability to satisfy specified or implied needs” [6]. The IEEE [9] defines quality as “the degree to which a system, component, or process meets specified requirements and customer or user needs or expectations”.

ISO and International Electrical technical Commission (IEC) which is also a standard organization developed one of the most popular software quality standards. This quality standard is called ISO/IEC 9126. In this study ISO/IEC 9126 is used since it was the quality standard followed by Netoptions AB.

In section 4.4, ISO/IEC 9126 is explained.

## 4.4 ISO/IEC 9126

International standard organization (ISO) and International Electrical technical Commission (IEC) have developed the ISO/IEC 9126 Standards for Software Engineering – Product Quality [6] that provides quality model and quality attributes for evaluating the quality of software products.

ISO/IEC 9126 uses a common language for specifying user requirements which is understandable for developers, users and those who evaluate the quality [6]. ISO/IEC 9126 standard includes 4 parts. Part 1 defines software product quality in three categories which are: internal quality, external quality and quality in use. [19]

The other three parts in ISO/IEC 9126 give a set of specialized measures and measurement recommendation for each category defined in part 1. These parts are defined as following:

Part 2: External quality

This part deals with measuring the quality of the software product externally and presents the characteristics which are measured during execution time. [20]

Part 3: Internal quality

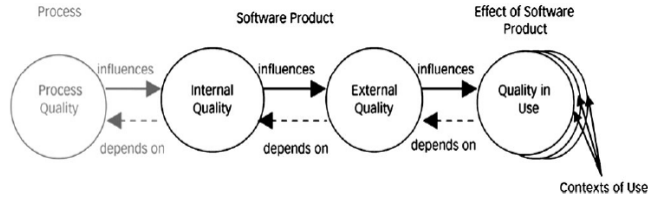
This part deals with measuring the quality of the software product internally and presents the characteristics which are measured during development process. [20]

Part 4: Quality in use

This part deals with evaluating the quality of the software product from user's view. [20]

There is a dependency between these three parts in ISO/IEC 9126. Achieving quality in use is dependent on the external quality for the relevant sub-characteristics, which in turn is dependent on internal quality.

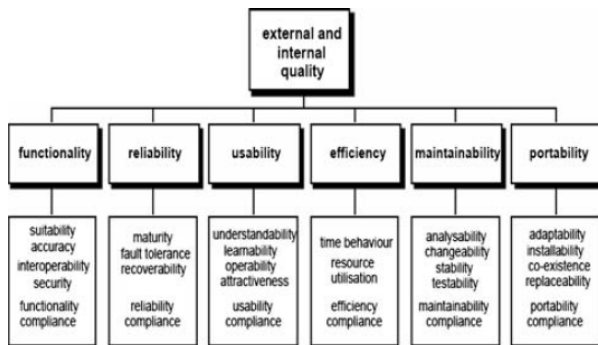
Figure 3 shows the relationship between these categories in ISO/IEC 9126 quality model and as it is shown internal quality influences external quality which in turn influences quality in use.



**Figure 3: Quality in the software life cycle—ISO 9126-1 [19]**

The quality model presented in ISO/IEC 9126 part 1 is represented in a form of two-part quality model in which the characteristics and sub-characteristics are integrated and a software product should follow it in order to have a good quality. In figure 3 and 4, these two parts are shown: [19]

In this quality model the characteristics are categorized as functionality, reliability, usability, efficiency, maintainability and portability. Each category is broken into sub-characteristics that are shown in figure 4. [20] “Accuracy” and “Time behavior” attributes in this study are used when defining metrics in the experiment introduced later.



**Figure 4: Quality model for internal and external quality [19]**



**Figure 5: Quality model for quality in use [19]**

Figure 5 shows the breakdown of the quality in use into 4 characteristics as effectiveness, productivity, safety and satisfaction.

In this study the focus is on external quality attributes for defining the quality model for evaluating the quality of the prototype. The details of this evaluation are further discussed.

## 5. Research Methodology

As defined before, the aim of this research is to identify the quality characteristics/attributes and prioritize them for investigating the quality of the prototype in which web services are integrated.

The chosen methods to conduct this research, are literature review and interview.

The literature and documents were studied on basic concepts of web services integration and its quality evaluation. The domain of quality evaluation which is discussed in this study is just limited to the developed prototype. At first the literature review was started in web services integration and after collecting the basic knowledge, interviews were run to collect the data which helped to find the right solution. For instance, several ways of web services integration were reviewed during the literature review but the interview result showed that for Netoptions AB the best solution could be a web application in which web services get integrated. Interviewees were selected from development and management teams at Netoptions AB. By the end of the interview, a prototype was developed as a web application in which the web services that are used at Netoptions AB were integrated. In the next step the stress was considerably put on defining the right quality model of the developed prototype and measuring the quality attributes defined in that model. Finally the literature review was continued in order to find out the proper quality model. Software quality as a part of software engineering is discussed mainly in current work.

### 5.1 Data collection

Followings are the methods that were used to collect data:

#### 5.1.1 Literature review

Searching the literature was started by selecting some online databases. Initially the internal documents at Netoptions AB were analyzed to give direction and in parallel Google scholar and books24x7 were used as sources for finding the preliminary results. Then some definitions and terms in these results helped to find more relevant articles in databases like IEEE, ACM, SpringerLink, Wiley online library, ScienceDirect, Elsevier and books24x7 databases. Additionally, the references in collected articles helped to go forward and find more related articles.

Searching was done based on the keywords which were categorized into web services and software quality. Basically for the software quality category the keywords were: Software quality metric, measuring software product quality, ISO/IEC 9126 and quality models and for the web services the keywords were service oriented architecture and web services integration.

#### 5.1.2 Interviews

In addition to literature review, data were collected via interviews. First of all, several interviews with the chief developer at Netoptions AB were done. These interviews were made of two main parts: 1) discussions about the requirements of defined prototype 2) questions about unclear definitions in internal documents at Netoptions AB. After finishing interviews with the chief developer and collecting the requirements, the interview step was complemented by having another interview with the sales manager in that company in order to verify the requirements which were related to customers’ invoices and orders.

#### 5.1.3 Experiment

The result of the literature review finally led to identifying the right quality model of the prototype and prioritizing its quality attributes. In order to measure the prioritized attributes in that



model an experiment was designed. This section explains how this experiment was designed and conducted.

### 5.1.3.1 Experiment Design

The main goal of this experiment is to evaluate how much the result of the web services integration and the implemented comparison are accurate and to analyze which parameters can improve the accuracy level and what factors have good influence on the result.

In this experiment two variables are defined: independent and dependent variables.

Independent variable: The accuracy of the solution which was used in the prototype to integrate the web services and perform the defined comparison operation on the integrated data. In this study a task list was created in which five tasks were defined in order to measure the level of accuracy in the prototype. By performing these tasks by users, those installations for which the system was not able to perform the comparison task correctly were reported. The dependent variable was defined as the total number of incorrect comparison results.

### 5.1.3.2 Experiment Subjects

For performing the experiment first the subjects were selected. All subjects were chosen from the employees at Netoptions AB. These subjects were separated into two groups.

- Group 1: Those employees who were selected from sales managers, administrator and accountant groups who worked with existing web services at Netoptions AB every day and had very good experience in working with them. The members of this group did not have any knowledge about development. This group is considered as the worst-case situation since they did not have knowledge about web service technology.
- Group 2: Those employees who were selected from developers and did not have so much experience in working with existing web services at Netoptions AB but they had knowledge about their design technology. This group was expected to do this experiment in the best way since they had knowledge of how these web services work and how they can be connected to each other.

Three employees for the first group and four employees for the second group were selected.

The combination of these two groups helped to find out if the knowledge of the users about these web services could have influence on having more accurate result. For instance one of the steps in the experiment task was setting the Global Unique identifier (GUID) which is an identifier for each installation. From a developer point of view, this step is vital in order to integrate two web services, but from a normal user perspective this step might be forgotten.

### 5.1.3.3 Experiment Task and procedure

This experiment included three phases. In the first phase an introduction session was held to introduce the prototype and explain the purpose of the experiment. In the second phase users were asked to complete the experiment tasks by running the prototype and recording their results. Additionally, during this phase the instruction was distributed to subjects and a MS

Excel file was given to them. This file contained the data of 80 companies (customers at Netoptions AB) and the details of their orders.

In the last phase a short interview with them was done and their suggestions and recommendations were collected.

Following describes the tasks that subjects had to perform.

#### - Task1- Importing the data of all companies into the database of the prototype

In this task user was asked to import the data of all companies. These companies were customers at Netoptions AB. This task was supposed to be done before all other tasks. It was done by selecting the "Import" option in the left menu. Figure 6 displays the import task.

<input type="checkbox"/>	Company Name	ID
<input type="checkbox"/>	SOS Alarm Sverige AB	10482
<input type="checkbox"/>	20:20 Mobile (SWE) AB	10262
<input type="checkbox"/>	5050 Poker Ltd	11185
<input type="checkbox"/>	6:e AP-fonden	10280
<input type="checkbox"/>	AAC Global AB	13263
<input type="checkbox"/>	AB Nordiska Kompaniet	10148
<input type="checkbox"/>	AB Storstockholms Lokaltrafik	11324
<input type="checkbox"/>	AB Tingstad Papper	11907
<input type="checkbox"/>	Academic Work Sweden AB	10673
<input type="checkbox"/>	Actea AB	14074
<input type="checkbox"/>	Actea Consulting AB	11415
<input type="checkbox"/>	ACTIC Sverige AB	14008
<input type="checkbox"/>	Actionbase Stockholm KB	11878
<input type="checkbox"/>	Actron AB	10598

Count: 388

Figure 6: List of all companies in task 1

#### - Task2- connecting each company to its modules in Bizwizard

Once the companies were imported into the database of the prototype, each company should have been connected to the modules that were used by that company. This was done by retrieving the license key of the company from Bizwizard. In order to do that, user was supposed to enter the URL and GUID of that company from the provided data in MS excel file.

In this task user should have run the "New installation" feature in the left main menu.

#### - Task3- Running comparison operation for each installation between the modules that customers used and the modules were in invoice

According to the installation definition, each company has an installation which refers to a license key that represents requested modules. In this task users were supposed to create the compared list which verifies if the generated invoice is correct. They should have run the "view installation" feature in the prototype for the installation in a given document. In this feature a comparison between the modules that customer was using and the modules in the invoice, was created for the selected installation.

Figure 7 shows the comparison list which was generated as the result of task 3 for one subject. This

result was generated by the prototype. As it is seen in this figure, there are six mismatches between customer's using features (in Bizwizard column) and customer's orders by which he/she was supposed to get paid (in e-economic column). There is also one other mismatch at the end of these two columns which refers to "Max Users" and "Number of recipients". All these mismatches alarm Netoptions AB to check customer's invoice and upgrade it correctly.

e-economic	Bizwizard
<input checked="" type="checkbox"/> S&U BizWizard Permission System	<input checked="" type="checkbox"/> S&U BizWizard Permission System
<input type="checkbox"/> S&U BizWizard Pro	<input checked="" type="checkbox"/> S&U BizWizard Pro
<input type="checkbox"/> S&U BizWizard Customer Dialogue	<input checked="" type="checkbox"/> S&U BizWizard Customer Dialogue
<input type="checkbox"/> S&U BizWizard Spam Check	<input checked="" type="checkbox"/> S&U BizWizard Spam Check
<input type="checkbox"/> S&U BizWizard Statistics	<input checked="" type="checkbox"/> S&U BizWizard Statistics
<input checked="" type="checkbox"/> S&U BizWizard Add limited user	<input type="checkbox"/> S&U BizWizard Add limited user
<input checked="" type="checkbox"/> S&U BizWizard Add limited user	<input type="checkbox"/> S&U BizWizard Add limited user
Max Users:1 + 1	Max Users:4
Number of recipients:	Number of recipients:0

Figure 7: Result of the task 3 for one subject

**Task4-Retrieving data directly from existing web services at Netoptions AB**

In this task user was supposed to connect to web services directly and retrieve the data for the same company as in task 3. When the data was fetched then user should have performed a comparison on the data. This task is performed in following steps:

- Viewing customer's ordered modules in the e-economic system.
- Viewing the modules that customers used in "Bizwizard" system.
- Comparing the items in e-economic invoice with used modules in "Bizwizard" system for the selected company and finding the mismatches.

**Task5- Comparing the result of Task 3 and task 4**

When tasks 3 and 4 are finished for one installation then subjects had to compare the result of them. If the results were not the same then they had to record that installation. As the number of recorded installations was increase the accuracy of the prototype came down.

## 5.2 Data Analysis

Data analysis was performed on the data that was collected in "Interviews" and "Literature Study" steps. The analyzed data forms the following outcomes:

- A clear definition of the prototype specification and the list of functional and non-functional requirements of the prototype.
- Web service architecture.
- How to define the quality model for the prototype?
- Which quality standard should be followed to define a quality model?

- What are the prioritized characteristics and how to conduct an experiment to evaluate them?

In further sections the prototype specification and its quality model are discussed.

## 6. Prototype specifications

Users' needs and expectations are the basis of the requirements for a software product. They specify the real specifications of the software product.

Netoptions AB was the only user of the prototype that was developed as a web application in this study. Figure 8 displays this integration clearly. Superoffice, OnTime, E-economic and Bizwizard are the web services which are invoked by the prototype which is NAS (Netoptions Administrative System) web application. The incoming data from these web services are processed in this prototype to address the defined demands. As it is shown in this figure the prototype invokes the methods of all these web services but only Bizwizard invokes the service of the prototype and this is because of the functionality which was defined in this prototype. By this functionality, when a message is sent to the several recipients through Bizwizard application, a service in the prototype is called which saves the number of these recipients in the database of this prototype.

The main demand of this prototype is controlling the customers' invoices precisely, that is achieved by integrating these web services. Each invoice includes several modules that a customer orders. Once the web services are integrated in the prototype, two lists are generated for the specific installation. One from paid modules and the other from the modules that customer is using at that moment. By performing the comparison which was defined by Netoptions AB specifically, the difference between these two lists is revealed. This difference plays a significant role for business management at Netoptions AB. In sections 6.1 and 6.2 the collected functional and non-functional requirements of this prototype are reviewed.

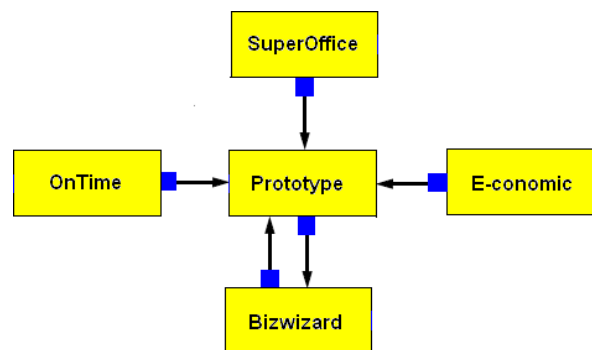


Figure 8: Prototype for integrating the web services

## 6.1 Functional Requirements

In this section the functional requirements of the prototype are described.

### 6.1.1 Importing companies from e-economic system into NAS database

In order to start working with NAS, the data of all companies which exist in e-economic system should be downloaded into NAS database. By "Import companies" feature all companies are imported into NAS database. User is also able to select only the desired companies to be downloaded.

### 6.1.2 Verification in “OnTime” and “Superoffice” systems

When a company in e-economic is imported into NAS database then “OnTimeId” and “SuperOfficeId” fields in NAS database are filled with E-economic id automatically. But there is no guarantee that the company id in OnTime and Superoffice are the same as in E-economic. So verification should be performed to check it. If they are not correct then user must change it. The verification process is done based on company name.

### 6.1.3 Search

The prototype searches in three entities such as companies, installations and their URLs. The search feature is available in all pages. When a value is entered to be searched, these entities are searched and the match objects are listed as link which means user can view each found item with details in a related page.

### 6.1.4 Installation management

The most important operation in this prototype is processing the installations. Installation refers to the modules that customers are currently using. Installations data is not saved in any database at Netoptions AB. So, NAS is responsible for saving, managing and performing the defined calculations on them. There are some features that enable users to create, view, edit and remove an installation.

### 6.1.5 Companies list

All companies with their saved installations are listed. Each company can have one or more installations. User is able to view all installations with their URLs as nodes of a tree.

### 6.1.6 URL management

The prototype provides the features by which user is able to define URL for an installation or remove it. These features are accessible through adding new installations or modifying them.

Assigning URL to an installation is an important step which effects on “Getting license key” functionality that further will be explained.

### 6.1.7 View installation

User can view the details of stored installations. By this feature, in addition to the installation details, a comparison between the data that is retrieved by decrypting license key and the data in E-economic system is done and the result is shown. Decrypted license key shows the modules that customer is currently using. These modules are compared with the modules that are retrieved from e-economic system. The modules from e-economic are those which customer has paid for them.

### 6.1.8 Get License Key

Updated license key plays the most important role at Netoptions AB business system. This value is retrieved through a web service in Bizwizard system. This web service needs URL and GUID (globally unique identifier) of an installation to be able to retrieve its license key.

## 6.2 Non-Functional Requirements

As it was explained, in ISO 9126 quality model the characteristics are categorized as functionality, reliability, usability, efficiency, maintainability and portability. Between these six characteristics “functionality” and “efficiency” are the two selected characteristics of this prototype.

As it was discussed, functionality includes suitability, accuracy, interoperability, security and functionality compliance sub-characteristics while efficiency includes Time behavior,

resource utilization and efficiency compliance sub-characteristics.

For this prototype “Accuracy” and “Efficiency” are the two selected sub-characteristics to be discussed. All these two requirements are discussed completely in the next section.

Between these two requirements the functionality is in higher level of importance for Netoptions AB. These two non-functional requirements are further explained in the next section.

## 7. Quality Model of the Prototype

In this study, ISO/IEC 9126 as a quality standard was selected to assess the quality of the developed prototype. Based on this standard and the collected requirements the quality model of the prototype was defined.

In this prototype the main quality challenge was on correctness of the result of a comparison process which was performed after web services were integrated in the prototype. So, it was the main need during the definition of the quality model of the developed prototype and selection of relevant quality characteristics in ISO/IEC 9126 standard.

To address the defined research question in current study following steps were performed:

- Analyzing the requirements and quality needs of the prototype and prioritizing them.
- Identifying the applicable quality characteristics and sub-characteristics according to ISO/IEC 9126 standard.
- Identifying the metrics for selected characteristics.
- Measuring the quality of the prototype based on the prioritized characteristics of the prototype and the relevant metrics for them.

### 7.1 Quality Attributes of the Prototype

Based on the collected data and by investigating the characteristics presented in ISO/IEC 9126 the quality attributes were chosen for the prototype.

Among the six characteristics in ISO/IEC 9126, the two quality characteristics such as functionality and efficiency were chosen for defining the quality model of the developed prototype since these two were the non functional requirements collected during data collection phase. These two selected quality characteristics with their sub-characteristics are further explained.

#### Functionality

Functionality of a software product is related to the functionalities that are described in Software Requirement Specification document. For evaluating this important quality characteristic of the prototype, ISO/IEC 9126 was applied. According to this standard, functionality has five sub-characteristics: suitability, accurateness, interoperability, compliance and security. By evaluating these sub characteristics, the quality of software product’s functionality is specified. For evaluating the functionality of the prototype, accurateness attribute was selected since the assessment of the result of the comparison operation that is performed on the data that is fetched from integrating the web services, is of high significance to that company.

- **Accurateness**  
**Definition**

“Capability of the software product to provide the right or agreed results or effects with the needed degree of precision [21]”

**Metric name**

Comparative accuracy

**Metric description**

Total count of recorded installation codes in C which is defined as following:

**A:** the data list from the comparison operation by running the prototype for the given installation code

**B:** the data list directly from web services for the given installation code

**C:** the installation code is recorded if A and B have different result

**Efficiency**

Based on ISO/IEC 9126, efficiency has three sub-characteristics: time behavior, resource utilization, efficiency compliance. By evaluating these sub characteristics, the efficiency is evaluated. For evaluating the efficiency of the prototype, time behavior attribute was selected.

- **Time behavior**

**Definition:**

“The capability of the software product to provide appropriate response time, processing time and throughput rates when performing its function under stated condition [22]”

This sub characteristic is important when user performs the “view installation” functionality of the prototype that integrates the web services and then runs the comparison operation and displays the result. This is important for Netoptions AB how quick does the system respond.

**Metric name:**

Response time of displaying the compared result

**Metric Description:**

1. For each installation code:
  - a. Perform the comparison task minimum 3 times
  - b. Calculate the average time to get the compared result list
2. Calculate the maximum value of the average time to get the compared result data for all installation codes.

**8. Measurement and Experiment result**

After the quality attributes were defined, the quality evaluation was started in order to measure the most prioritized attribute of the prototype which is “Accuracy”. This measurement was performed by designing and conducting an experiment. The design of this experiment has been explained in section 5. In this experiment different groups of subjects were defined and each subject was given the predefined tasks and asked to record his/her result.

By studying the results of the subjects and reviewing the installations which were recorded by them, it was concluded that the issues which made the wrong results, were caused because of one of the following defect categories:

Defect I: License key of a company is not fetched correctly in the prototype.

Defect II: There is a fault in the implementation of comparison operation in the prototype.

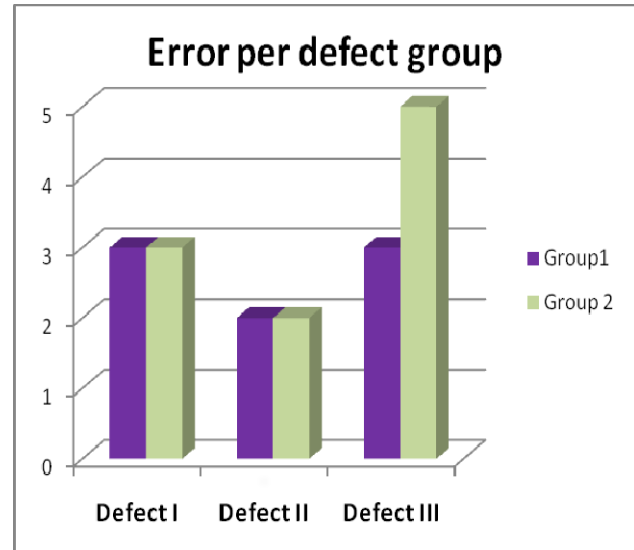
Defect III: User’s mistakes in one of the steps in the defined tasks that led to the wrong result.

Figure 9 provides the experiment result. In this chart the average number of errors in each defect category is shown. The defect types form the horizontal axis of this chart.

According to the chart, most errors are in the defect types which are not related to the software product. These errors were mostly produced by users when they interacted with the prototype.

By analyzing the chart (figure 9) it can be concluded that most errors belong to the defect group III. Most defects in category III are as follows:

- They selected the wrong company name that was similar to the one in experiment data. So the wrong code was registered in application database and integration result was incorrect.
- They entered the GUID and URL which did not belong to the selected company and finally a wrong license key was fetched.
- Selecting wrong data in “OnTime” verification.



**Figure 9: errors in each defect category for the two groups of subjects**

Defect III was mostly caused by group 2 because this group was not familiar with customers’ data. The first group had more experiences in working with customers’ data so made fewer mistakes. Group 1 contains the real users who are supposed to work with the prototype.

In defect types I and II, group 1 was encountered with the same number of errors in comparing with group 2, because these two defect types are only related to the prototype implementation and user does not have any considerable role in producing them.

Most errors in defect type “I” were made by a problem in connection to Bizwizard web service. Netoptions AB has a plan, in a near future, to use a technology which also helps this prototype to remove this problem.

The errors in defect type II were made because of the following reasons:

- License key decryption failure.
- Failure in fetching invoices from e-conomic web service.
- Failure in comparing decrypted license key with the invoice come from e-conomic.

These defects can clearly reflect how much accurate is the system. As it is shown in figure 9 these errors were not reported so much and it shows the level of accuracy in the implementation of this prototype.

## 9. Conclusion

In this study the efforts were made to define the quality model for a prototype that was developed as a web application in which some web services were integrated. This web application was developed to control the daily business at Netoptions AB which is located in Göteborg, Sweden.

For defining this quality model the ISO/IEC 9126 standard was selected and applied. This standard presents a quality model which has the most complete quality characteristics for software product evaluation.

Based on this standard, the quality attributes were specified for the prototype and prioritized. According to the defined requirements of this prototype, the quality attributes which were important for this product were accurateness and time behavior. Since accurateness was defined more important, an experiment was designed for measuring it.

This experiment was performed by a group of employees at Netoptions AB. Each subject performed the experiment tasks for the provided list of companies. Chart 9 displays the average number of errors. The result of this experiment proves that this prototype is in a very good accuracy level. By looking at the chart in general it can be mentioned that despite group 1 is placed in worst-case situation, their result is really satisfactory. The main focus of this prototype was on integration of web services and despite group 1 had no idea about integration concept, their results were very acceptable.

## 10. Recommendations and future studies

Once the experiment was completed, subjects were asked to provide their feedback regarding to the prototype. The majority of them were satisfied and believed that by the aid of this application, the quality of customers orders management is guaranteed. Previously they had to do this checking manually which demanded much effort and could contain considerable defects. Moreover some additional suggestions for improving the accuracy of the prototype were proposed by subjects. These suggestions related to adding user interface tools and checking functions in order to decrease user errors and achieve a more accurate result.

The developed prototype has presented a proper solution to Netoptions AB demands. But yet there are some spaces for functionalities improvements which enable Netoptions AB to monitor more business tasks in future. However, the proposed study will help those companies which are interested in finding solutions for integrating web services in order to generate new functionalities or investigating the quality of the solution. By implementing the proposals contained within the present study software companies will be able to produce methods that evaluate the quality of their solutions.

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Appendix A

a) Class Diagram

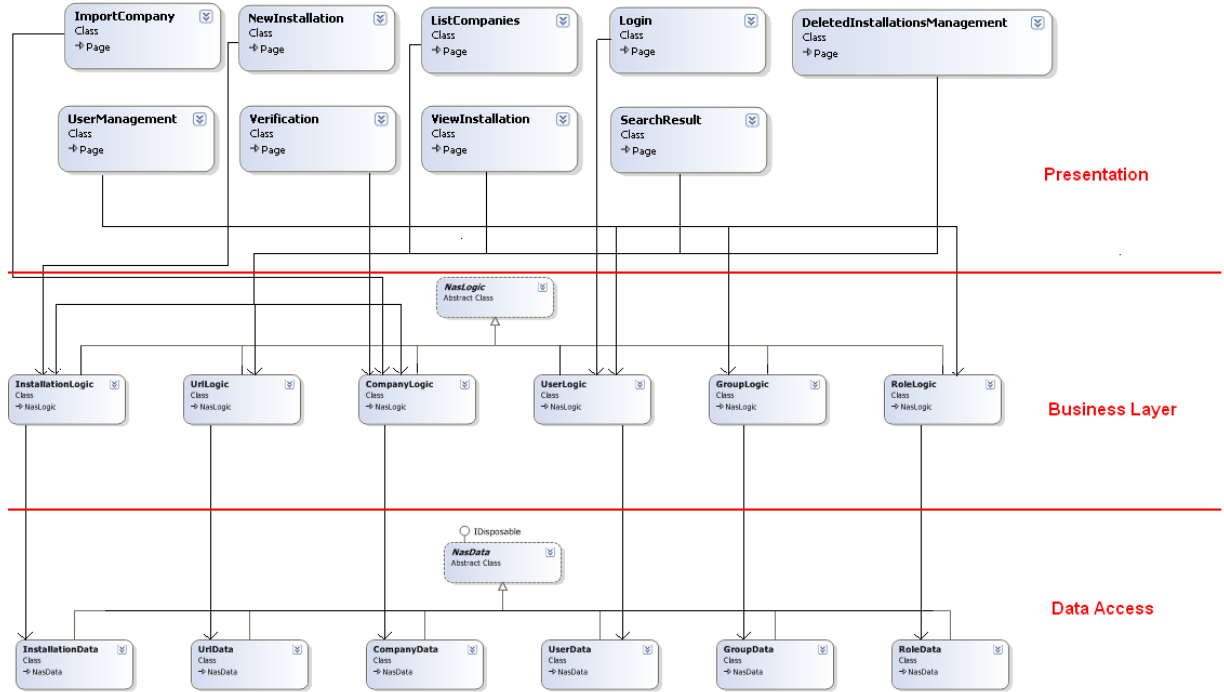
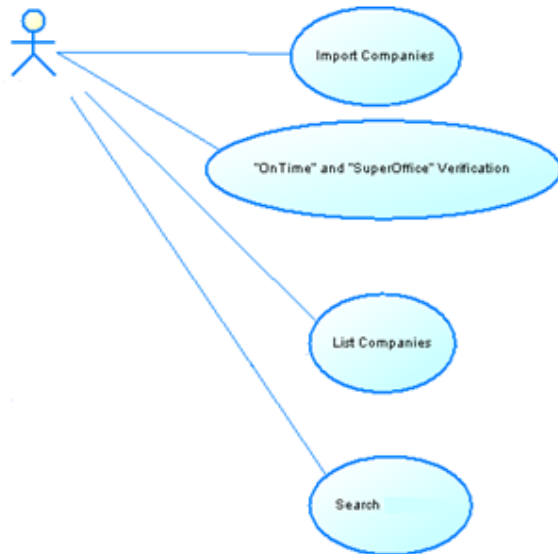


Figure 10: Class diagram of NAS prototype

b) Use case diagram

b-1) Company management



- Import companies

With this feature all companies are imported into NAS from e-economic system.

<b>Business Goals and Benefits:</b>	Some key values of each company in e-economic system should be saved in NAS database to enable NAS to save some information for that company.
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<b>Actor:</b>	Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Import” button in “Import company” page.
	<b>Pre-conditions:</b> User opens “Import Company” page and clicks on “Get All companies” button and then all companies in e-economic system are listed. Each company is shown with a checkbox near to it. User selects the desired companies.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> There are two fields in NAS database which are “OnTimeId” and “SuperOfficeId”. When a company is imported in NAS database then these two fields are filled with E-economic id.
<b>Extension Points</b>	-

- “OnTime” and “SuperOffice” Verification

The verification process is done based on company name. If they are not correct, user must manually check OnTime or SuperOffice systems and retrieve the correct id and enter it in related text box. Again user can click on “Verify” button to check whether this new entered id is correct or not. After this editing, user can save the updated OnTime id in NAS database.

<b>Business Goals and Benefits:</b>	Making sure the right id will be saved for OnTime and SuperOffice fields in NAS database.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Verify” button in “OnTime & SuperOffice Verification” form.
	<b>Pre-conditions:</b> <ul style="list-style-type: none"> <li>- “Import Companies” should have been performed in order to have data in “OnTimeId” and “SuperOfficeId” fields in NAS database.</li> <li>- User opens “OnTime &amp; SuperOffice Verification” page. Then all existing companies in NAS database are loaded in a combobox and when user selects a company in that combobox then its OnTime id and SuperOffice id in NAS are shown. Now for verifying that the id in “OnTime” and “SuperOffice” is correct, user can click “Verify” button.</li> </ul>
<b>Post-conditions</b>	<b>Post-conditions on Success</b> If they are correct, a verification message is shown under the text box otherwise a mismatch message is shown under the id (OnTime id or SuperOffice id) that doesn’t exist in OnTime or SuperOffice system.
<b>Extension Points</b>	-

- Companies list

<b>Business Goals and Benefits:</b>	A clear list of all customers with their installations is shown. These modules are the ones that customers currently are using.
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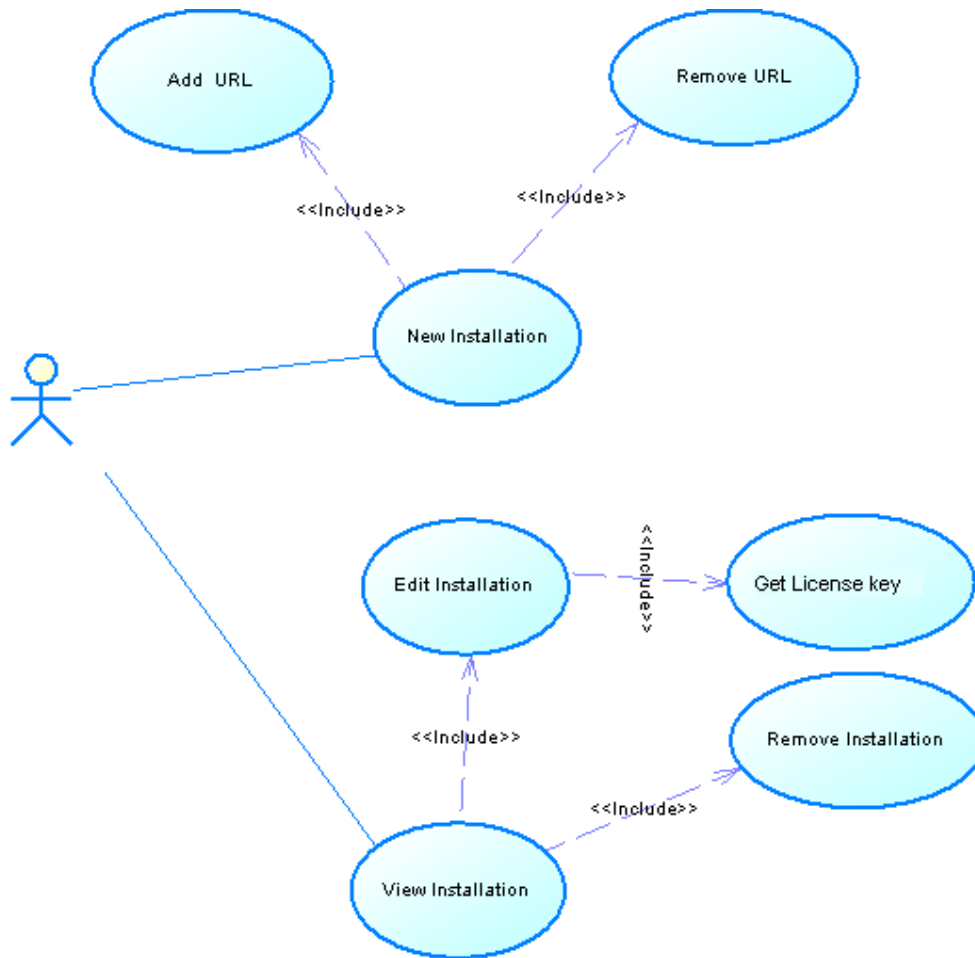
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User opens "Companies List" page.
	<b>Pre-conditions:</b> -
<b>Post-conditions</b>	<b>Post-conditions on Success</b> Companies are loaded and listed like the nodes of a tree. If a company node is clicked, its installations are loaded like its sub nodes. Finally if any of these "installation" nodes is clicked the existing URLs of this installation are loaded like the sub nodes in that tree. When user clicks on each URL the related web site is displayed in the web browser.
<b>Extension Points</b>	-

- Search

When user enters some text in search textbox and clicks on Search button then

<b>Business Goals and Benefits:</b>	Performs searching on companies, installations and urls.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on "Search" button which is located on all NAS web pages.
	<b>Pre-conditions:</b> -
<b>Post-conditions</b>	<b>Post-conditions on Success</b> The search result is shown in new page. The results are displayed in link format and whenever user clicks on each link then the view page of the selected item is shown. E.g. if found item is a url then a web browser is opened. When "Search" process cannot find any result then "No result was found" message is shown.
<b>Extension Points</b>	"View Installation"

b-2) Installation management



- New Installation  
With this feature a new installation can be created.

<b>Business Goals and Benefits:</b>	When customers at Netoptions AB order some modules, these modules are not saved in a database and they are only registered in an MS excel file. By the help of this feature these modules are saved in a database and lots of calculations can be performed on them.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on "Save" button in "New Installation" page. <b>Pre-conditions:</b> When user selects a company from loaded list then he has information about company's SuperOffice id, E-conomic id and Ontime id. But user must enter the data for other fields in this page like: customer type, installation type, URLs and GUID. Additionally the "Get License key" operation should be performed which is explained further.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> The new installation will be saved in NAS database.
<b>Extension Points</b>	-

- Delete installation

Installations can be removed. All installations can be removed but not physically and they should be kept in database as flagged records. None of the defined operations consider them.

<b>Business Goals and Benefits:</b>	When an existing installation is cancelled, by this feature it can be marked as a deleted data and no more processes are done on it.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Delete” button in “View Installation” page.
	<b>Pre-conditions:</b> When user clicks either company node or installation node in “Installations List” page, then “View Installation” page is shown.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> The current installation object will be marked as deleted in NAS database.
<b>Extension Points</b>	-

- Edit Installation

Installations can be modified.

<b>Business Goals and Benefits:</b>	
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Edit” button in “View Installation” page.
	<b>Pre-conditions:</b> When user clicks either company node or installation node in “Installations List” form then “View Installation” page is shown. User clicks on “Edit” button in “View Installation” page.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> The current installation object will be marked as deleted in NAS database.
<b>Extension Points</b>	“New Installation”

- Add URL

By this feature a new URL is added to one installation.

<b>Business Goals and Benefits:</b>	Assigning URL to an installation is an important step which effects directly on “Getting license key” functionality that future will be explained.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.

<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Add URL” button in “New Installation” page.
	<b>Pre-conditions:</b> User is either in editing or adding an installation page.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> The new entered URL is added to the URL list in “New Installation” page.
<b>Extension Points</b>	-

- Remove URL

By this feature a selected URL of an installation can be removed.

<b>Business Goals and Benefits:</b>	In order to remove an existing URL of an installation
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Del” link in “New Installation” page.
	<b>Pre-conditions:</b> User is either in editing or adding an installation page.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> The URL next to the “Del” link is removed from installation object. In order to remove this URL from NAS database, “Save” button should be performed.
<b>Extension Points</b>	-

- Get license key

<b>Business Goals and Benefits:</b>	Updated license key plays the most important role at Netoptions AB business system. This value is retrieved through a web service in Bizwizard system. This web service needs URL and GUID (globally unique identifier) of an installation to be able to retrieve its license key.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<b>Triggers:</b> User clicks on “Get license key” button in “New Installation” page.
	<b>Pre-conditions:</b> GUID and URL of an installation should be entered.
<b>Post-conditions</b>	<b>Post-conditions on Success</b> License key is retrieved from Bizwizard system.
<b>Extension Points</b>	-

- View Installation

In this page some information related to the selected installation of a company is shown.

<b>Business Goals and Benefits:</b>	User can view the details of stored installations. By this feature, in addition to the installation's details a comparison between the data that is retrieved by decrypting license key and the data in E-conomic system is done and the result is shown. Decrypted license key shows the modules that customer is currently using. These modules are compared with the modules that are retrieved from e-conomic system. The modules from e-conomic are those which customer has paid for them.
<b>Actor:</b>	Primary: Sales manager and project technical leader who interactively work with the NAS (Netoptions administrative system) application.
<b>Rules of Precedence</b>	<p><b>Triggers:</b></p> <ul style="list-style-type: none"> <li>- When user clicks on a company node then "View Installation" page is shown with its first installation node.</li> <li>- When user clicks on an installation which exists in search result list.</li> </ul> <p><b>Pre-conditions:</b></p> <ul style="list-style-type: none"> <li>-</li> </ul>
<b>Post-conditions</b>	<p><b>Post-conditions on Success</b></p> <p>"View installation" page is opened and its data is displayed.</p>
<b>Extension Points</b>	-