Quality of Service - FFI
IT2901 - Group 7

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Abstract

Background:

A proof of concept project on behalf of FFI looking into the possibilities and viability of QoS prioritisation of web service data in military and/or low bandwidth networks. We'll be looking into a way to implement QoS in a web service network on WSO2 and with a custom client library. Using them together we'll be looking into how such a layer would affect the efficiency of both low priority and high priority requests on the network for various network bandwidths.

Results:

Our results shows that applying prioritization at the application level will have an effect on the speed of which messages arrive in a network with constricted bandwidth. However due to the variation in experiments we can not say much about the actual gains that can be achieved, but we did observe large enough changes so as to say this is a viable way to research more.

With our implementation we can see that depending on the available bandwidth and the relative settings there are major gains to be had by prioritizing at the application level. If we compare with and without our prioritization layer we can see that there is a large gap between the average time taken to get messages from the client, to the service and back from the service which is so substantial that it could not be accounted for by chance. The gains are in order of magnitudes better with prioritization.

Adding such a prioritization layer to the web service side did not have a great impact on the performance of the network when there were more than enough bandwidth suggesting that the overhead should not be to large.

Conclusion:

From our approach to the problem, it seems QoS in the application layer of the OSI model is a viable way to make sure packages are prioritized in low bandwidth networks, despite having a certain communication overhead.

Acknowledgements

A big thank you to our customer representatives at FFI for an interesting challenge as well as great feedback during the project.

A thank you to Magnus Skjegstad at FFI for use of the MobiEmu library for easy system testing.

We'd also like to thank Oleg Kalnichevski on the Apache Synapse and Http Components mailing lists for all his help solving the issues we had and getting our patch accepted.

Thanks are extended to our supervisor and everyone else who helped with feedback during the project as well.

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1 Project Introduction

This is the final report documenting our progress in the course IT2901 - Informatics Project II. It will give a description of the problem we were presented with, how we planned the work for the project, how we organized our group and what development methodology we ended up choosing etc. We will also give a brief discussion about why we have made the decisions we have.

1.1 Project Background

> *Essential to Network Based Defence (NBD) is the concept of end-to-end QoS, which in turn requires employing cross-layer QoS signaling. This means that QoS must be considered at all layers of the OSI model, and that QoS information must traverse these layers...* - Motivation[1]

This was the introduction we got for our motivation to work on this project. In many ways it illustrates the background of the project and why the customer wanted us to work on it. As the customer is working with wireless networks with very low bandwidth they need to be able to control the flow of messages. The reason for these strict requirements is the command hierarchy and the risks involved which means that some messages in the network are more important than others. To be able to separate those messages there needs to be a collaboration between all the applications and libraries used. Currently there is no or little support for this cooperation on the application level which is what we were tasked to do. For us this assignment would be a challenge not just because it is some what uncharted waters, but also because of the strict requirement to prioritize.

1.2 Customer

Our customer were two senior researchers at the Norwegian Defence Research Establishment(FFI) [2] working in the SOA division. They had this to say about FFI.

[1] Please see (I) - Quality of Service (QoS) support for Web services in military networks
[2] Forsvarets Forskningsinstitutt (FFI) - [http://www.ffi.no/]

The Norwegian Defence Research Establishment (FFI) is the prime institution responsible for defence-related research in Norway. The establishment is the chief adviser on defence-related science and technology to the Ministry of Defence and the Norwegian Armed Forces' military organization. FFI addresses a broad spectrum of research topics ranging from the assistance of operational units to the support of national security policy via defence planning and technology studies. FFI also has a research unit in Horten focusing on maritime research.

1.3 Course

In this course, students will work in groups to carry out a software project. The department will present a list of available projects. Students are required to work on their project and to attend common activities and supervision meetings. The results from each phase must be clearly documented in the mid-term and final report. [3]

The focus of the course is to give customer interaction and experience in larger development projects with extensive parts of planning and documentation.

1.4 Students

The student education is common among the group members. We're all studying informatics on our third year of our bachelors degree. Most of us started studying straight out of high school and have little or no relevant skills besides the university courses. Although some members have done some work outside of university.

Among the experience in the group some people have experience with Git. We have one person which have done several large scale project which will help us immensely. Some of the people have some experience with NS3 which would come in handy. And everyone have extensive experience with Java.

1.5 Supervisor

The institute(IDI) had assigned us a supervisor. The supervisors role was to give guidance to the group related to matters of group dynamics and project management. The supervisor would also assist in the process of solving conflicts in the group, if any. The supervisor would also step in as a mediator if we had experienced any problems with the customer which we could not resolve on our own. The supervisor have also given us feedback on our report and progress throughout the project. This has been valuable feedback that we have used to improve our report.

We have had biweekly meetings with the supervisor throughout the project. Every week we sent our weekly report and activity plan to the supervisor to inform him of our progress.

[3] Course description fetched from the course pages at NTNU.no, 29.03.12 - [http://www.ntnu.edu/studies/courses/IT2901]

1.6 Document Structure

This document is structured in a fashion to show you, the reader, our process throughout this project. It should give you a view into each part of the project from the early weeks when we were struggling to understand the initial design right up until our final moments with testing.

We begin with describing the task and the requirements in *Task Description and Requirements*. This is the details of the task we were given by the customer, and the high level requirements that we, together with the customer, agreed upon.

Prestudy continues with our initial thoughts around the project. It includes the architecture we envisioned for the client and the server early on in the project and it will give you some insight into what we initially thought and will serve as a good comparison with our end result.

Next is the chapters about *Project Management* and *Development Methodology*, these two chapters combined should give an impression of our thoughts and plans for collaborations to reach our end goals. It should also give you an idea about how all of our appended documents, such as Activity Plans, have played a role during the course of the project. After reading theses sections, the team structure and the distribution of responsibilities in the group should be explained.

The chapter about *Design and Implementation* will focus on the design of our two pieces of software in some detail and should give you a good idea about the overall architecture of the system. After that follows a section which should give the necessary details about our code and how the system works deeper down. Last in this chapter is a section about what has changed from the original design.

The next chapter outlines our *Testing*. Here we will explain how to setup the testing suite and will detail our test. These tests will be connected with the requirements and it should detail why we wanted to run each tests. The ability to reproduce our whole testing setup will also give you the confidence that we have in our results. We will end this chapter with a look at our results and some thoughts about how these findings relate to our initial problem.

Finally we will wrap up with *Project Evaluation* and *Conclusion* which together will wrap up the report. This will look at the future work for this research and give you our final thoughts about the course, project and process.

2 Task Description and Requirements

Our task was to provide a Quality of Service[4](QoS) layer to web services for use in military tactical networks. These networks tend to have severely limited bandwidth, and our QoS-layer will therefore priorities between different messages, of varying importance, that clients and services want to send. Our software will have to recognize the role of clients, and, together with the service they are trying to communicate with, decide the priority of the message.

[4]Quality of Service refers to several related aspects of telephony and computer networks that allow the transport of traffic with special requirements.[http://en.Wikipedia.org/wiki/Quality_of_service]

2.1 Description

Our assignment was to create a Java application which will function as a middleware[5] layer between Web Services[6], and clients trying to use these services. The middleware needs to process SOAP[7] messages, which is the communication protocol for most web services, in order to be able to do its task. On the server side, the middleware needs to process messages and understand SAML[8] in order to deduce the role of the client. This role, together with information about the service the client is trying to communicate with, decides the overall quality of service the messages should receive.

Our software needs to be able to modify the TOS/DiffServ packet header[9] in order for the tactical router[10] to prioritize correctly. At the time of writing NATO has just defined one class, BULK, which is to be used with web services. It is defined in the STANAG 4406 as Military message Handling system. This standard may change in the future and our middleware must handle these upcoming changes gracefully.

In addition to this, the middleware needs to be able to retrieve the available bandwidth[11] in the network, which in the real system will be retrieved from the tactical routers. In our testing this information will come from a dummy layer, but how this information is obtained should also be very modular, so that the customer can change how the bandwidth information is obtained later.

With all this information, the role of the client, the relationship between the client and the service, and the available bandwidth, our middleware layer should be able to prioritize messages. Our product should, as much as possible, use existing web standards, the customer outlined some of their choices and options we have for implementation, like SAML, XACML[12], WS-Security[13] and WSO2 ESB[14]. In addition to this, our middleware needs to work with GlassFish[15], as that is the application server the customer uses.

2.2 Requirements

As the customer wanted all documentation written in English, we decided to use this for all written communication and documentation, in order to keep things

[5]In the report middleware will refer to the program we are making. Other distinctions should be made explicitly in the text.

[6]Web Services - A software system designed to support interoperable machine-to-machine interaction over a network.[http://www.w3.org/TR/2004/NOTE-ws-gloss-20040211/#soapmessage]

[7]SOAP - A lightweight protocol intended for exchanging structured information in the implementation of web services in computer networks.[http://www.w3.org/TR/soap12-part1/#intro]

[8]SAML - Security Assertion Markup Language.[https://secure.wikimedia.org/wikipedia/en/wiki/SAML]

[9]TOS - Type of Service, a field in the IPv4 header, now obsolete and replaced by DiffServ.[http://en.wikipedia.org/wiki/Type_of_Service]

[10]Tactical router - A Multi-topology router used in military networks

[11]Bandwidth - Available or consumed data communication resources.[https://secure.wikimedia.org/wikipedia/en/wiki/Bandwidth_(computing)]

[12]eXtensible Access Control Markup Language. [https://secure.wikimedia.org/wikipedia/en/wiki/Xacml]

[13]WS-Security - An extension to SOAP to apply security to web services

[14]WSO2 ESB - An Enterprise Service Bus built on top of Apache Synapse. [http://wso2.com/products/enterprise-service-bus/]

[15]Application server written in Java. [http://glassfish.java.net/]

consistent.

The way the course is structured in terms of deliveries of reports and documentation also creates a fairly natural implicit sprint period to work off of, and using an agile methodology will help in easily producing and maintaining said reports and documentation. In addition to the reports and documentation, we will try to deliver a prototype to the customer before the final delivery in May.

The customer did not require any prototypes along the way, just a working piece of software by the end of the project, so the deadline we set for the prototype was self-imposed.

The customer had not given us many strict requirements, but instead they suggested a few things that we could do. Given this freedom, we decided that we would improve on the base requirements by adding most of the things mentioned in this section.

The following is a list of technology requirements. We have a scale from 1 to 4 where we rate the importance of our requirements. 1 is the most important while 4 is the least important. There are requirements that share a priority as they are equally important to the completion of the project.

ID	1
Name	Written in Java
Priority	1
Purpose	Java is chosen to ensure that the code can be reused, that it is easily readable for others, and that it is OS independent.
Constraints, assumptions, dependencies	The Java JVM and skills in Java programming.
Functional	Working on all platforms that support Java. Not OS dependent.
Non-Functional	Ensure good code quality and code conventions
Design constraints	Because we chose to work with WSO2 ESB we decided that we would just use Java version 6. This is because the ESB is hardcoded to use Java version 6, we felt that this was not a big hindrance

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ID	2
Name	Message prioritizing
Priority	1
Purpose	Differentiate the messages being sent and make sure that high priority messages is sent before low priority messages.
Constraints, assumptions, dependencies	-
Functional	High priority messages must arrive, even at the cost of dropping lower priority messages.
Non-Functional	-
Design constraints	-

...

ID	3
Name	Standards
Priority	1
Purpose	Use standards where they can be used
Constraints, assumptions, dependencies	-
Functional	SAML, Diffserv
Non-Functional	Use web standards were we can and it makes sense
Design constraints	-

...

ID	4
Name	Testing
Priority	2
Purpose	Use NS3[16] for testing.
Constraints, assumptions, dependencies	We will be limited in the types of network we can create. Since this is also not real world testing we can only say something about a best case scenario in the simulation.
Functional	The testing framework should be working and we should have test results from it.
Non-Functional	We used unit tests while coding to make sure that the code worked correctly.
Design constraints	The tests have to be designed with the functionality in mind, not the existing code.

...

ID	5
Name	Documentation
Priority	2
Purpose	To have extensive documentation on every part of our project. This will ensure that anyone can replicate our results later. This is also important to the customers as they want to replicate our results to see if this type of QoS could be used in an actual network.
Constraints, assumptions, dependencies	-
Functional	The documentation should be so extensive and thoroughly written that anyone can replicate our results. And the use of our library should be documented to help anyone wanting to use it.
Non-Functional	All documentation shall be in English and be written to the best of our abilities to ensure good quality.
Design constraints	There are some constraints that were set by the institute. These constraint dictates sections that has to be present in the report.

...

ID	6
Name	Use metadata to determine priority
Priority	3
Purpose	The purpose of this requirement is that our software should use metadata to determine the priority of clients. As the server side has to tell clients which priority they get they have to use metadata to inform the clients.
Constraints, assumptions, dependencies	Since we have to support SOAP messages we are limited in they ways we can express this metadata.
Functional	The metadata has to be presented in a way that a client using SOAP can interpret.
Non-Functional	-
Design constraints	-

...

ID	7
Name	GlassFish
Priority	2
Purpose	Make it easy to use Web Services in a production environment.
Constraints, assumptions, dependencies	This puts some constraints on the type of services we can deploy.
Functional	GlassFish must be supported as the application server.
Non-Functional	-
Design constraints	-

...

ID	8
Name	Set package priority
Priority	2
Purpose	Currently there is only one priority class defined by NATO, the BULK class, but this will most likely change in the future, as such our middleware layer needs to be expandable enough to handle this change in the future.
Constraints, assumptions, dependencies	Since we are using Java we are constrained to IPv4 as Java does not support setting the Type of Service field on IPv6[17].
Functional	Must be able to set priority on network layer packets. There must also be an easy way to configure this priority so that future NATO DiffServ classes will be supported.
Non-Functional	-
Design constraints	-

...

ID	9
Name	Network Resources
Priority	3
Purpose	Minimize the usage of network resources. Use the given resources the best way possible.
Constraints, assumptions, dependencies	Since we are to use as little network resources as possible we have some rather large constraints on the messages we can exchange. This would imply among other things that the metadata we want to exchange can not be sent as separate messages, but should be piggybacked on other messages.
Functional	Use as little network resources as possible.
Non-Functional	-
Design constraints	-

...

ID	10
Name	Resource usage
Priority	4
Purpose	Minimize overhead and runtime. The faster it goes, the better. The less resources it uses the better.
Constraints, assumptions, dependencies	-
Functional	The customer has only said that we can expect the product to be used on a standard laptop with full Java support. This means that as long as the program runs on our laptops we should be good to go resource wise.
Non-Functional	-
Design constraints	-

3 Prestudy

This project was one that requires quite a lot of prestudy before we could begin coding or even designing the architecture. Since the customer wanted us to implement existing technologies, such as Glassfish, WSO2, SAML etc. we needed to spend some time researching those technologies to figure out what to use, and how to use it. The following sections will describe the the overall architecture of how we imagined our system to be like.

3.1 Server side Architecture

The server side architecture consists of several components, the WSO2 ESB, the Tactical Router and the GlassFish server. Most of them are visible in the initial architecture shown in figure 1. All of these components are already available, so what we needed to make was mediators[18] in the ESB.

Before the client can request a web service it has to have an identification. To get an ID-token it has to contact the Identity Server using the ESB as a

[18]Mediator - A component in WSO2 ESB which can be used to work on incoming or outgoing messages that passes through the ESB

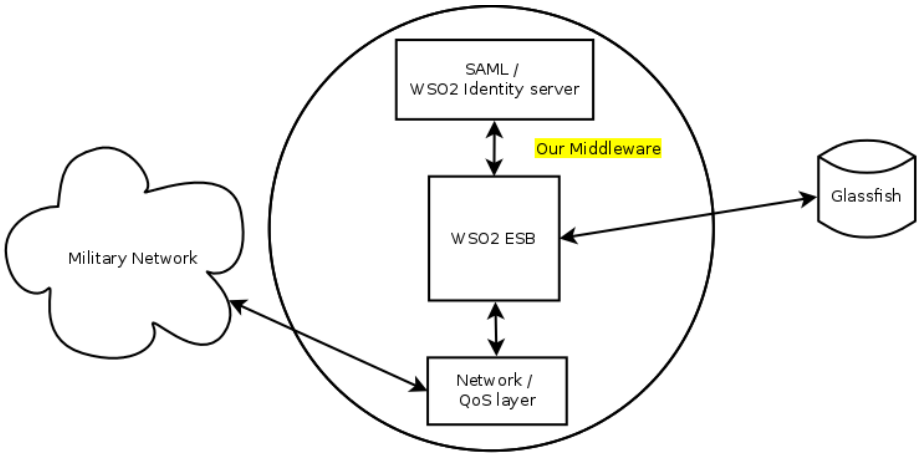


Figure 1: Basic server architecture
This shows our initial thoughts of how the servers side architecture would look like. This was changed later in the project.

proxy[19] (Fig.2-1). Then the client can request a web service from the ESB. Several things will then happen in the ESB. First the request message is sent to the SAML mediator (Fig.2-2), this mediator contacts the Identity Server to validate the clients ID-token (Fig.2-3). If the token is validated and the client is supposed to have access to the requested service, the message is passed on to the GlassFish proxies (Fig.2-4), otherwise it is dropped. The ESB acting as a proxy will then send the request along to the requested service on the GlassFish server (Fig.2-5).

When the request is received at the service, it will probably start sending some data to the client. This is also done through the ESB. First the message is sent to the QoS mediator (Fig.2-6). This mediator will first look at the role, or identity, of the client and the service requested, and use this information to assign a priority to the connection. Then the Monitoring Service[20] on the Tactical Router is contacted for bandwidth information (Fig.2-7), which is used together with the priority to determine whether the message should be sent right away or held back until some higher priority message is finished sending.

Either in the QoS mediator, in the ESB's network layer, or after that, the Diffserv (ToS) field of the IP header will have to be set (Fig.2-8) before the message is sent to the client (Fig.2-9). This field is used by the routers in the network to prioritize packet sending. This step is quite important to the whole procedure as this is one of the few requirements the customer has given us, as such this step can not be dropped from the final product.

[19]Proxy - A proxy server acts as an intermediary between clients and servers
[20]Monitoring Service, a service that provides bandwidth monitoring, running on the same server as the Tactical Router

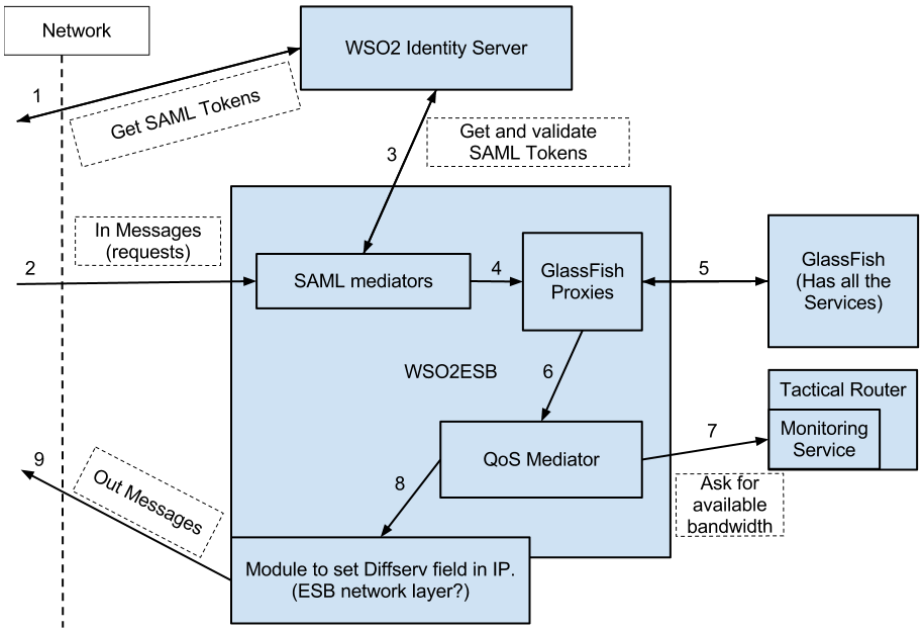


Figure 2: The Server side Architecture
This is the overall design of our implementation of the server side. It shows the modules in the server and the flow in the system.

3.2 Client side Architecture

The client-side architecture will be composed of altered (already existing) client software, the OpenSAML[21] library as well as our client library implementation.

Before the client library can ask for the data the client needs to get a SAML authentication token from the identity server (Fig.3-1). The communication here will most likely be handled by our library, but the SAML packages will be created and analyzed by the OpenSAML library.

The client library then sends the request from the client to the server (Fig.3-2), appending the SAML token to the package as well as adding some metadata in the SOAP header related to the client role and setting the TOS field of the package to a default value.

The reply from the server is examined by our client library for the metadata the server has embedded in the SOAP header, relevant metadata is stored for future communication and the package is passed to the client application (Fig.3-3).

When new communication is initiated after this first connection is made the client should, if everything went as expected, have the necessary information to prioritize new messages. This means that the client can now take an informed decision about how it should prioritize messages, but in order to do this to the best of it's abilities it also has to take into consideration available bandwidth

[21] OpenSAML - A set of open source C++ and Java libraries to support developers working with SAML. [https://wiki.shibboleth.net/confluence/display/OpenSAML/Home/]

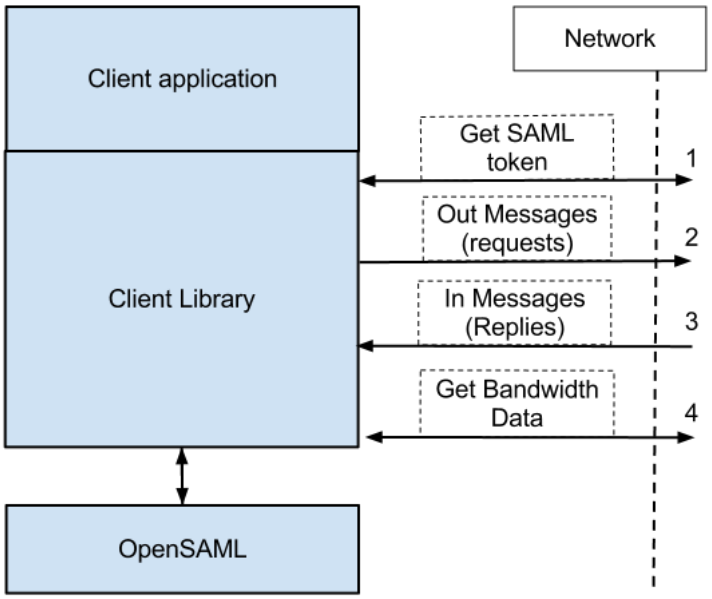


Figure 3: The Client side Architecture
The client architecture shows the basic thought of what the system should look like and the communication to and from the client library.

(Fig.3-4).

3.3 Unit testing

We decided quite early on that we wanted to do unit testing of every piece of code that we would produce, i.e. test driven development. The reason behind this choice is that we think it will result in better code quality. An added bonus is the simplification of integration testing, due to easier discovery of whether a new code addition will integrate with the old code. Also writing the tests first lets us concentrate more on exactly what the methods should do, instead of the content and how it should do it. One of the problems with test driven development however, is the possible bias that could occur, we could end up only satisfying the test and not the actual requirements. This could be countered to some extent by writing more comprehensive tests. Another positive point in favour of unit testing is the requirement we have, which states that the product has to be written in Java where such test are easy to integrate and write using JUnit.

3.4 Integration testing

For integration testing, we decided that we wanted to do automated system testing every other week in collaboration with code reviews. The procedure we are going to follow will be coding new features in a separate branch. Once every other week the finished branches will have all their unit tests run thoroughly,

followed by a code review of at least one person. Then if the automated system tests are fully operational, they will also be run to look for additional errors which the unit tests can not pick up. This point is likely to change in the future as a two week time interval might be too long given the short implementation period. The advantage of doing this integration testing is better overall code quality, since we will test code before it is used by other parts of the system. Since we are also doing code reviews, people will also gain experience with other parts of the system which they previously had not worked on. This will benefit everyone since knowledge about the system is shared, and it will help in the eventuality of someone getting sick. The advantage of developing in separate branches is the reduced risk of polluting code other people are working on, and a better separation of stable and unstable code.

3.5 System testing

When it comes to system testing, the customer was quite insistent that we test the product thoroughly in an emulated network situation. Since we have had some experience with NS3 we decided that we wanted to do the system testing on it. Following we describe the initial advantages of the testing freamework and test cases we were going to use.

The advantage with this, is that the customer has already set up some testing scenarios and helper-scripts designed for NS3, which they offered for our use. This will greatly reduce the time needed for setting up the test suite, and it will also give us the ability to have automated tests, which we don't have to monitor or interact with.

Another added advantage is easy testing, as we only have to start a script in order to run the whole suite, but that comes at the cost of actually setting up the whole thing. As of the midterm report, we have set quite a lot of time aside in order for us to implement the proper NS3 support we need.

To monitor what is happening during the test-runs, our applications will output all important information regarding what is going on, in addition to this we will have a packet sniffer on each end which will capture network traffic. Using this information we should be able to tell a whole lot about what is going on in the network and we should be able to decide whether we have met the requirements or not.

Below are some of the detailed test cases which we want to automate on top of NS3. The testing itself will be automated, but in order to get some result from the tests, some human interaction is needed to interpret the output data.

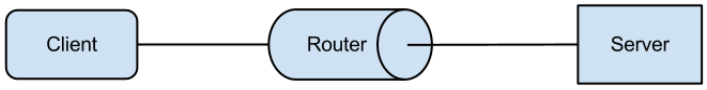


Figure 4: Simple message sending
One client communicates with one server through one router.

Simple message sending:
In this test, shown in figure 4, we want to test the ability of the client and

the ESB to communicate. We want to see that the client is able to send messages(definition can be found in glossary under message) to the server and get a response back. For monitoring purposes, this test will rely on both applications to log their behavior. In order for us to give this test the green light we must see a message going out from the client then passing through the ESB to GlassFish. Then finally a reply should be sent back from GlassFish to the ESB and then to the client.

Setting Quality of Service:
In this test, we want to test the client and the ESB's ability to set the DiffServ field in the IP header. The first requirement is that the test "Simple message sending" has been passed. For this test to be considered a success, the client has to send a message to the ESB, which will responds with the DiffServ value in the SOAP header. The ESB must at this point have set the DiffServ value in the IP header. The client should then use a service on GlassFish, but this time the IP header must contain the correct DiffServ value. In order to monitor this test, only a packet sniffer located on the client and ESB side needs to be used. The packets must be examined, and the correct DiffServ value must be present in the IP header of all packets, except the first one going out from the client.

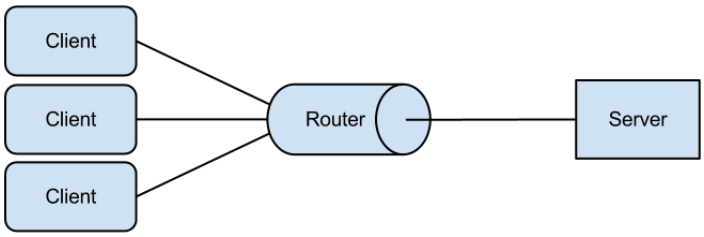


Figure 5: Three clients message sending
Three clients communicate with the same server through the same router. One of the clients will have a higher priority than the two others, in order to test the servers ability to prioritize.

Prioritizing messages:
In this test we want to test the ESB's ability to prioritize messages. The scenario will be set up as shown in figure 5, with two clients sending lots of messages in an attempt to flood the capacity of the network. All of these messages should have the same priority, but intermittently, a third client with a higher priority will attempt to send some messages. What we are looking for is that these higher priority messages should be sent out from the ESB before the ones with lower priority and, if necessary, it has to stop some already being sent messages. For this test to be successful, we must see some lower priority messages being preempted or held back. To do this, the log file of the ESB must be studied, and there should be some clear indications of one of the requirements.

Changing DiffServ value:
In this test we want to check the ESB's ability to change the DiffServ value after a reconfiguration. The test can be performed and the result examined the same way as "Setting Quality of Service", but this time the test has to be run

twice. One where the configuration has one DiffServ value, and a second run where the DiffServ field has a different value. For the test to be successful, one would have to examine the resulting pcap[22] files on the server side, and check each run to see if the two tries have different DiffServ values.

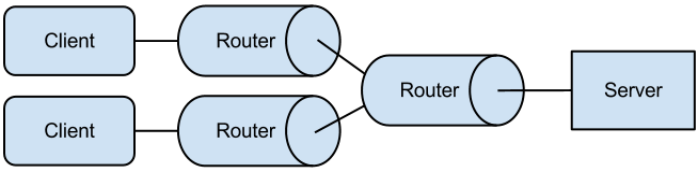


Figure 6: Two Clients with different paths
Two clients communicating with the same server, but with different paths.

Multipath server routing:
In this test we want to look at the ESB's capabilities to talk to the MS and understand the routing result. From the MS the ESB should get some routing information about the topology of the network. As you can see in figure 6, if the link between the server and the first router is not the limiting factor, the two clients should not get in each others way. Therefore, since we get the information about the last router from the MS, the ESB should understand that there is likely no problem and should not preempt any messages. To check if this is actually the case, the ESB will need some time to adjust as it does not get the full picture of the network topology, but after this time, no messages should be dropped from the ESB's side.

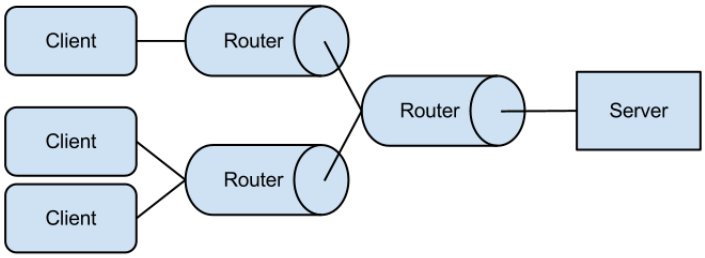


Figure 7: Three Clients where two are competing
Three clients communicate with the same server, but only two of them share the path.

Competing clients in a multipath environment:
This test is a compilation of the tests "Multipath server routing" and "Prioritizing messages". For this test we want to make sure that the ESB is smart enough to only preempt the messages going to one of the competing clients. As you can see in figure 7, there is one client which should not affect either of the two others if the link between the server and the first router is not a bottleneck.

[22]Pcap is short for Packet capture, which in our text usually refers to a program which captures the traffic on a given socket

This should allow this client to receive messages even though the two other clients are competing for scarce resources. To check that this test is successful, a combination of the clients log files and the server log files will have to be used. If most(over 96%) of the messages arrive at the higher priority client and the third client is not affected then this test is successful.

Competing clients in a low bandwidth scenario:
In this test we want to test that the ESB can manage to prioritize messages in a network with a joint bottleneck, but with different endpoints. In figure 7, if the link between the server and the first router is the bottleneck, the ESB should after a small initialization period understand that it has to preempt messages going out to all clients, in order to let a higher priority client get the service it is supposed to get. The scenario will be set up in such a way that one of the two competing clients will have higher priority than the two others, the two lower priority clients should then send a steady stream of messages, which should fill the bottleneck link. The third client should then start sending some messages which must now fill the entire bottleneck link, and create a situation where the ESB has to hold back or preempt messages going to either of the two other clients. As before, a combination of the ESB and the clients log files have to be examined.

3.6 Alternative solutions

The customer also gave us a paper[1] which described a previous project they had worked on which tried to solve something quite similar to what we were tasked with. The paper described a system which were used in conjunction with Tactical Routers to retrieve bandwidth information and to control transmission of messages into this network. As the customer explained this work was not something we could directly copy as the project had not used a lot of web standards and had focused more on the tactical routers as opposed to web services. What we could take out of it however was how they throttled messages. The paper contained five methods which we could easily implement and use their result as an indication of what methods we should use to throttle or hold back messages.

One architecture, which our customer suggested for the project, was to have a proxy in between nodes and creating a custom QoS layer which would sit in front of both the client and the services. This layer would then communicate with a SAML server for authentication, and would have to do all the message prioritization based on the same criteria as our architecture. There are several points about this architecture which would make it a good fit for us. Since the QoS layer would be identical on both client and server side it would mean less work, and more code that could be shared among components, but this freedom comes with some downsides. The first and most glaring problem encountered would be that services on the server would have to be altered to be able to communicate with this front end. Even though we were free to choose architecture ourselves, the client expressed a wish that we would not choose this model because the customer wants to use COTS[23] services which would not be compatible with the new front end.

[23]COTS - Commercially available Off-The-Shelf

Even though the above mentioned architecture is not the best fit for us we wanted to take some aspects of the architecture further. Since clients can easily be altered, the above mentioned solution is not applicable for server side, the solution could however be used for the clients. Having a proxy on the client side could be quite good, but because of the work involved and probable time constraints we chose not to go with this solution. On the server side however a front end is not the best solution for us. What we instead are looking into, is to use an ESB which would be configured together with the services and work as a proxy. Because many ESBs have integrated SAML processing we could easily take advantage of such facilities along with custom message processing, with which we would then extend the ESB to support our needs. The clients would have to point to the ESB, but this should both be trivial to do and the customer has expressed their agreement that this is satisfactory. We could eventually expand the functionality with service discovery, which then would be a good solution to the problem.

So far we have outlined major alternative architectures which could be alternatives to our project, but there are also alternatives within our proposed solution. One such alternative is not to use a premade ESB, but rather build one ourselves. This solution was thoroughly investigated, but was eventually turned down because of the massive amount of work that would involve, the quality of an already made ESB is much higher than we could ever achieve during this project, and lastly, the open source tools available to implement the functionality needed for SAML was not very well documented, and would take considerable time to get familiar with.

On the client side we also have the choice of having either a HTTP[24] proxy or writing our own custom library. Both have some advantages and disadvantages, a proxy would be better for integration with client programs, but creating this proxy or configuring and customizing an already existing solution is not trivial. On the same note, creating a library for use in client programs is easier, but this would mean that client programs would need to be altered to be usable with our middleware, which isn't that desirable. We chose to go down the road of least resistance, as we see it currently we would have do quite a lot of research into proxies which could in the worst case scenario result in just wasted time as far as our product goes. A client library would from our perspective be easier as we would have more control, the overall design should be easier and we know that with this sort of library we can integrate OpenSAML which is a huge advantage.

3.7 Process model

Before we started this project we were quite unsure how we were going to work on the project we had heard lots about Scrum, but few of us had ever used it in a project of this scale. For us this meant that we had lots of options, but we did not know a lot about them.

After we talked to the customer about what the task was, and understood what we were going to do, we decided that we wanted to use a Waterfall model of software development Waterfall model[25]. Because our assignment is quite research focused we need to start with a planning stage in order to completely

[24]Hypertext Transfer Protocol

[25]Waterfall model - A sequential design process. [http://en.wikipedia.org/wiki/Waterfall_development]

comprehend the task ahead and how we are going to solve it. This method of working lends itself very well to the Waterfall model, but we feel that it would not work so great with Scrum or a more agile method. Secondly the customer does not have the resources to meet with us every week to have scrum meetings and be a part of our team. This does not make Scrum completely impossible, but it would be harder than the Waterfall model with little extra reward. Our choice of process model is described in section 5.2.

To practice some agile development we decided that we want to do the implementation phase as agile as possible. This would mean weekly sprints with code review and rapid delivery. This would be something that we could do after the planning phase is done to hopefully produce higher quality code. The reason behind this decision was our interest in Scrum or agile development and the thought that weekly sprints with code review will improve the overall code quality and help us keep our eyes on the prize.

3.8 Tools

We had no clear outline of what tools we were going to use in the prestudy phase. The tools we ended up using is described in *System Technology 5.3*

4 Project Management

In this section, we'll take look at how we organized the team, a brief risk assessment, and an evaluation of the work process.

4.1 Team Organization

This section describes in detail how we organized ourselves, and how we split roles and tasks among the team members. We had a flat team structure[26] and have shifted our focus accordingly over to team communication.

4.1.1 Team Structure

We already knew each other coming into the project, so we chose a flat organizational structure (Fig:8), with no intervening levels of management, since all decisions within the team would, to a high degree, be made by all the members together either way. Relying on the entire group for decisions both involves and invests everyone in the project and will works well with our already existing group dynamic.

[26] Flat organization structure is a structure with few or no levels of intervening management. The idea is that well-trained workers will be more productive when they are directly involved with decision making. [http://en.wikipedia.org/wiki/Flat_organization]

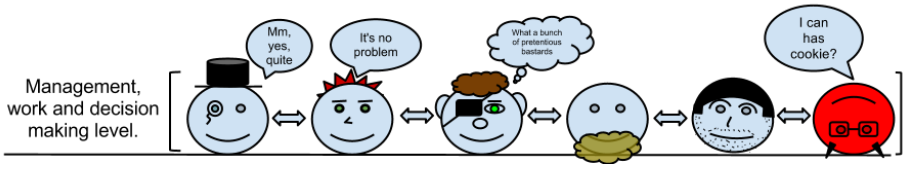


Figure 8: Team Organization chart
It was made during lunch, but the general principle still remains, that the structure is flat.

As the structure shows in the chart (Fig:8), there was no difference in what responsibility level anyone would have, or what role one had. The concept of changing roles weekly is good for a learning situation, but very inefficient where knowledge and research are key components in a limited timed project. We anticipated that the time for this project probably wouldn't be sufficient for any role changes, and therefore we had to keep people focused on the task they had been assigned to. The efficiency of the current task relied on having the current research fresh in mind. If we were to change the roles every week, the newly assigned person would spend a lot of time getting up to date at the beginning of every week, which in turn wouldn't yield any measurable gains.

Rather than focus on responsibilities within the group, we chose to focus on tasks. The task would to some degree still represent areas of responsibilities, and since tasks would be spread across several group members, we didn't run the risk of a single missing member crippling the entire group. Instead the remaining member assigned to a task would be able to pick up the slack. This, together with thorough documentation of a members knowledge, would just about eliminate the problems associated with an absent group member.

Further, the team structure and the distribution of responsibility gave us the chance to define how we want to deal with tasks and their priorities. The work flow that we had, made us prioritize tasks continuously to get the most pressing task done at the correct time. It's similar to a max heap. We put tasks in to the heap, heapify(prioritise tasks) and choose(pop) the maximized task, the task that has the highest priority.

When we chose a task, we considered the person's interest, experience and existing knowledge. Most of the time, the tasks fell naturally to one person that had worked with similar tasks earlier in the project. Other times, there was more of a lottery, where the task had no prerequisites. Often we relied on a person's initiative to take a task or, we easily delegated them with a question, "Can someone do that?". Task delegation and sharing the work load has not been a problem in the project.

4.1.2 Team communication

We decided that we would work together from 10 to 16, Monday through Thursday every week, with exceptions for lectures and such. Group members could also work in their free time to make up for missed collaboration hours, or to just put in some extra work. This means more work than the course requires, but we decided that we want to do it this way so that we could either take some

time off now and then, or have more time for the exams in May.

We would not be able to have frequent face to face meetings with the customer, because the customer is located in Oslo. We decided to have weekly meetings using Skype instead, as well as e-mail communication as needed. Since we have seen what happens in projects where there is little to no communication, we decided, in agreement with the costumer, that we at least wanted to have weekly meetings in order to keep a good dialog with the customer, and also give them the opportunity to take part in the development of the project.

4.1.3 Roles

Our team structure is discussed in *Team Structure* (ref:4.1.1). It describes the general structure and the ideal situation and delegation.

But to make this work in practice roles are unconsciously delegated to different people. A person ends up with a role loosely based on the first delegation of a task.

When a person works on a task, experience is gained. This experience is useful when the same, or a similar, task occurs again.

This means that the person best suited to deal with this task is the same person that dealt with it last time. To get the most efficient result the same person is picked to deal with this task as well.

A good thing about this is the that the same person don't have to waste time to read up on necessary information to deal with the task at hand.

How the roles actually worked is described in section 8.2.

4.2 Risk Assessment

To help us avoid most problems, we created a risk list which should contain most of the problems that we could encounter during this project. A risk list can never cover all the cases that could occur, but we think that our risk list contains most of them. To cover the last cases which we might have overlooked we decided that we would add some *Risk Management* strategies to this section to explain how we will handle unforeseen risk as they appear.

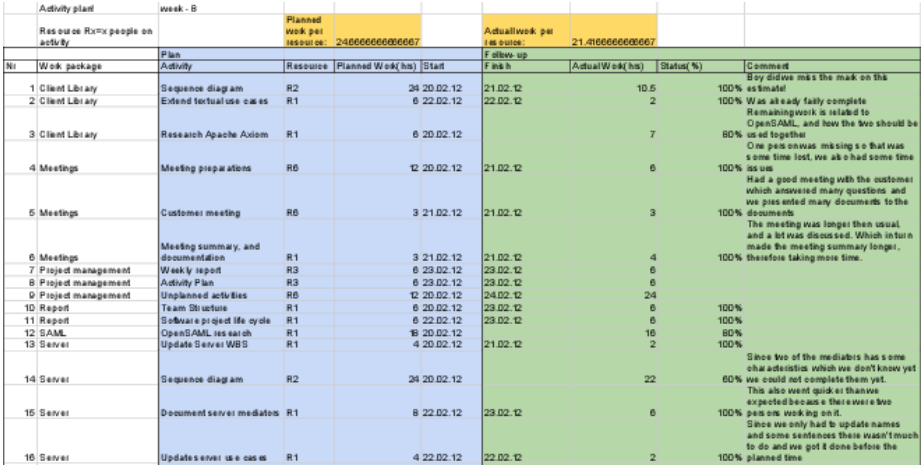
To handle most of the risks that we have not written down in our risk list, we would try to have a close dialog with the customer so that if an unforeseen risk should occur, they will be informed about it. That way, we could discuss the problem together, and come up with a solution that was satisfactory for everyone. Having this open dialog with the customer also ensured that they wouldn't be surprised by any choices we made.

A natural approach to risk management would be to first accept the situation and involve the whole group. Then we would assess the situation and pinpoint the problem and its cause. When the problem and it cause are found there will be a lot of different approaches to solve the situation, depending a lot on the actual situation.

When a risk is present and confirmed we have to deal with it as best we can. The way we would do this is open, frank and honest. This will put all the information on the table and we can then continue the process with a better understanding of the situation. Then we would continue with finding a solution and coordinate our collaboration within the group and with the customer and supervisor to ensure the best solution possible.

4.3 Progress tracking and Documentation

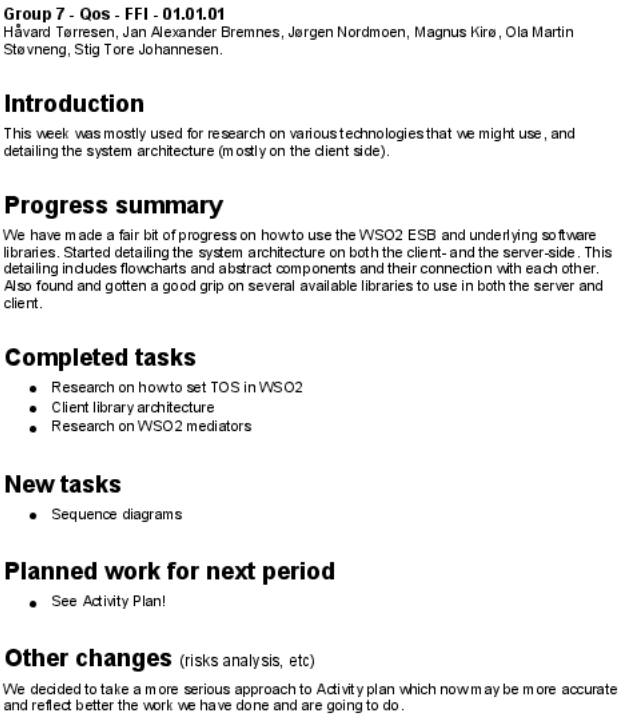
In the beginning we had a summary every day where we wrote what we were working on and what had to be done. We stopped doing this after we got good activity plans because the daily summaries became unnecessary.



	Activity plan	week - 8						
	Resource Rx=x people on activity		Planned work per resource:	24666666666667		Actualiwork per resource:	21.416666666667	
		Plan				Follow-up		
Nr	Work package	Activity	Resource	Planned Work(hs)	Start	Finish	ActualWork(hs)	Status(%)	Comment
1	Client Library	Sequence diagram	R2	24	20.02.12	21.02.12	10.5	100%	Boy didwe miss the mark on this estimate!
2	Client Library	Extend textual use cases	R1	6	22.02.12	22.02.12	2	100%	Was already fairly complete
3	Client Library	Research Apache Axiom	R1	6	20.02.12		7	80%	Remainingwork is related to OpenSAML, and how the two should be used together
4	Meetings	Meeting preparations	R6	12	20.02.12	21.02.12	6	100%	One personwas missing so that was some time lost, we also had some time issues
5	Meetings	Customer meeting	R6	3	21.02.12	21.02.12	3	100%	Had a good meeting with the customer which answered many questions and we presented many documents to the documents
6	Meetings	Meeting summary, and documentation	R1	3	21.02.12	21.02.12	4	100%	The meeting was longer then usual, and a lot was discussed. Which in turn made the meeting summary longer, therefore taking more time.
7	Project management	Weekly report	R3	6	23.02.12	23.02.12	6		
8	Project management	Activity Plan	R3	6	23.02.12	23.02.12	6		
9	Project management	Unplanned activities	R6	12	20.02.12	24.02.12	24		
10	Report	Team Structure	R1	6	20.02.12	23.02.12	6	100%	
11	Report	Software project life cycle	R1	6	22.02.12	23.02.12	6	100%	
12	SAML	OpenSAML research	R1	18	20.02.12		16	80%	
13	Server	Update Server WBS	R1	4	20.02.12	21.02.12	2	100%	
14	Server	Sequence diagram	R2	24	20.02.12		22	60%	Since two of the mediators has some characteristics which we don't know yet we could not complete them yet.
15	Server	Document server mediators	R1	8	22.02.12	23.02.12	6	100%	This also went quicker thanwe expected because there were two persons working on it.
16	Server	Update server use cases	R1	4	22.02.12	22.02.12	2	100%	Since we only had to update names and some sentences there wasn't much to do and we got it done before the planned time

Figure 9: Example Activity plan
This figure displays the structure of our activity plans. It's meant as an overview. See the appendix for full weekly reports. (ref:J.3)

The activity plans(Fig:9) now have the role of our day to day summaries and work progress. We updated the activity plan as we went along. This way we had a complete overview of tasks and work hours that we were planning that week. As we updated the activity plan, we had an overview of the work done that week and where we had missed with our time estimation.



Group 7 - Qos - FFI - 01.01.01
Håvard Tørresen, Jan Alexander Bremnes, Jørgen Nordmoen, Magnus Kirø, Ola Martin Støvneng, Stig Tore Johannesen.

Introduction

This week was mostly used for research on various technologies that we might use, and detailing the system architecture (mostly on the client side).

Progress summary

We have made a fair bit of progress on how to use the WSO2 ESB and underlying software libraries. Started detailing the system architecture on both the client- and the server-side. This detailing includes flowcharts and abstract components and their connection with each other. Also found and gotten a good grip on several available libraries to use in both the server and client.

Completed tasks

- Research on how to set TOS in WSO2
- Client library architecture
- Research on WSO2 mediators

New tasks

- Sequence diagrams

Planned work for next period

- See Activity Plan!

Other changes (risks analysis, etc)

We decided to take a more serious approach to Activity plan which now may be more accurate and reflect better the work we have done and are going to do.

Figure 10: Status report example
This is an example of one of our status reports. We create them every week. All the weekly reports can be found in appendix J.2

As can be seen in the weekly report (Fig:10), the status report had a standard setup. We created a template early in the project, so that we could reuse it later and reduce work. In the process of creating the template, we put some thought into it so that we would get a template that would work throughout the project without further changes. Despite the thought process of creating the templates, we had to make some small changes throughout the project.

4.4 Progress Evaluation

We assessed our progress every week. This has been done with weekly reports, schedules and activity plans. These can be seen in the attachments appendix (ref:J).

This documentation process took a substantial amount of time every Thursday. The documentation part that we did every week, consisted mainly of three things. Writing the weekly report, updating the activity plan and creating the next activity plan.

The time spent on this varied quite a bit. This was mainly due to a variation in how accurate our plans were, compared to what we managed to do that week. Sometimes everything went according to the plan, and there was little to write about in the report. Other times, me miscalculated greatly, and had to transfer tasks to the following week or find new ones, because we had finished all of the tasks on the plan.

The weekly reports and activity plans have been used to inform the customer and supervisor, and get feedback on our progress.

The schedules tracked our time usage and is kind of a log for what has been done by whom. We did not use the schedules to point out people that had put down more or less work in this project. It is merely a document for the group to keep track of things.

5 Development Methodology

We did not follow any established development methodology, such as Scrum[27] or XP[28], as this project required more planning and configuration of existing solutions, than actual coding. In the process of choosing a development methodology we considered scrum, waterfall, agile, xp, and some others in addition to combination of these. In the end we chose a mix of the Waterfall model[29] and Agile methods[30], we discuss these decisions in the sections below. You will also find a list of the tools we chose to work with, and why we decided to use them.

Because this was a research project, the customer would act more as an advisor than a customer, and would have more suggestions and advice than demands and requirements. We had been given a clear understanding of what the final product should be, and we had a list of requirements that would be met. Other than that, we were relatively free regarding how we go about solving the problem. Because of this, a single methodology, like Scrum, wouldn't work for us, as it would require us to be in close and frequent contact with the customer, presenting a prototype at regular intervals, and continue development based on the customers feedback and demands.

As mentioned, this was a project that required quite a lot of planning before any programming could be done. This necessitated that we started the development according to a waterfall model in terms of the architecture planning, as well as the requirements specification. By using the waterfall model in these first phases, we ensured that the planning was done thoroughly in order to minimize the amount of trial and error during the later implementation phase.

As the project progressed we switched to a more agile development method, in order to allow iterative development and facilitate necessary changes that have turned up as code was produced, as opposed to waterfall-coding, where we would have to strictly follow our plans. Agile also let us use the flat organizational structure we had chosen, which we believed would greatly help cooperation within the team.

[27] Scrum - An agile software development methodology. [http://en.wikipedia.org/wiki/Scrum_(development)]

[28] XP - A type of agile software development. [http://en.wikipedia.org/wiki/Extreme_programming_practices]

[29] Waterfall model - A sequential design process. [http://en.wikipedia.org/wiki/Waterfall_development]

[30] Agile methods - A group of software development methodologies based on iterative and incremental development. [http://en.wikipedia.org/wiki/Agile_software_development]

5.1 Project Organization

We divided the project tasks into work packages. These packages are represented in a WBS[31] (ref:H). The schedule for the project is represented in a Gantt Chart[32] (Fig.11). The figure is part of our full Gantt chart. As the full diagram cannot be included nicely in the report we have attached it as an HTML document (ref:I).

Tasks

WBS	Name	Start	Finish	Work	Priority	Complete	Cost	Notes
1	Planning	Jan 18	Jan 20	18d		100%		
2	Work on preliminary report	Jan 23	Feb 3	60d	10	100%		
3	Submission of Preliminary Report	Feb 6	Feb 6					Thu 26 Jan 2012, 14:55 This is a note
4	Architecture planning	Feb 6	Mar 5	126d	9	8%		
5	Work on midterm report	Feb 6	Mar 9	150d	7	0%		
6	**Work on prototype client**	Mar 8	Apr 16	84d 2h				
6.1	Open SAML	Mar 8	Apr 16	27d 4h		0%		
6.2	**Client library**	Mar 8	Apr 16	56d 6h				
6.2.1	Metadata interpreter	Mar 8	Mar 22	10d 3h		0%		
6.2.2	Prioritizer	Mar 22	Apr 9	15d 3h		0%		
6.2.3	Tactical router communication	Apr 9	Apr 16	5d 7h		0%		
6.2.4	**Interface**	Mar 8	Apr 16	28d				
6.2.4.1	Client integration manual	Mar 27	Apr 16	14d 6h		0%		
6.2.4.2	API	Mar 8	Mar 27	13d 2h		0%		
7	**Work on prototype server**	Mar 8	Apr 16	131d 5h				
7.1	ESB	Mar 8	Mar 23	12d		0%		
7.2	Identity server	Mar 20	Apr 3	11d		0%		
7.3	Glassfish	Mar 29	Apr 16	12d 4h		0%		
7.4	**SAML mediator**	Mar 8	Apr 16	27d 4h				
7.4.1	?	Mar 8	Apr 16	27d 4h		0%		
7.5	**QoS mediator**	Mar 8	Apr 16	41d 3h				
7.5.1	Metadata interpreter	Apr 2	Apr 16	10d 3h		0%		
7.5.2	Prioritizer	Mar 8	Apr 6	22d		0%		
7.5.3	Tactical router communicator	Mar 28	Apr 9	9d		0%		
7.6	**WSO2 network layer**	Mar 8	Apr 16	27d 2h				
7.6.1	?	Mar 8	Apr 16	27d 2h		0%		
8	Creation of test suite	Mar 13	Apr 6	38d		1%		
9	Testing of prototype	Apr 9	Apr 16	11d		0%		
10	Work on final report	Mar 12	Apr 16	152d 2h		0%		
11	Submission of Alpha	Mar 9	Mar 9					
12	Submission of midterm report	Mar 9	Mar 9					
13	Submission of Beta	Apr 16	Apr 16					
14	Submission of final report draft	Apr 16	Apr 16					
15	Bug fix, polishing, wrapping things up, buffer	Apr 17	May 25	28d 1h		0%		
16	Deadline	May 25	May 25					

Figure 11: Part of our Gantt diagram
This is an example to show that the gantt diagram exists and what it looks like. Se full diagram under file attachments (ref:I).

5.2 Software project life cycle

For our project life cycle we chose agile. Originally we started out with the intention of using Scrum and Scrum only. That idea was quickly scrapped as we found out that our task was very research heavy. This made us rethink our approach to the development cycle and turn in the direction of agile software development.

Early in the project we expected that we could begin coding and prototyping before too long. This proved to be wrong as there was a lot of research to be done. Scrum was originally a tactic to improve product flexibility and production speed. This works very well in software development when you already know what you are supposed to do and the major part of the task is to implement the required functionality. When the functionality has to be designed and researched extensively, scrum becomes unsuitable.

[31] WBS - An oriented decomposition of a project into smaller components. [http://en.wikipedia.org/wiki/Work_breakdown_structure]

[32] Gantt Chart - A type of bar chart that illustrates a project schedule. [http://en.wikipedia.org/wiki/Gantt]

With the agile method there are elements that suits us better than others. "Individuals and Interaction" and "Customer Collaboration" are two important elements that we use. The full description of the agile method can be found in the Agile Manifesto[33].

"Individuals and interactions" is strongly connected with the organization of our team (ref:4.1). The flat team structure forced us to have a good dialog among the group members. This increased the team members interaction and strengthens the team communication. The strengthened communication promotes the individuals of the group and the team members confidence, which in turn increases the total productivity of the group. The frequent interactions with the customer are also a part of our adaption to the agile development method.

"Customer Collaboration" is the aspect of the group contacting the customer and keeping a good dialog with them. This was to make sure that we produced the product that the customer wanted. To achieve this part of the agile manifesto we had meetings with the customer every week, and had frequent email correspondence to iron out the bumps in our product. The frequent communication with the customer helped us to create a more precise and consistent system with better documentation. The main part of the communication with the customer was for the benefit of the project, and constant improvement. The constant improvement and iterative work flow is a central part of the agile method.

Scrum is an agile development methodology. Waterfall is not. Waterfall takes development very much a step at a time. While agile like approaches like scrum run around a track, repeating its steps over and over. The common steps of waterfall and scrum agile are: planning, build, test, review, deploy.

Scrum does these steps in an iterative manner. First planning, building, testing and then review. These steps are repeated several times before another bigger review is done, followed by testing. This cycle repeats over and over, until the project is done.

Waterfall does these steps one at a time. First the planning part until all the planning is complete. Then the implementation part where all the coding is done. Testing follows as a natural step. The testing is thorough, so that no more coding or testing has to be done. Then the review part follows, where functionality, requirements and completeness is assessed. And deployment comes as the last step, when everything is working as it should and everything else is complete.

We ended up using something like iterative waterfall. Where we planned a lot in the beginning, started coding and testing nearly at the same time, the testing consisting of unit tests at that stage. While coding we had reviews and a bit of quality control of the code. And when the code was complete we started system testing. System testing and code improvement went in iterations as we found problems and mistakes that were overlooked before. Then we followed with the documentation part, representing a sort of deployment phase of the waterfall methodology.

[33] Agile Manifesto, the key elements of the agile software development method. [AgileManifesto.org]

5.3 System Technology

To begin with we intended to use JUnit[34] tests throughout the project. This started well in the implementation phase, but faded away towards the end of the implementation phase. Especially when the implementation was a week delayed and we used a lot of time debugging and making the system actually work.

At the beginning we planned to have code reviews and go through all the code and fix code deficiencies. This was meant to happen every other week. As good as this intention is we didn't manage to do it as often as we would like. In the server side we had two code reviews. With the client we had none. We also experienced that the code reviews didn't really work out as we had planned. While debugging the client library and the server side of the developed application we found a lot of bugs and logic errors after the code reviews. This means that our code reviews were bad and that they didn't really fulfil their purpose.

One of our requirements were that the system should be thoroughly tested. To accomplishe this requirement we decided to use the MobiEmu framework. MobiEmu is a network emulator that emulates network traffic and behaviour. It is based on NS3 and can test multiple nodes in a virtual network. This gives us the advantage of testing our system to a good extent of the real time battle situation that the system is thought to operate in. Another reason that we used this testing framework is that one of our group members had previous experience with it. The testing framwork gave us useful test results that are discussed in section 7.

Furthermore we used Git[35] and GitHub[36] to handle our files and repository.

Along with git we used Google-docs, now drive, to store and share documents. This helped us greatly in the cooperation of this project. Google docs allowed us to be multiple people to working on the same document at the same time.

LaTeX[37] is obviously the preferred report scripting language for the task of writing this report. Latex helped us a lot in the report writing process. Syntax highlighting, easy integration of figures and good structure to the report files are examples of benefits we got from using .

With input from the customer and their approval we decided to use Apache2 license for our code. As far as all parties could find there was no negative sides for any of us.

As for the personal development environment. The individual person was responsible to get his system to work. While the choice of environment is free we presume that we acchieved greater productivity than if everyone was foreced to use the same environment, e.g: ubuntu with eclipse.

As for a total list of tools that was use, see the section about Tested tools, (ref:G)

[34] JUnit - A testing framework for the Java programming language. [http://junit.org/]

[35] Git - A free and open source, distributed version control system. [http://www.git-scm.com]

[36] GitHub - A web-based hosting service for software development projects that use the Git version control system. [http://www.github.com]

[37] LaTeX - A document preparation system for the TeX-typesetting program

6 Design and Implementation

In this section we will discuss the design and implementation of the whole system. First off is the section about the client side of the system and then follows the server side.

Below is a first taste of how our system works. In figure 12 you can see a cloud of clients which can be on the same local network or be on different networks. The *ESB* talks to *GlassFish* where services are placed and clients talk to the ESB which mediates the message into GlassFish. In order for the ESB to know how much bandwidth each client can utilize, it is dependent on the *Monitoring Service* which relays that sort of network information.

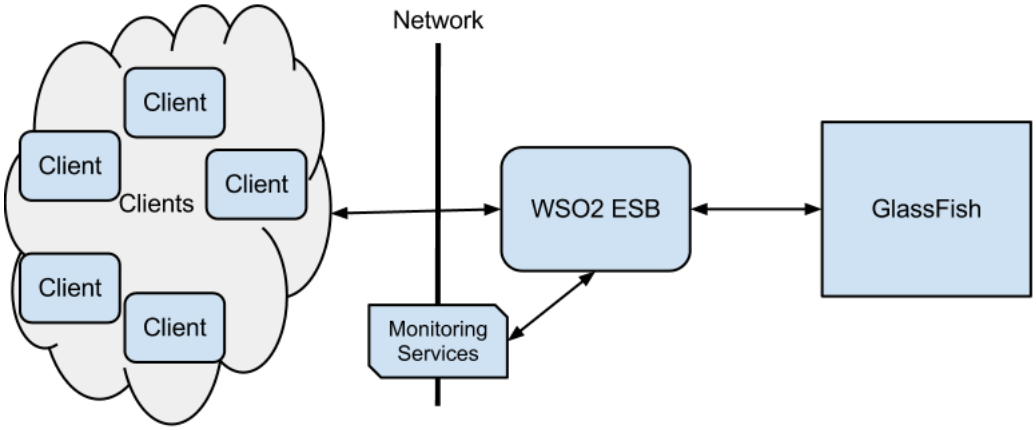


Figure 12: Total Overview
This figure shows roughly how our project looks from a bird's-eye view.

6.1 Client Side

This chapter will introduce the client side design, and architecture of our system. Section 6.1.1 will introduce the different components that make up the entire client, and includes a description of the different components that make up the client library. Next, section 6.1.4 will describe the use cases, and section 6.1.5 will take care of the data flow, followed by a detailed architecture description 6.1.6. Finally, section 6.1.7 will go through the sequence diagrams.

The class diagram, found in appendix I, is a useful addition when understanding the architecture of the client library and its functionality. The descriptions and diagrams in this section might become clearer when looking at the class diagram and see the connections between classes and the more specific contents of the classes.

6.1.1 Introduction

The client architecture consists of the following two components: The client application and the client library. Additionally, the library makes use of some external components to do some of its work.

6.1.2 Component description:

Client application:
The user-controlled applications that utilize web services. These must be modified to send all communication through the client library in order to get the priority it should get, and to interact properly with our server setup.

Client library:
This component will handle all communication with the service providers, as well as authenticating users and prioritizing their messages, based on who they are, and what their current role is. The authorization will involve a component from the server side of the project, the identity server, which returns a token if the client is authorized. Client applications connect through a simple interface to provide credentials and data.

6.1.3 External libraries:

Axiom:
This component will be used to parse and manipulate XML[38] data in the form of SOAP and SAML. These are fairly extensive and complex data structures so an easy to use external library is essential here.

Apache HTTPComponents:
A lightweight component for easily setting up and using HTTP connections. While not strictly necessary this component will allow us to connect and communicate across networks far more easily than the standard Java components.

6.1.4 Use Cases

Title: Accept client info
Actors: Client software, Client Library Interface
Main:

1. Client software connects to the library interface
2. Client delivers its credentials
3. Credentials are passed from the interface to the sequencer.
4. Credentials are checked by the sanity checker and passes.
5. Credentials are passed from the sequencer to the token manger.
6. Credentials are stored in the credential store.
7. Buffer, for previous tokens, is flushed

Extension:

[38] XML - eXtensible Markup Language

4a. Credentials are clearly invalid

5a. Return error

Precondition: None
See: Requirement 6 (Section 2.2)

Title: Accept data to be sent
Actors: Client software, Client Library Interface
Main:

1. Client delivers data to be sent.
2. Data is passed to the sequencer.
3. Sequencer creates DataObject and ReceiveObject.
4. ReceiveObject is returned to client.

Precondition: Client has established connection to the Library interface and it's credentials are accepted.
See: Accept client info

Title: Connect to server
Actors: Client Library, Server
Main:

1. Connection manager connects to the server
2. Set priority on socket based on SAML-token and related metadata

Extension:

1a. Unable to connect to server

2a. Return error

Precondition: DataObject has been created, and contains both bandwidth info and a token
See: Accept client credentials, Accept data to be sent and Fetch bandwidth info, requirement 8 (Section 2.2)

Title: Get SAML token
Actors: Client library, Server
Main:

1. Client library sends client credentials to server
2. Server verifies the credentials
3. Server returns SAML-token
4. Token is parsed into a token object
5. Token object is put into DataObject.

Extension:

2a. Client credentials not valid

3a. Server returns error

4a. Client library throws error

Precondition: Client has given library credentials and data to send, and a SAML token for the destination doesn't already exist. Connection to server has been established.
See: Accept client credentials, Accept data to be sent, Fetch bandwidth info and Connect to server, requirement 2, 3 and 6 (Section 2.2)

Title: Transaction towards server
Actors: Client lib, server, client
Main:

1. MessageHandler sends buffered data to server
2. Server returns reply to data.
3. The ReceiveObject in the DataObject gets the data from the server.
4. MessageHandler send data to sequencer.
5. Sequencer sends data to interface (QosClient)
6. Client fires a data received event to all listeners.

Extension:

2a. Server unavailable, reply doesn't arrive within timeout, etc.

3a. Throw error.

Precondition: Data to send exists, SAML token is in cache, connection to server active.
See: Accept client credentials, Accept data to be sent, Fetch bandwidth info, Connect to server and Get SAML token

6.1.5 Data Flow

Client credentials (Visualized in Fig.13)

1. The Client application sends credentials to the library interface
2. The interface passes the credentials on to the token manager, through the sequencer
3. The token manager stores the credentials in the credential storage
4. The token manager sends the credentials to the SAML communicator in order to fetch a token
5. The SAML communicator requests a token from the identity server
6. The identity server sends a token to the SAML communicator

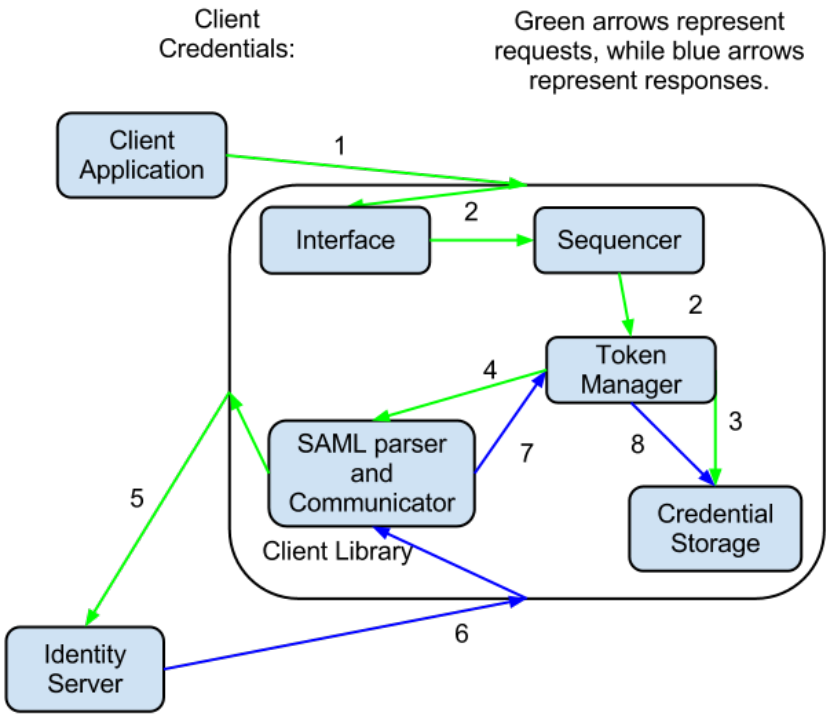


Figure 13: Client Credentials Flow
This figure describes how the client credentials are sent through the client library and through the system in general.

7. The token is returned to the token manager
8. The token manager stores the token in the credential storage

Client Data (Visualized in Fig.14)

1. The client generates data and sends it to the library via API/Interface
2. The data moves on to the sequencer and down to the message hander
3. The message handler tells httpCore to establish a connection to the server, and the data is sent
4. The server sends a reply that is picked up by httpCore and forwarded to the messageHandler
5. The interface is notified of the reply
6. The interface notifies the client that the reply is ready

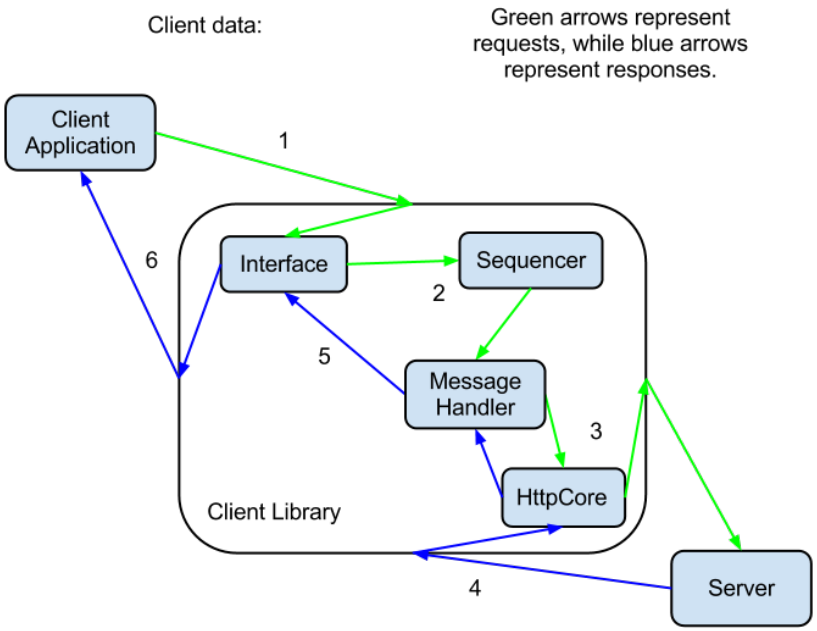


Figure 14: Client Data Flow
This is the message sequence. It describes the route the individual messages takes through the system.

6.1.6 Architecture

All the following sub paragraphs in this subsection are parts of the client library which is shown in figure 15.

Interface
Known in the class diagram as "QosClient", responsible for providing a clean and easy to use interface for the clients.

Sequencer
The central piece of the client library. Responsible for keeping a record of all other modules in the system and communicate between them as well as making sure everything happens in the right order.

Sanity checker
This modules single purpose is to check the credentials provided by the client for sanity, in other words make sure they're conform to the rules for the credentials. It does however not verify that they are valid.

Token Manager
This provides a nice and clean interface for the sequencer to store credentials

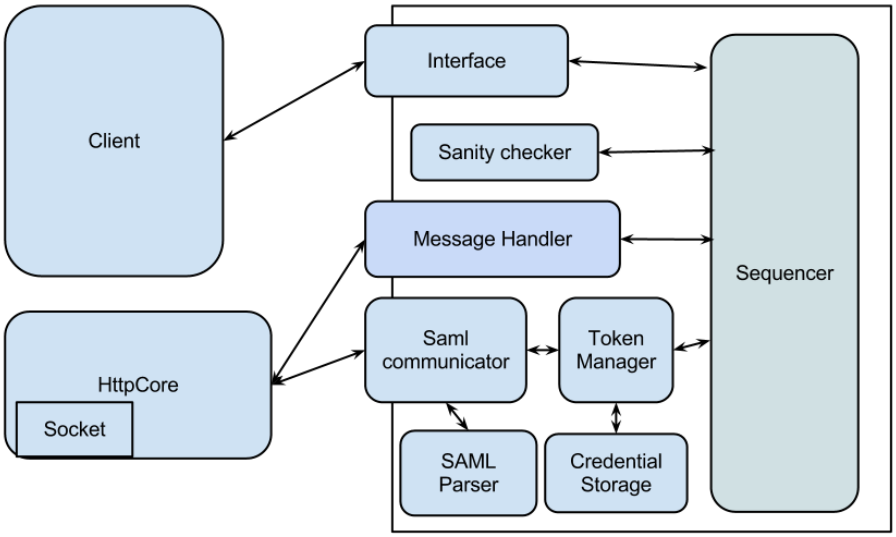


Figure 15: Detailed Client Architecture
This shows in detail the structure of the client library in detail.

and fetch tokens for data transmissions.

Saml Communicator
This module will take care of the communication between the client library and the identity server.

Saml Parser
This takes the reply from the identity server and parses it into a token object so that it can be easily used and stored.

Credential Storage
Responsible for storing token objects as well as user supplied credentials. Also makes sure that no token objects are returned if they are invalid or expired.

6.1.7 Sequence Diagrams

This section contains all the sequence diagrams for the client, with descriptions for each one.

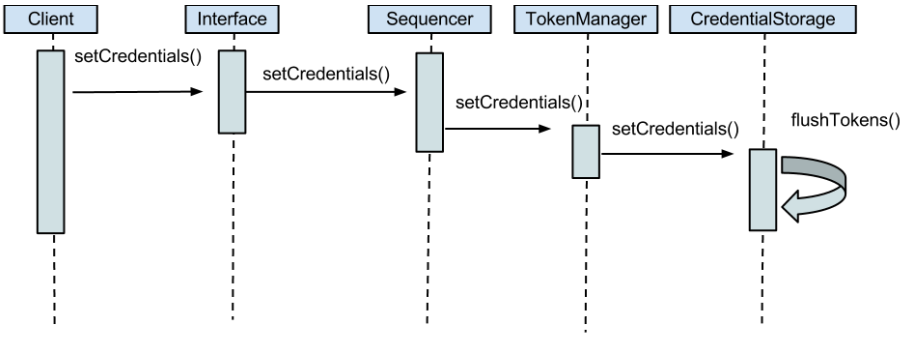


Figure 16: Accept client info
This shows how the client credentials are passed from the client, through the interface and into the credential storage.

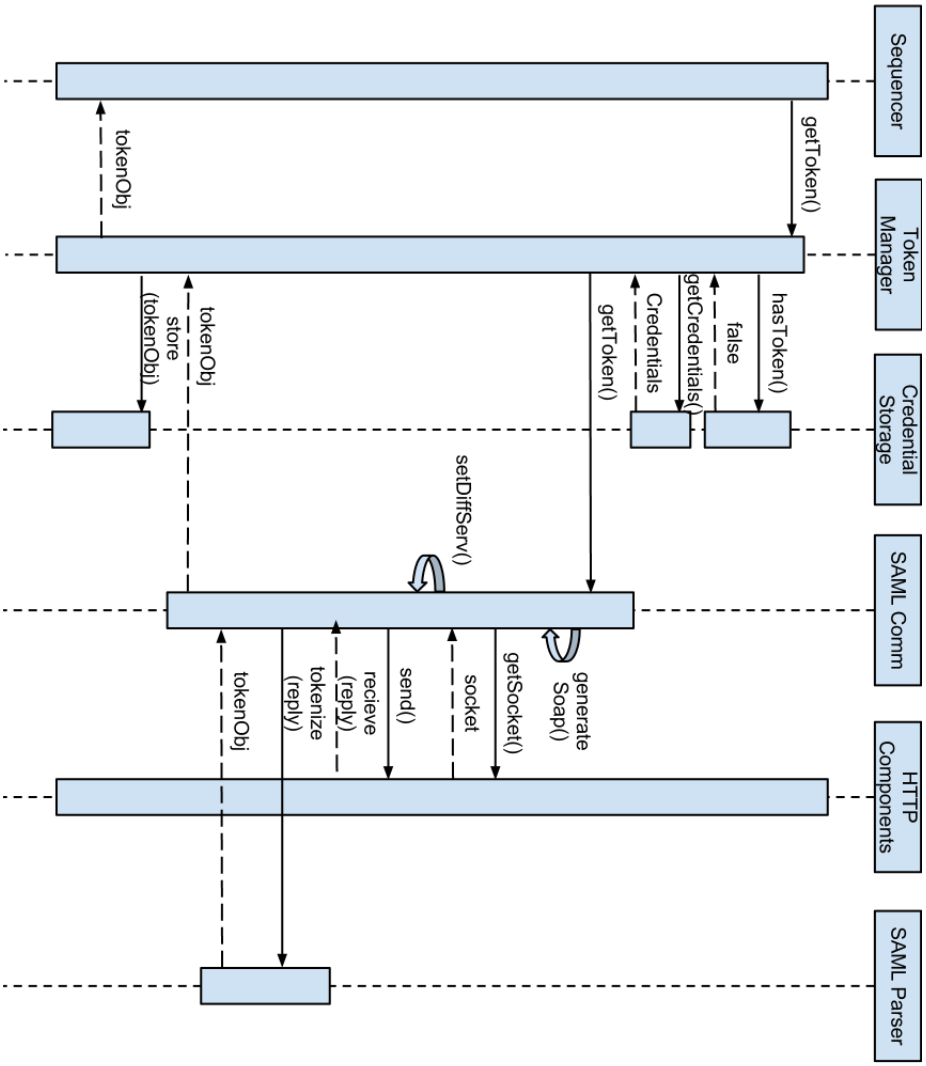


Figure 17: Getting non-stored token
This shows how the client library acquires a token from an external source, and stores it, when can't find the desired token in the storage, or if the token is invalid.

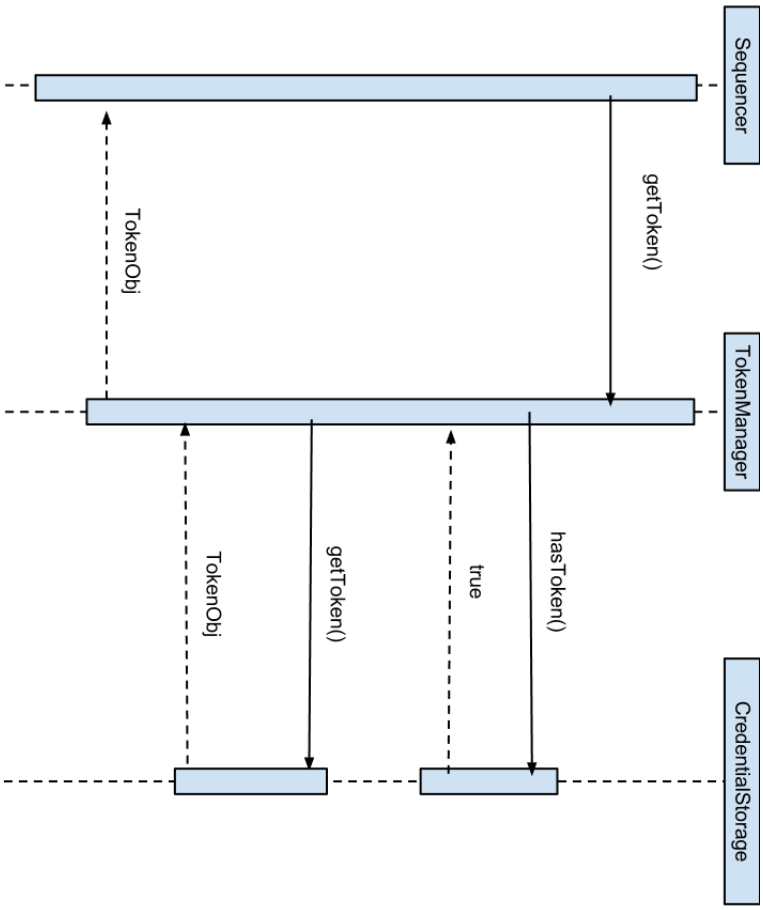


Figure 18: Getting stored token
When a token exists, we return that token instead of creating a new one.

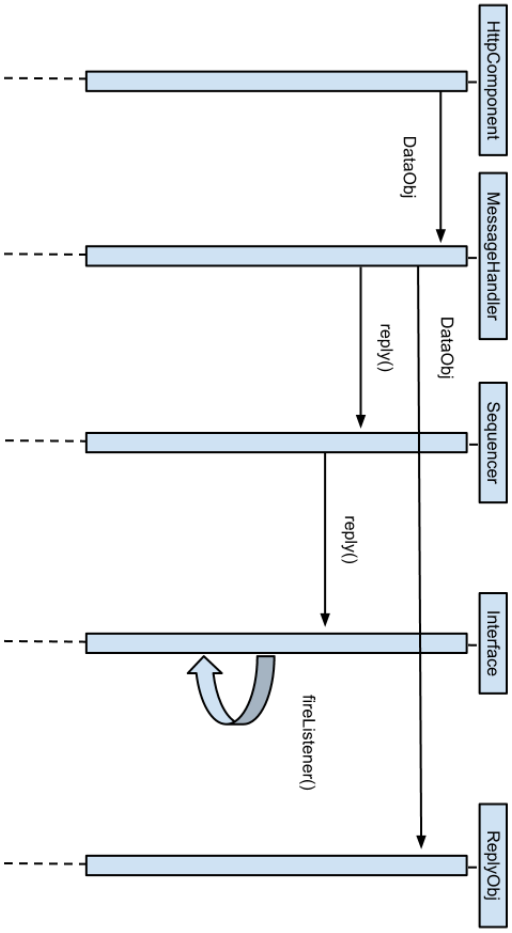


Figure 19: Receive reply
This diagram shows how the client library receives a reply and sends it to the client.

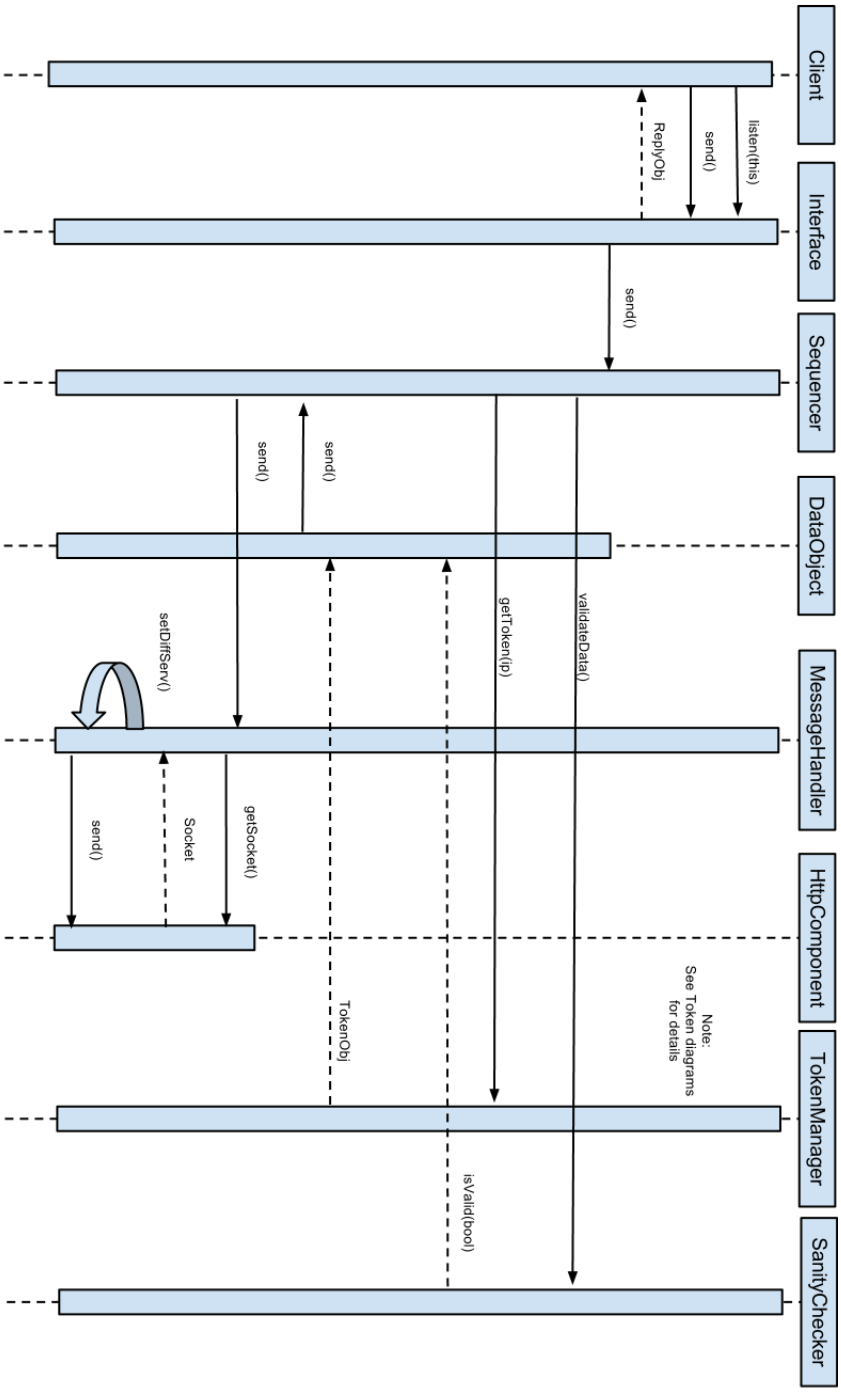


Figure 20: Send data
This diagram shows how data moves through the client library, receives a token, and eventually gets sent to the server.

6.2 Server Side

In this chapter we are going to introduce the design, implementation and configuration that we have done on the server side. In section 6.2.1 we will introduce the framework that we have built upon and what we are going to do with it. Next follows use cases, 6.2.2. Section 6.2.3 will go into more detail about what the framework consists of. The section will also guide you through the basic processing units which is used in the framework. The next section, 6.2.4, contains the dataflow through the server side, which will help you get a good overview of our design. 6.2.5 goes into detail in describing our custom components in the framework, and together with the dataflow should give you a good understanding of the whole server side. Together with section 6.2.6 you should get a good overview of the system. Section 6.2.7 will give you the details about how we have configured the framework, it will not contain description of how we have set variables during testing, but using this description should make it possible to get the framework up and running.

6.2.1 Introduction

The server side architecture consists of several components, the WSO2 ESB, the Monitoring Service and the GlassFish server. The GlassFish server is not necessary to modify and the MS is something we must assume exist in the network. The ESB is what we have to modify, configure and extend to meet our requirements.

The ESB will be used to implement QoS for the web services. To do this, it will have to communicate with the MS, in addition to the clients and the services. The ESB must be configured to work as a proxy for the services on the GlassFish server. It will also be configured to use certain mediation sequences for incoming requests and outgoing responses. The extensions to the ESB consists mainly of custom mediators used in the mediation sequences. These mediators will have the tasks of determining priority of messages, contacting the MS for bandwidth data, and enforcing the priority. There will also be made modifications to the source code of one of the ESBs libraries to allow DiffServ to be set in the IP header.

6.2.2 Use Cases

This section will outline the use cases that we have thought of in relation to the server side. With the help of these you should get a rough idea of what we want the server side to be able to do.

Title: Request mediation
Requirements: 3, 7
Actors: Client, ESB, GlassFish
Main

1. Client sends SOAP message with SAML Token to ESB proxy
2. ESB extracts SAML token to get the client role
3. ESB removes SAML metadata from message

4. ESB adds metadata to message context.
5. ESB sends message to GlassFish endpoint

Extensions:

2a. SAML Token is invalid

2b. ESB sends error message to client

Precondition:

- Client is connected to ESB

Title: Response mediation
Requirements: 2, 3, 7
Actors: Client, ESB, GlassFish
Main

1. GlassFish sends message to ESB
2. ESB sets priority metadata in message context and SOAP header.
3. ESB retrieves bandwidth information (See Monitoring Service communication use case)
4. ESB prioritizes message (See Prioritize message use case)
5. ESB sends message to Client

Extensions:
Precondition:

- Request mediation

Title: Monitoring Service communication
Actors: Monitoring Service(MS), ESB
Main

1. ESB requests bandwidth information from MS to a specific address
2. MS returns bottleneck bandwidth to the ESB, as well as an identifier for the last Tactical Router before the endpoint.

Extensions:

1a. ESB specifies an invalid address

2a. MS returns no information

2b. Address is in the same sub net as the ESB

Precondition:

- Response mediation

Title: Prioritize messages
Requirements: 2, 6, 8
Actors: ESB
Main

1. ESB acquires QoS information through settings
2. ESB adds QoS information to the SOAP header of the message
3. ESB sets DiffServ field in IP header

Extensions:
Precondition:

- Response mediation
- Monitoring Service communication

6.2.3 Description of ESB concepts

In this section we will shortly describe some important concepts of the ESB and message mediation.

A mediator is the basic processing unit in Apache Synapse[39]. Each message going through the ESB gets mediated through a sequence of mediators, which can be configured through either XML or WSO2's graphical user interface. As long as the mediator inherit from a Synapse interface, any custom mediator can be used in the same manner as the built in mediators. To control the flow of messages through the ESB, there are two paths that can be controlled, the "in sequence" and the "out sequence", which can also be configured to only apply for certain endpoints.

The ESB is built around the notion of a message context, this object contains all the information regarding the message and the context around it. In the message context we can add properties, manipulate the message itself and manipulate the sending streams of the message. All the properties added during the receiving of a message is also added to the outgoing message, which we can use to our advantage.

Each mediator in the sequence get access to the message context of the incoming or the outgoing message and can thus manipulate the context to its liking. When the mediator is done with the work it is supposed to do, it either calls the next mediator, sending it the possibly altered message context or returning true to indicate that the work is done.

As you will soon see, we have taken full advantage of the modularity in the ESB. This means that even though much of the functionality in our mediators could be moved into one or two mediators we have decided to make many. For us this means much easier testing of each component and it gives each mediator a more clearly defined role. For our customer this means an easier setup where they can mix and match each mediator and easily create custom sequences with just the functionality they need.

[39] Apache Synapse - An enterprise service bus

6.2.4 Dataflow

This section describes the data flow through the ESB with the help of two diagrams. As a bonus, these diagrams show the general architecture of the server side very well.

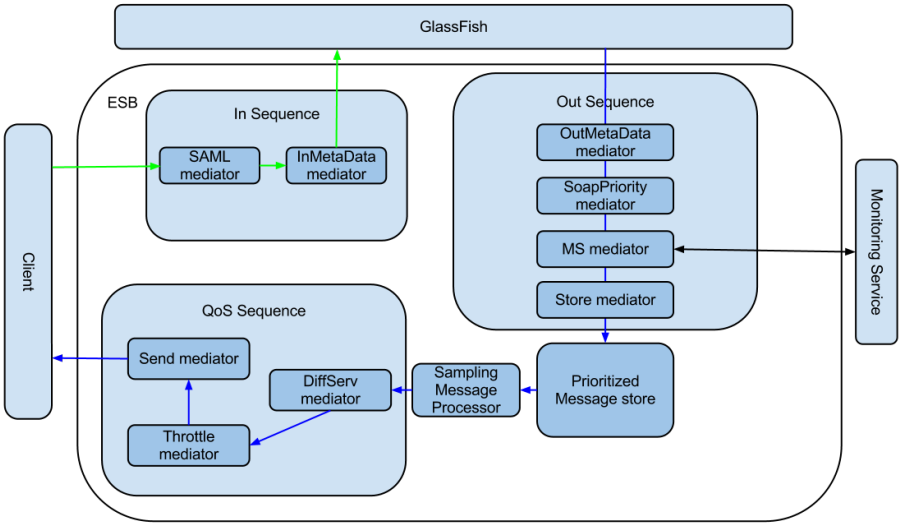


Figure 21: Server Data Flow
This diagram shows how the data flows through the server side.

Service Request :
To follow this flow, trace the green arrows in figure 21. The ESB receives a request message from a Client, it is then sent to the SAML mediator, and then to the InMetadata mediator which when done sends it to the service endpoint on the GlassFish server, and the flow is over.

Service Response:
To follow this flow, trace the blue arrows in figure 21. The ESB receives a response message from the Service, it is then sent through a sequence of mediators, first the OutMetadata mediator, SoapPriority mediator, MS mediator and then the Store mediator. The Store mediator stores the message in the Prioritized Message Store. The message is stored until the Sampling Message Processor picks it out before sending it on to another sequence of mediators. First in the sequence is the DiffServ mediator, then the Throttle Mediator and finally the Send mediator. The send mediator sends the message back to the client and the flow is completed.

SAML Authentication Request:
This flow is shown in figure 22.The ESB receives a request (from a Client) directed at the dummy Identity Server, the ESB then uses the SendBack mediator to send the same message it got in back. The message then travels to the Out

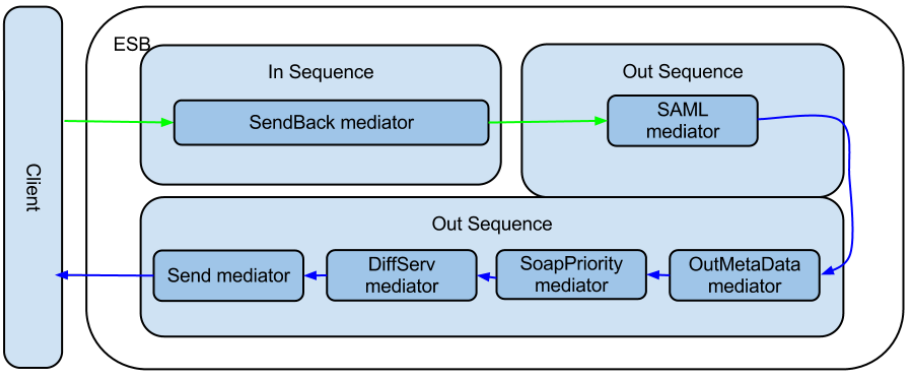


Figure 22: SAML Authentication Flow
This describes the flow of an authentication request.

sequence where it gets a priority, a DiffServ value and some metadata gets added to the header of the message. The reason why this is done is explained in section 6.3.4.

6.2.5 Extensions to the ESB

This section will contain a textual description of all the mediators used in the ESB. First we will describe all the custom mediators and then a short description of the built-in mediators we will use. All of our custom mediators have an accompanying sequence diagram to give a detailed overview of their inner working which is referenced in the title.

Custom mediators:

SAML mediator(24):
This mediator retrieves the user role from the SAML authentication and set this as a property in the message context. The service is retrieved from the 'recipient' field also found in the SAML authentication and added as another property. Depending on the configuration of the ESB this mediator can also detach the SAML authentication if this is no longer needed.

InMetadata mediator(25):
This mediator adds the IP of the client to the message context, which is done in order for the MS mediator to do its work. It will also set the Time-to-Live values in the message context if this is present in the SOAP header.

OutMetadata mediator(26):
This mediator retrieves the client role and service properties from the message context. These properties are then used along with a persistent registry to infer a priority for the message, and what the DiffServ field in the IP header should be set as. The priority and DiffServ values are then set as new properties in the message context. The DiffServ property in the message context will be used in

the synapse core to set the DiffServ field before sending the message (See B).

SoapPriority mediator(27):
This mediator adds the DiffServ value and the priority as two custom SOAP header items. We use these fields on the client side in order for the clients to use the same DiffServ value.

MS mediator(28):
This mediator retrieves the IP address[40] of the receiving client from the endpoint reference in the message context. It sends this IP address to the Monitoring Service and gets an identifier for the last Tactical Router on the path to the client, as well as the limiting bandwidth on the path. The mediator then sets this information as properties in the message context before sending the message to the next mediator.

Prioritized Message store:
This is not a mediator, but it is an important part of the response mediation sequence. This is a message store that stores messages in a priority queue. The queue is mainly ordered by the priority property of the message context, and secondly by the time when added. When retrieving messages from this store, the message on the top of the queue is returned. This ensures that high priority messages are processed before lower priority messages.

DiffServ mediator(29):
The DiffServ mediator sets the correct DiffServ value on the Socket. The DiffServ value is retrieved from the same value as the OutMetadata mediator put in earlier. Since correct use of DiffServ was very important to the client this mediator also does extensive logging which is important to look at when debugging.

Throttle mediator(30):
This mediator is used to ensure that high priority messages are sent first, by disrupting already sending messages, and it tries to ensure that the network is not being overflowed by this server by holding back messages. To determine what to disrupt and what to hold back, and for how long, several properties are used; the priority of the message, the available bandwidth, the IP address of the client side Tactical Router, and the real time demand of the request. In order to do this, the mediator must keep a list of sending messages and where those messages are going.

SendBack mediator:
This mediator sends the message back to the client, but before it is sent it is mediated through the out sequence of the ESB.

Built in Mediators:

Send mediator:
This is a built in mediator that sends the message to an endpoint (the requested service).

[40]IP address - A numerical label assigned to each device connected to the Internet

Store mediator:
This is a build in mediator that stores the message context in a message store, here this is the Prioritized Message store.

Sampling Message Processor:
This is not a mediator. It is a built in class that takes messages out of the Prioritized Message Store at a defined interval. And then sends them to a mediator sequence, here starting with the DiffServ mediator.

6.2.6 Sequence Diagrams

This section contains some sequence diagrams which can be use to get a more in depth look at the code and methods used in the mediators above. The diagrams may not reflect the actual method names or display the full complexity of the code, but they should be sufficiently detailed that it should be possible to recognize them in the code.

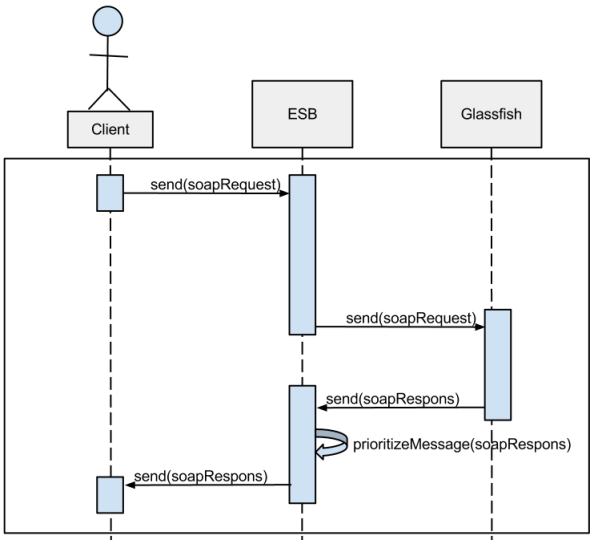


Figure 23: System-level sequence diagram
This high level diagram shows how the client communicates with web services through the ESB.

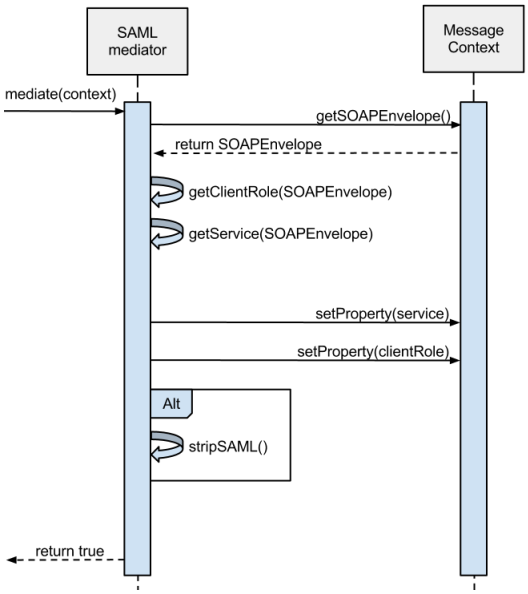


Figure 24: SAML mediator sequence diagram
This diagram shows how the SAML mediator will get data from the message, and set it in the message context so it can be used later in the response sequence

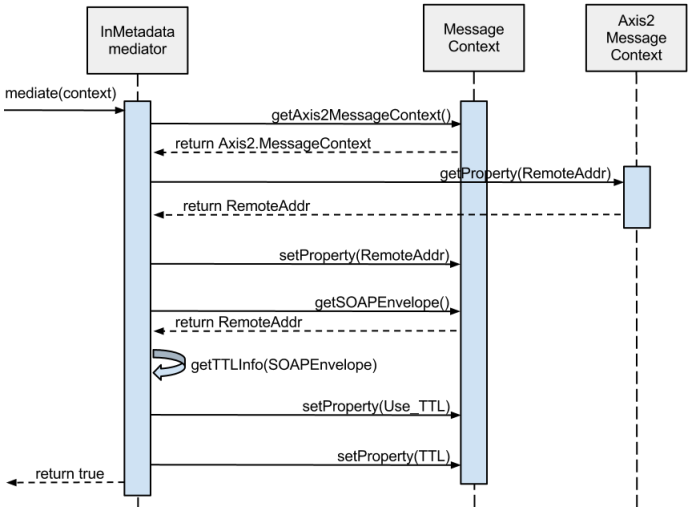


Figure 25: InMetadata mediator sequence diagram
This diagram shows how the InMetadata mediator works when it adds the IP address and Time-to-Live.

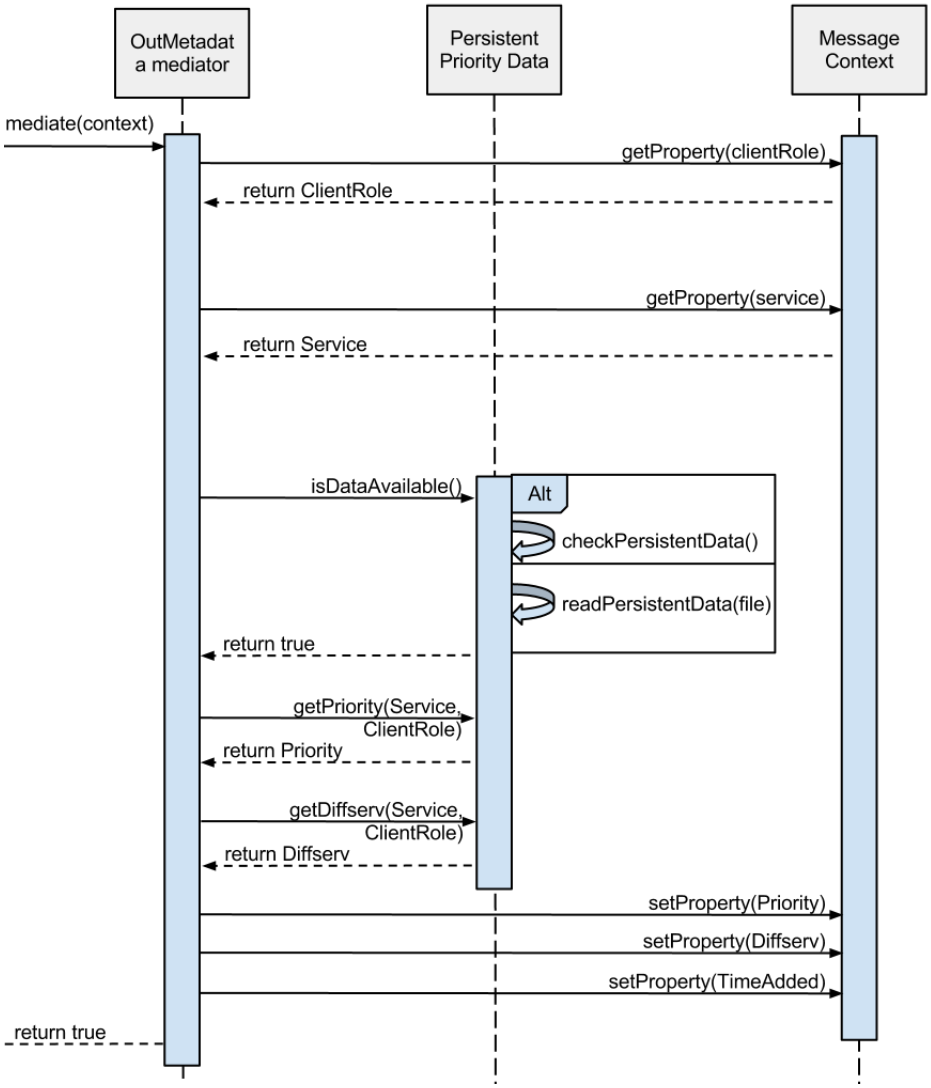


Figure 26: OutMetadata mediator sequence diagram
The diagram shows how OutMetadata mediator works.

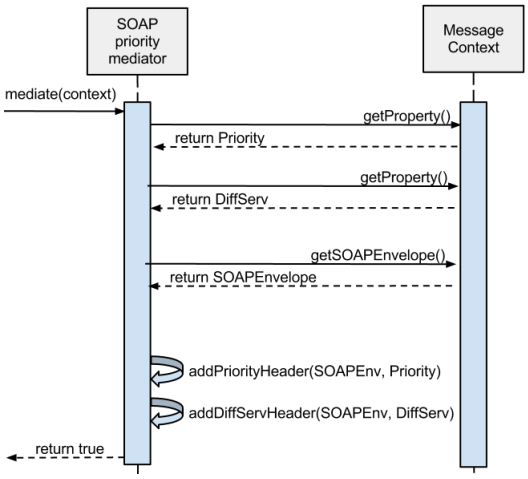


Figure 27: SOAP Priority mediator sequence diagram
This diagram shows the inner working of the SOAP priority mediator.

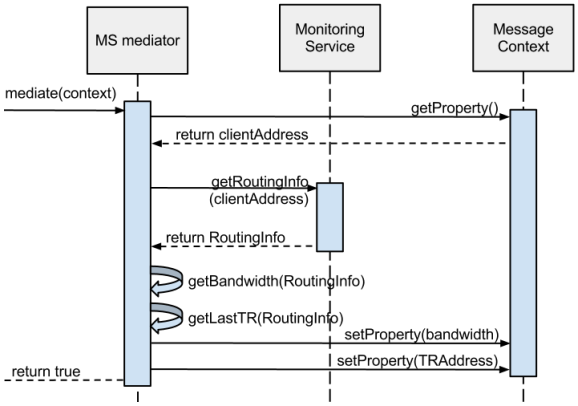


Figure 28: Metadata mediator sequence
This diagram shows how the MS mediator retrieves the routing information from the MSCommunicator and add it to the Message Context.

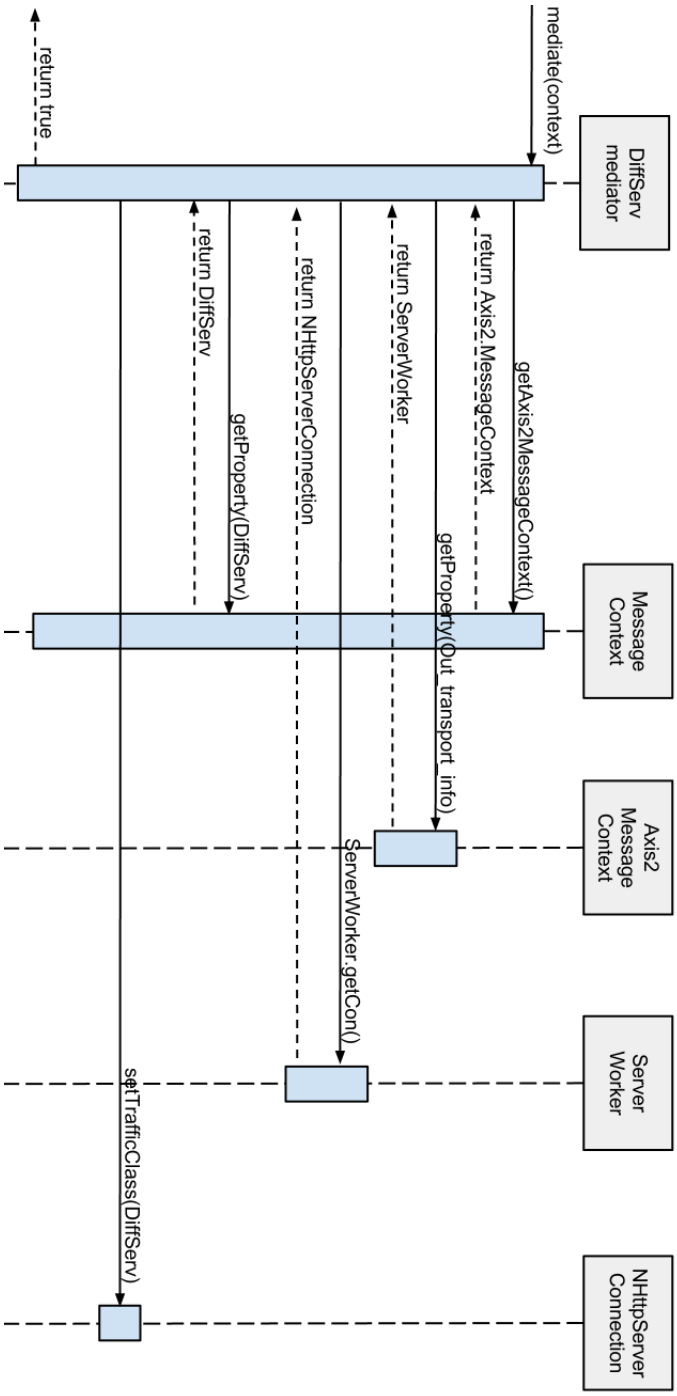


Figure 29: DiffServ mediator sequence diagram
How we set DiffServ priority on the underlying Socket.

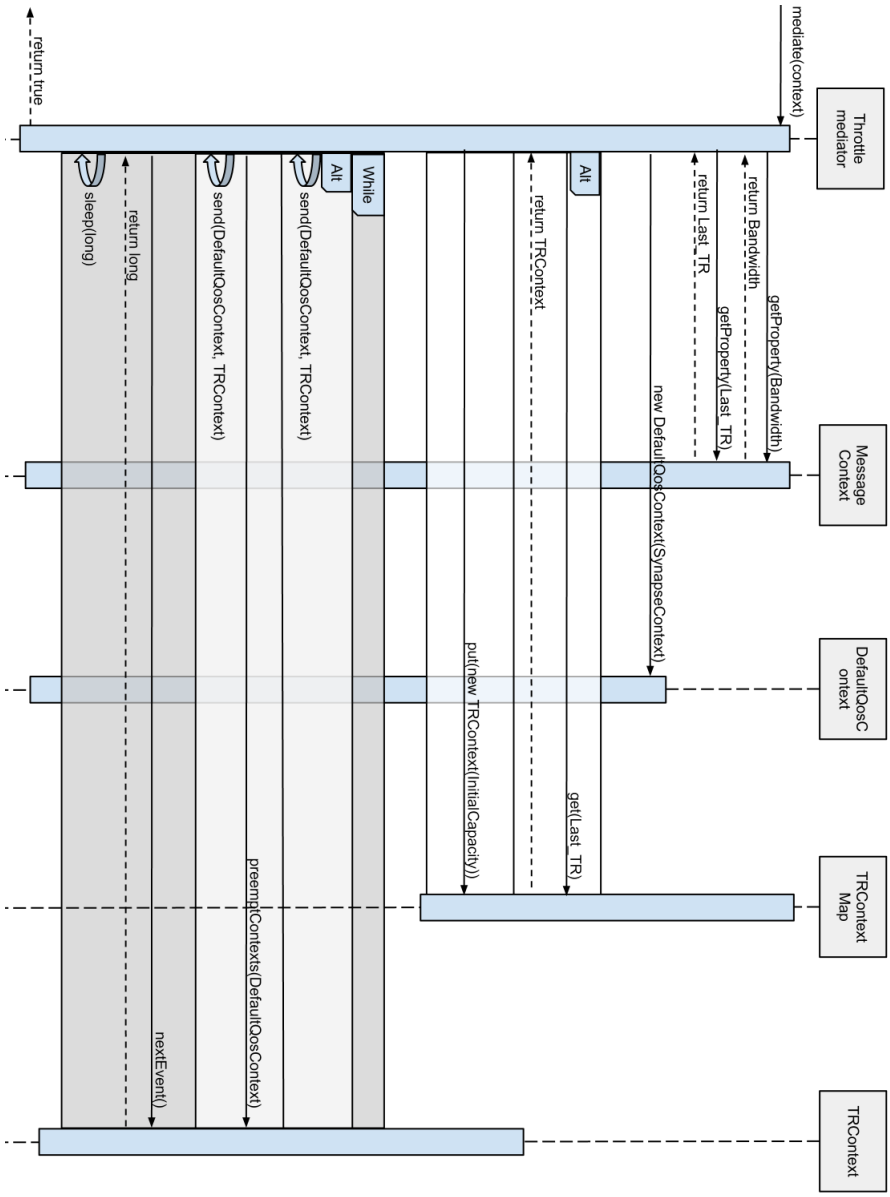


Figure 30: Throttle mediator sequence diagram
The meat of the server side mediators.

6.2.7 Configuration of the ESB

In this section we will explain how to configure the ESB. For general configuration of the ESB, eg. configuring new services or WS-Discovery, please refer to the official WSO2 ESB or Apache Synapse documentation.

It is highly recommended that you follow appendix B for an in depth guide on how to setup the ESB with the needed modifications before you read this

section.

First we will look at the file “ppd.xml”, which should now be in “/path/-to/wso2esb/”, ppd is short for Persistent Priority Data. This file contains maps from “service name” and “client role” to “priority” and “diffserv”. Here “service name” should be the path to the service on the ESB, “client role” should be the name of the client’s role, “priority” is the internal priority we use in the ESB (higher is better) and “diffserv” is the value that will be set in the IP header on communications with the client. Both DiffServ and priority must be integers. The service element also has the useDefault property, which when set to true lets roles not configured in this file use values in the default role. When useDefault is set to false unconfigured clients will get a priority and DiffServ of 0. If useDefault is set to false there is no need to configure a default client for the service. Below is an example setup of a service in ppd.xml.

Listing 1: ms.xml

```
<config>
   <services>
            <service name="/services/EchoService"
            useDefault="true">
                  <client role="clientRole1">
                    <priority>100</priority>
                    <diffserv>10</diffserv>
                  </client>
                <client role="Default">
                    <priority>321</priority>
                    <diffserv>8</diffserv>
                </client>
            </service>
   </services>
</config>
```

Next we look at a file that is specific to our implementation of the MSCommunicator (Monitoring Service Communicator). Since our implementation does not actually have a monitoring service to contact we use the file “ms.xml” in “/path/to/wso2esb/” to configure data groups of destination IP, name of last Tactical Router before client and the bandwidth capacity of the ‘weakest’ link on the path measured in KiBps. Below is an example configuration.

Listing 2: ppd.xml

```
<config>
   <RoutingInfos>
            <RoutingInfo>
                <destIP>127.0.0.1</destIP>
                <lastTR>bob</lastTR>
                <bandwidth>0.2</bandwidth>
            </RoutingInfo>
   </RoutingInfos>
</config>
```

If the MSCommunicator is modified to communicate with a Monitoring Service this file will not be needed anymore.

The last file we will look at is synapse.xml (ref:I - synapse-configs.zip), which should now be in "/path/to/wso2esb/repository/deployment/server/synapse-configs/default/". This file contains configuration for proxies, endpoints, message stores, mediation sequences, and more. The important things here are:

- The sequence qos where we can find the configuration for the throttle mediator. Here we can set the property minBandwidthPerMessage (integer, measured in Bps) and timeout(integer, measured in ms). Timeout is the longest time a message will be allowed to try sending before it is discarded.
- The messageProcessor. here the parameter interval can be set. This determines how often a message should be taken out of the message store. This is measured in milliseconds.

Other things in this file should mostly be untouched, as they define what the ESB does with messages, most of which is needed to do the prioritizing and throttling.

6.3 Changes

There are a lot of changes from the initial prestudy design to the final design described in this chapter. The prestudy design did not go into a lot of detail because of limited knowledge about the systems we were to be using. Some of the assumptions we made proved to be wrong, and a lot of difficulties popped up along the way. We had a very long planning phase before the implementation in this project. Before we started the implementation we were much closer to the final design than we were in the prestudy, with only a few notable changes made during implementation. These changes are what we would like to discuss in this chapter. This discussion should help you get a better understanding of some of our discoveries, and maybe why we ended up with the product we now have.

6.3.1 Client Specific Changes

Sanity checker:
The design of the client library initially called for a sanity checker to validate the messages the client was trying to send and the credentials the client supplied. During implementation we discovered that in order to sanity check the SOAP message it would either have to be an excessively simplistic sanity check, or we would have to parse the entire message. Parsing the entire message would sanity check it far more thoroughly than we would have been able to, so the sanity checking of SOAP messages was removed from the sanity checker module, and we ended up relying on the sanity checking built into the parser in Axiom.

MSCommunicator:
Initially the plan was to integrate the MSCommunicator module in the client library. But we realized that bandwidth data is not necessary for deciding on the DiffServ-value, as that is decided by the Identity Server and returned through SAML. Additionally, due to the fact that the data sent by the client will be

smaller than the data returned from the web service most of the time, and the network will usually consist of several clients connected to one service we saw no need to prioritize and hold back messages on the client side based on the bandwidth of the network.

6.3.2 Server Specific Changes

On the server side there was not a lot of big changes during the implementation.

The biggest change from early design to final design is probably the ThrottleMediator. Before we started the implementation, we were very unsure of what we would be able to do in this mediator. So we wrote down a few things we wanted to try, most of which we managed to implement. We wanted to make it more dynamic, and maybe learn something from how long data took to be sent to the different endpoints. Time was a limited resource, but we ended up making more out of it than what was initially anticipated.

Initially OutMetadataMediator did the work of SoapPriorityMediator as well, but we split them up because we figured several more specialized mediators would be more modular and easier to modify later.

During implementation we found out that we had to get the IP address of the client in the 'in' sequence for use later in the 'out sequence, so we made InMetadataMediator take care of this as well as getting potential time to live data.

Because of the lack of the Identity Server we needed an alternative to send the diffserv value back to the client. So we made the SAML-sequence described in 6.2.3 under SAML Authentication Request.

6.3.3 Changes that affect both sides

OpenSAML:
OpenSAML is not used at all. If we had succeeded in implementing the Identity Server, the IS would take care of all SAML generation. Since we use a dummy layer in the ESB to "simulate" the IS, the client needs to generate SAML, but it takes far too much time to initialize the OpenSAML libraries for it to be useful in our case, so we decided not to use it, and instead use Apache Axiom to build a proper SOAP-wrapped SAML-message based on some hardcoded strings, and variable roles and timestamps.

Tokens:
The biggest change since the initial design finalization is how tokens are fetched and used in our implementation. The initial idea was that the server side would contain an identity server, which our client would identify itself towards. As it turned out, setting up and using the identity server was far more difficult than anticipated (see details on why below), and would have taken us far beyond our project deadline, so together with the customer it was decided that since this wasn't a part of the requirements for the project, it could be dropped. What we ended up with was a far simpler system where the client itself creates a token, which is then sent to a simple echo service on the server to get the SOAP headers we needed from it.

6.3.4 Regarding the Identity Server

Our original design called for the implementation of the WSO2 Identity Server, but our final product does not include it as we ran into some problems while trying to set it up. After discussing our situation with the customer, they agreed that we could drop it. It was, after all, not a functional requirement from their side, though it would be preferable to have it included.

There are several reasons why we failed to implement the Identity Server, one of which is that we started our research of the IS too late, only two weeks before our prototype demonstration, and we only had one group member working on it. After seeing how well documented and fairly easy to use the WSO2 ESB was, we figured that the IS couldn't be much worse, but we figured wrong. Which leads us to the next source of our problems; the WSO2 Identity Server product page at http://wso2.com/products/identity-server is severely lacking in documentation. The user guide and administration manual contains barely no information about how to configure it and set it up to be usable in different usage scenarios. They provide links to some blog posts that employees had written back in 2009, and even though the blogs contained some useful information, and sometimes provided example configuration files and client code, they did not state which versions of the different products they were basing their examples on, so we don't know if there were compatibility problems between different versions of the IS and ESB.

We used this blog post http://blog.facilelogin.com/2009/05/accessing-proxy-services-in-wso2-esb.html to try and set up communication between the IS and ESB. It was not entirely similar to our use case, as it uses X509 signing and encryption with HTTP transport, instead of using HTTPS and let the transport layer take care of security. When we tried to use the supplied client code and configuration files, we got some problems with the latter, as the client code would not accept them, throwing exceptions stating that they were not of the correct format, though the IS and the ESB accepted them. If we changed the configuration files so that the client would accept them (the only adjustment needed was to change the name of a tag in the WS-security policy XML-file, from <sp:Policy> to <wsp:policy>) then the IS and ESB would not accept them. Since it was just a minor adjustment, and the rest of the policy stayed identical, we don't believe this caused any problems, but it is an example of how frustrating it could be trying to use the code provided, as it was poorly commented and assumed one had previous knowledge of how Apache Axis2, Axiom, Rampart and Tomcat worked, since the WSO2 IS builds upon these products.

After much trial and error, a lot of exceptions and googling for solutions, we managed to get the IS to issue security tokens and send them to the ESB, but the ESB failed in decrypting and verifying them. We were unable to figure out exactly why it failed, as the error message we got was that the ESB could not find the public key of the Identity Server, but using the Java keytool we could verify that the key was in fact present in the ESB key store. After spending quite a few hours trying different solutions, exporting the IS public key and importing it to the ESB key store under a new alias, importing the ESB public key into the IS key store etc. we gave up, as this specific use case was not the one we were after, and we had at least succeeded in getting the ESB and IS to talk to each other.

Next, we tried configuring the IS to issue username tokens and send them over HTTPS, which would remove the need for endpoint encryption and was after all the use case we had in mind. We could find no specific examples for this scenario, so we tried creating our own security policy file, since the one from the previous example specified endpoint encryption, and adjusted the settings in the ESB and IS. In this way we managed to get the IS to create username tokens, but nothing more, as it crashed when trying to send it to the ESB, stating that the SOAP header did not include a security element. Monitoring the SOAP messages we could see that the header actually did contain this element, so we don't know why the IS couldn't find it.

This was as far as we got before our prototype demonstration, and as already mentioned, our customer agreed that we could drop the Identity Server and instead use a dummy layer in the ESB. This means that our final product does not use the IS, and users cannot log on to the system because there is no user store, so the client will create static SAML-tokens which it sends to the dummy layer in the ESB, which then returns the same SAML-token, but wraps in in a SOAP message containing information about the clients priority in the system and its diffserv value.

Had any of us had some experience with WS-security from before, and been familiar with the WS-security policy language, and the Axis2, Axiom, Rampart and Tomcat from Apache, which the WSO2 Identity Server builds upon, we might have been more successful. We were quite frankly stumbling around in the dark, without knowing exactly where to begin.

7 Testing

This chapter will introduce our testing setup together with the result of our testing. We will start by introducing the testing suite, how the testing client works and we will also have a discussion about strengths and weaknesses of the system as a whole. Then we will introduce the actual tests and present our results. After reading this chapter it should be clear to you how to setup the testing suite, how to replicate our tests and you should have an in depth view of our results. The result section will also contain a discussion on the weaknesses which have had an effect on the tests and how we have interpreted our results despite this.

7.1 About the testing setup

All tests were run on a virtual machine running Ubuntu Server 11.10, using the software described in appendix G

7.1.1 Suite

Since we chose to do most of our testing on NS3 using the MobiEmu[41] framework most of our tests are fully automated. As we have not managed to integrate everything into the testing framework some variables are still static, but these will be highlighted where applicable.

[41] A framework for emulating mobile ad-hoc networks with Linux containers and ns-3. https://code.google.com/p/mobiemu/

Please refer to appendix C for instruction on how to set up the testing framework. And for a description of the different variables in the test.

As we alluded to in section 3.5 we had quite high hopes for how we were going to test the whole system. Unfortunately for us that did not pan out the way we wanted it to. We had some major problems regarding NS3 and how it connects its nodes to the Tap-Bridges created. This led us to having to rethink our whole test setup. We decided, after talking to the customer, that we would change the test and create a simpler network layout which would work with NS3. In figure: 31 we can see this new altered network layout. What this meant for the project was that we could not test all the functionality that we wanted to, but we are still quite confident that we can draw some conclusion about the results. In appendix F we have outlined the problems we faced and a possible solution that we did not have time to implement.

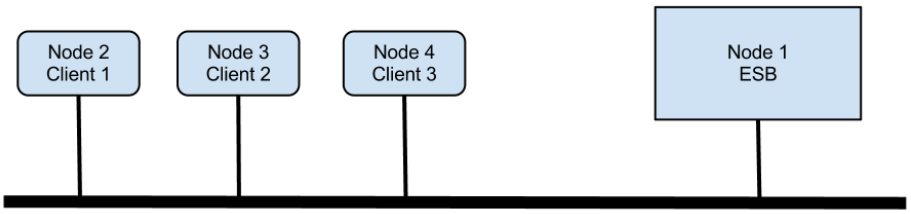


Figure 31: The layout of our network during testing
In this figure we have illustrated the layout of the network during NS3 testing.

This new layout limits the scope of the tests, and also what we could approve of functionality, but still we think we have a strong end product with results that will absolutely be relevant for the customer.

The MobiEmu testing framework operates by creating LXC and connecting these to tap bridges created by NS3. This then emulates any network possible to create in NS3. From the point of view of programs running inside the LXC, they are full Linux machines connected to a real network. This means that any program able to run on Linux should run properly inside the LXC and any messages they send out is sent through NS3. This means that we have full control over how our network behaves and we can emulate quite a lot of scenarios.

When MobiEmu start up it creates a number of LXCs, it then starts up NS3 outside of any LXC and connects each of the LXCs to a corresponding tap bridge in NS3. Inside each of the LXCs it then starts the experiment and waits for the whole thing to finish before it completes nicely. Before each run MobiEmu stores all files and folders in the whole folder in order to easily recreate an experiment. When the experiment is done the result files are moved into the result folder.

Our tests are set up as follows. We have three clients, two clients with low priority and one client with high priority. They send messages to the ESB which

is connected to the same LAN as all the clients. The specific test client we use is describe in the following section. In the section 7.2 we have a detailed description of the reason behind each case. We tested with several different bandwidths in order to test our setup and see how it handled a variety of different bandwidths. The last thing that we tested was using different "Timeout" values on the ESB, which was done in order to test what setting works better for the different bandwidths. We did it this way because of the static nature of configuration on the ESB, detailed in the section 6.2.7.

7.1.2 Test Client

In this section we will shortly describe the test client used for testing, "EchoClient-Client.jar"(ref:I).

The client starts by reading its configuration file. Its filename can be provided as the only command line argument, otherwise it defaults to "client.config'. This configuration file contains variables such as username, password, role, service to contact, what the request should be, how many requests to send and with what interval it should send them at, and some describing what to log.

The client expects the request to contain 'REQID' as part of the request message, and before sending it, the client will replace it with 'REQID=XX' where 'XX' is the number of the request. This way the client can check that it gets the right response by checking whether 'REQID=XX' is present in the response, and whether the ID is correct. This makes validating the response from the service easier, but it restricts the service to put the request message somewhere in the response. Another side effect of this being the only validation is that other errors in the response are not easily detected as long as the 'REQID=XX' is there. If for example the response is cut short, by the stream being cut, as long as the ID is present it will be treated as valid. The client also prints the length of the response, so scripts that parse the results can pick up on responses with abnormal lengths.

After reading the configuration file the client makes an instance of the client library described in section 6.1, using the username, password and role, and itself as an ExceptionHandler. By implementing itself as the ExceptionHandler the client will be notified about all the exceptions occurring in the client library, the client does not act upon these exceptions, but it does log them. A normal client might want to send a request again here.

A timer is used to start the sending/receiving in a new thread at the interval specified and the number of times specified. Starting new threads for every request and sending at a small interval is a good way to test how the client library handles concurrent requests.

The actual sending and receiving of data is rather simple, as you can see in this code snippet:

```
1 /* Uses connection.sendData(data, destination) to send a
      request. Here {REQID} in the request found in
      clientConfig is replaced with {REQID=reqID}. The client
      library will put the response in the returned
      ReceiveObject when it is received. */
2 ReceiveObject ro = connection.sendData(
3 config.get(DATA).replace("{"+REQID+"}", "{"+REQID+"="+reqID+
      "}"), destination);
```

```
try {
    logLine("Waiting for response "+reqID);

/* Calls the blocking method ReceiveObject.receive() to get
    the response. An alternative to this would be to make a
    DataListener and add it to connection This way, every
    listener would receive all the responses, and would be
    unsuited for this test */
    String response = ro.receive();
```

For more details about configuring the test client, read the example configuration provided in appendix I. For more detailed information on how the test client works, the TestClient.java file with Javadoc is also provided in appendix I.

7.1.3 Test Service

In this section we will shortly describe the test service used for testing, "EchoServiceLargeReply.war" (ref:I).

The test service is very simple and deployable with GlassFish. It expects a request like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<S:Envelope xmlns:S="http://schemas.xmlsoap.org/soap/
    envelope/">
    <S:Header/>
    <S:Body>
        <ns2:hello xmlns:ns2="http://me.test.org">
            <name>PAYLOAD</name>
        </ns2:hello>
    </S:Body>
</S:Envelope>
```

And responds like this:

```
<?xml version='1.0' encoding='utf-8'?>
<S:Envelope xmlns:S="http://schemas.xmlsoap.org/soap/
    envelope/">
    <S:Body>
        <ns2:helloResponse xmlns:ns2="http://me.test.org">
            <return>
                PAYLOAD!
                Lorem ipsum dolor sit amet, consectetur
                    adipiscing elit. Etiam sodales magna at
                    est iaculis vel fermentum velit tristique
                    . Cras nulla urna, ultrices vitae posuere
                     a, iaculis sit amet lectus. Aliquam
                    mattis sapien et elit commodo ...
            </return>
        </ns2:helloResponse>
    </S:Body>
</S:Envelope>
```

With PAYLOAD intact, and 10KB of Lorem Ipsum[42]. We add these 10KB of text to ensure that the response is considerably larger than the request, which should get us more realistic results when testing. We also send the original payload back so the test client can easily identify which request was responded to. Those 10KB of text also has a large impact on testing, it means that on lower than 10KBps bandwidth all the messages can't be sent in time. We chose to have it this way because it would give us a predictable test and also some static configuration on the ESB could be configured with this in mind.

7.1.4 Weaknesses

There are some weaknesses connected with our testing suite and how we do the testing. Chief among them is the limited scope made necessary by limitations encountered in NS3. However there are other areas where the testing suite could be expanded which could be done without butting heads with NS3.

One limitation that was self imposed is the fact that we only have one test network layout. This should have been expanded, but because of limited time at the end of the project we chose to focus more on the one test. With a more expanded network layout, which is quite feasible despite the problems encountered with NS3, one could add more clients and introduce several priorities to test how the ESB would behave. We theorize that the ESB should behave in the same way and we have created it in such a way to prioritize the highest priority messages no matter what the other messages does.

Another limitation to the test setup is that we have no easy way to communicate between the LXCs. What this means is that we can not coordinate when to terminate the whole test. What this means is that we have to enforce a cutoff time which does skew some test. Especially bad is this when we run the test without our Throttle mediator. Because without our Throttle mediator, even on the lower bandwidths, no messages should be lost and the percentage of successful messages should be a hundred percent. This will effect the test, but we decided to keep it this way because we mean the general trend on the results are still clear.

The test client also has some problems. For one it does not try to retransmit any messages. This has a profound effect on the results regarding successful message percentage which will be quite different with and without our Throttle mediator. With our Throttle mediator we will perceive a lower percentage compared to without the mediator, but this is just a result of us dropping messages which retransmitting would to some degree correct. Another thing worth mentioning is that we have scheduled all the clients to start about the same time, there is a slight delay between them, but this scheduling means that on lower bandwidths there will be a distinct sending period where all the clients sends messages and there will be a distinct receiving period.

For the lower bandwidth test, there is also the fact that the client library uses HTTPS, which we have observed in the lowest bandwidths does sometimes timeout due to the size of the handshakes, which somewhat interferes with the results. This should however be quite insignificant as the results sent back from the service is so large and would be guaranteed to time out if the smaller handshake messages times out.

[42] http://www.lipsum.com/ - simply dummy text

On the server side the biggest limitation is the static nature of the setup. We have tried to make the tests so that we could test as much as possible, but there is one variable which we have not gotten to tweak. On the ESB we can configure the interval in which messages are taken out of the message store, but because of limited time to perform the tests we could not test this. For the results this means that the time taken for the lower priority clients will be a bit skewed, but again the trend should be clear.

7.2 Test Cases

As most of the tests below are quite similar, the reasoning behind them is also fairly similar. The main difference between them is the "Timeout", which refer to the timeout the ESB uses. For more about the "Timeout" see 6.2.7.

Since this project had a research focus from the customers side we did not perform these test in order for us to validate our system. Instead we have run these tests to try and say something about the feasibility of the original question asked when we started. We will come back to this topic in the result section.

We used the same client setups for all of the tests. The low priority clients, Client 1 and 2, was configured like this:

```
1  %This is a comment
2  %variables are written with NAME:VALUE
3  %line without ':' or '%' is treated as end of file.
4  %doLog:boolean, whether to log or not, default is true.
5  doLog:true
6  %logToFile:boolean, whether or not client library should log
       to file, default is false.
7  logToFile:true
8  %username:String, Must be configured.
9  username:testname
10 %password:String, Must be configured.
11 password:testpassword
12 %role:String, Must be configured.
13 role:clientRole1
14 %service:URI, Must be configured.
15 service:https://10.0.0.1:8243/services/EchoService
16 %interval:long, between requests in milliseconds, only one
       request if not configured
17 interval:1000
18 %nofreqs: int, number of requests to send, send forever if
       not configured
19 nofreqs:100
20 %delay:long, wait before first request in milliseconds,
       default is 0
21 delay:10
22 %request:SOAP, Must be configured.
23 request:<?xml version="1.0" encoding="UTF-8"?><S:Envelope
       xmlns:S="http://schemas.xmlsoap.org/soap/envelope/"><S:
       Header/><S:Body><ns2:hello xmlns:ns2="http://me.test.org
       "><name>{REQID}</name></ns2:hello></S:Body></S:Envelope>
```

Client 2 had 0 as delay. While the high priority client, Client 3, had interval=3000, nofreqs=30 and delay=15.

ID	1
Description	In this test what we are looking at is how our system behaves with a very low timeout, since we have full control over the message sizes sent in the test we know that this timeout will be too low on the lower bandwidths, but should perform much better on high bandwidths.
Repetition(s)	10
NS3 variables	Datarate: 1kBps,5kBps,10kBps,20kBps,40kBps
ESB variables	**Timeout: 500**, interval: 500, minimum bandwidth per message: 10240
Automated	Yes
Expected Result	We expect to see that the ESB will time out even higher priority messages in the lower bandwidth tests because of the low timeout, but on higher bandwidths the sending time of the all the messages should be lower than on the later tests. To put that in the same setting as our results, we expect the percentage of successfully received messages to be lower than in the tests below, but we expect the time to also be lower across the board.
Folder with compressed test	In appendix I you can find the appropriate compressed test case.

...

ID	2
Description	In this test we have increased the timeout substantially, we expect to see some improvements on 10kBps and still retain some of the benefits of a lower timeout on 20- and 40kBps
Repetition(s)	10
NS3 variables	Datarate: 1kBps,5kBps,10kBps,20kBps,40kBps
ESB variables	**Timeout: 1000**, interval: 500, minimum bandwidth per message: 10240
Automated	Yes
Expected Result	We expect to have a higher percentage of completed messages on 10kBps than with a timeout of 500 and we expect the results on 1-, 20- and 40kBps to be relatively unchanged.
Folder with compressed test	In appendix I you can find the appropriate compressed test case.

...

ID	3
Description	Again we have increased the timeout and expect to see some improvements on percentage, but the total time taken should start to drop on higher bandwidths.
Repetition(s)	10
NS3 variables	Datarate: 1kBps,5kBps,10kBps,20kBps,40kBps
ESB variables	**Timeout: 2000**, interval: 500, minimum bandwidth per message: 10240
Automated	Yes
Expected Result	We expect all the messages on 20 and 40kBps to arrive, we expect that on 10kBps more messages should arrive, but not all. The time taken should again increase.
Folder with compressed test	In appendix I you can find the appropriate compressed test case.

...

ID	4
Description	In this test we want to see how the ESB copes with a much larger timeout.
Repetition(s)	10
NS3 variables	Datarate: 1kBps,5kBps,10kBps,20kBps,40kBps
ESB variables	**Timeout: 5000**, interval: 500, minimum bandwidth per message: 10240
Automated	Yes
Expected Result	We expect that 10-, 20- and 40kBps should be enough to get most of the messages for the high priority client through, the time taken should again increase and this should be noticeable on 40kBps compared to Test 1.
Folder with compressed test	In appendix I you can find the appropriate compressed test case.

...

ID	5
Description	In this test we have gone all out. The timeout is massivly increased to see how the ESB behaves on the lowest bandwidths, 1- and 5kBps respectively.
Repetition(s)	10
NS3 variables	Datarate: 1kBps,5kBps,10kBps,20kBps,40kBps
ESB variables	**Timeout: 100 000**, interval: 500, minimum bandwidth per message: 10240
Automated	Yes
Expected Result	We expect the same percentage on 10-, 20- and 40kBps as Test 4. What we want to see is that on 5kBps the percentage is increased quite substantially compared to the previous tests.
Folder with compressed test	In appendix I you can find the appropriate compressed test case.

...

ID	6
Description	In this test what we have done is to remove our Throttle mediator which should mean that our ESB setup will no longer be doing any throttling of messages. The message queue is still there so there will be some priority in the sending and receiving. We want to test this because this should give us some idea about how our setup will do against no QoS at all.
Repetition(s)	10
NS3 variables	Datarate: 1kBps,5kBps,10kBps,20kBps,40kBps
ESB variables	**Timeout: N/A**, interval: 500, minimum bandwidth per message: N/A
Automated	Yes
Expected Result	We expect that the average percentage of all the clients will be slightly above what our test can do, we refer to section 7.1.4 for some elaboration about this. What we want to see is that on lower bandwidths the average time taken for messages to arrive at Client 4 will be substantially higher than when we use the Throttle mediator. This will indicate that our Throttle mediator actually does some useful work and also indicate that this could be a viable strategy for our customer to continue researching.
Folder with compressed test	In appendix I you can find the appropriate compressed test case.

7.3 Results

In this section we will go over the results for each of the test cases in the preceding section. We will compare the results with each other and also compare most of the cases to the "No throttle mediator" scenario.

To see all the results of our tests in their raw forms, we refer you to appendix E.

Test case 1:
In test 1 we wanted to find out how the ESB would perform with a low timeout. From our expectations we want to see that the average time for messages to arrive is low, but we do not expect this test to have as good a percentage as the rest.

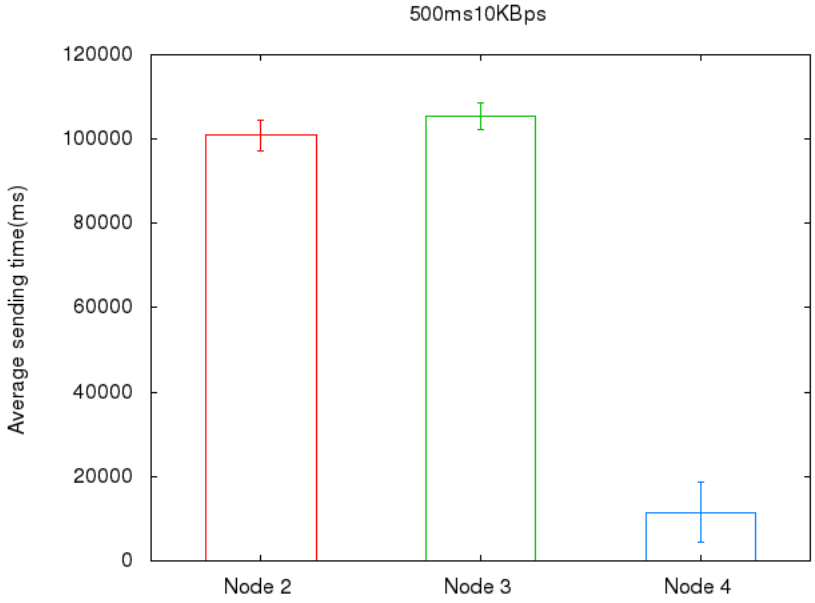


Figure 32: Time graph, timeout equal to 500 and bandwidth of 10kBps

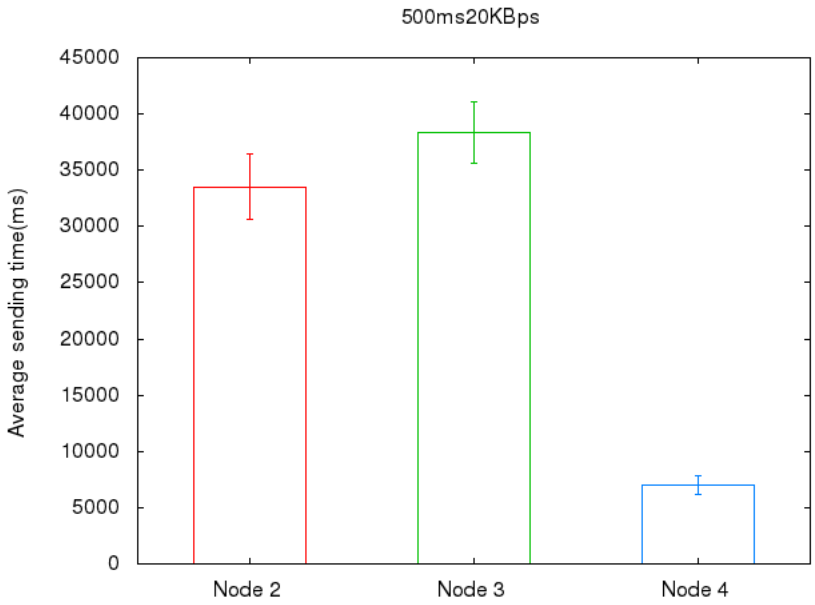


Figure 33: Time graph, timeout equal to 500 and bandwidth of 20kBps

The actual results do indeed match our expectation quite well. As you can see in figure 33 the time taken is quite low, if we compare that time to the time in figure 39 we can easily see that the lower timeout has an effect on the results

and in most of the cases it is correct that the lower timeout does make the ESB quicker.

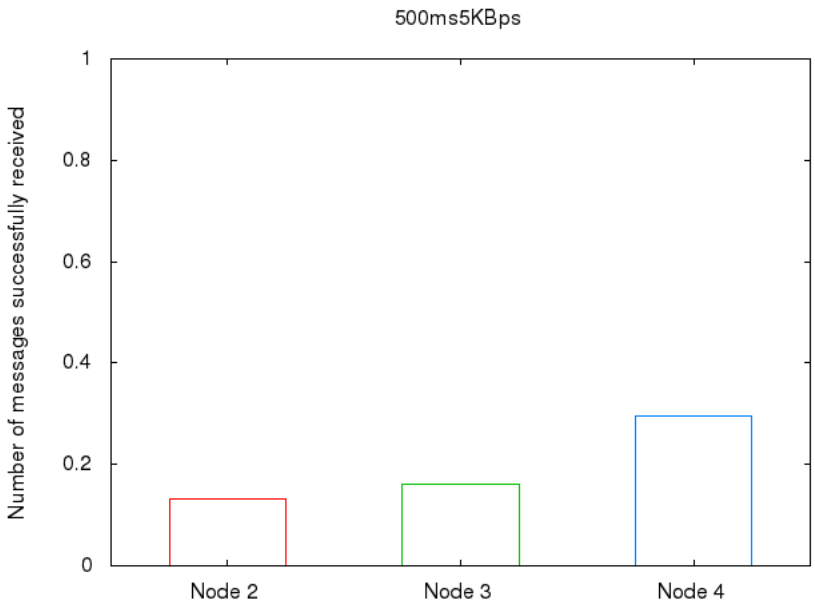


Figure 34: Message graph, timeout equal to 500 and bandwidth of 5kBps

As a last piece of result we have added the message graph with a bandwidth of 5kBps which should give a glimpse into how increasing the timeout effects the number successful messages received.

Test case 2:
As we stated in the section 7.2 we expect this setting to do a bit better than with a timeout of 500ms when it comes to number of successful messages.

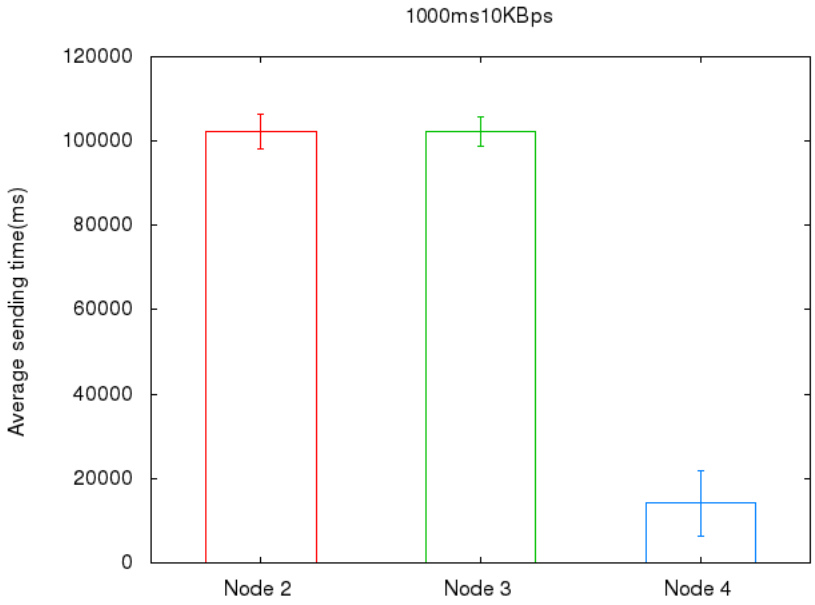


Figure 35: Time graph, timeout equal to 1000 and bandwidth of 10kBps

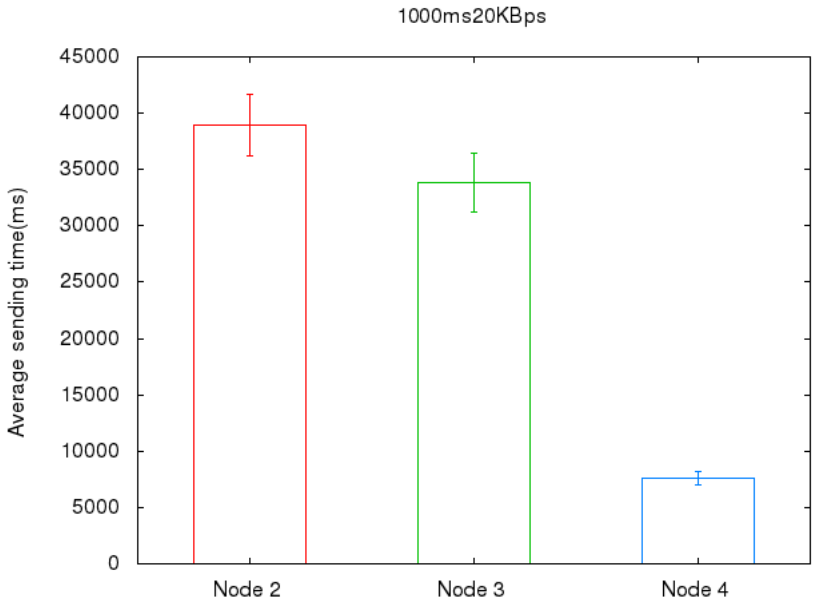


Figure 36: Time graph, timeout equal to 1000 and bandwidth of 20kBps

From the figures it might not be clear, but the results are actually not what we expected. The test is better with regard to successful messages with

a timeout of 500ms than on 1000ms and the time taken is within the standard deviation so we can't say much about that either.

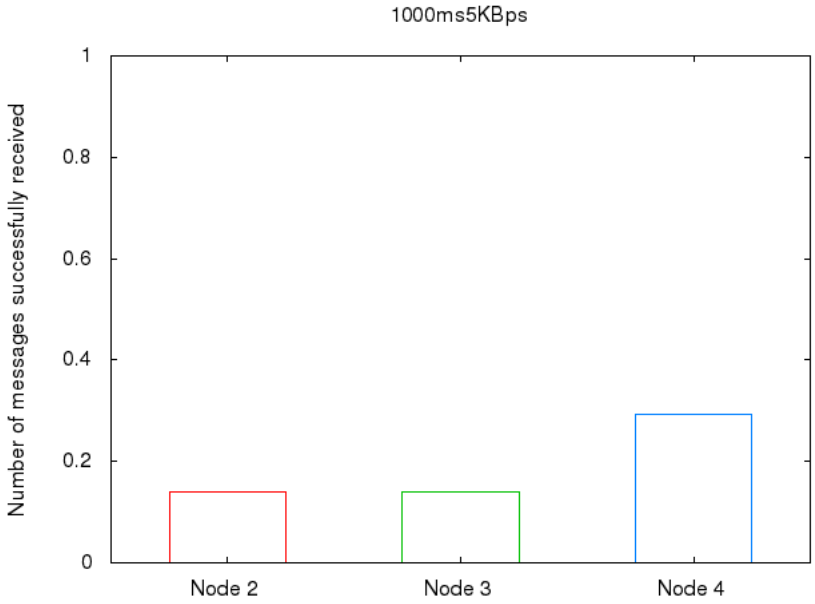


Figure 37: Message graph, timeout equal to 1000 and bandwidth of 5kBps

The history here is the same as with 500ms timeout.

Test case 3:

We expected this test to have some increase in successful messages compared to the two previous results. The average time taken should however drop slightly.

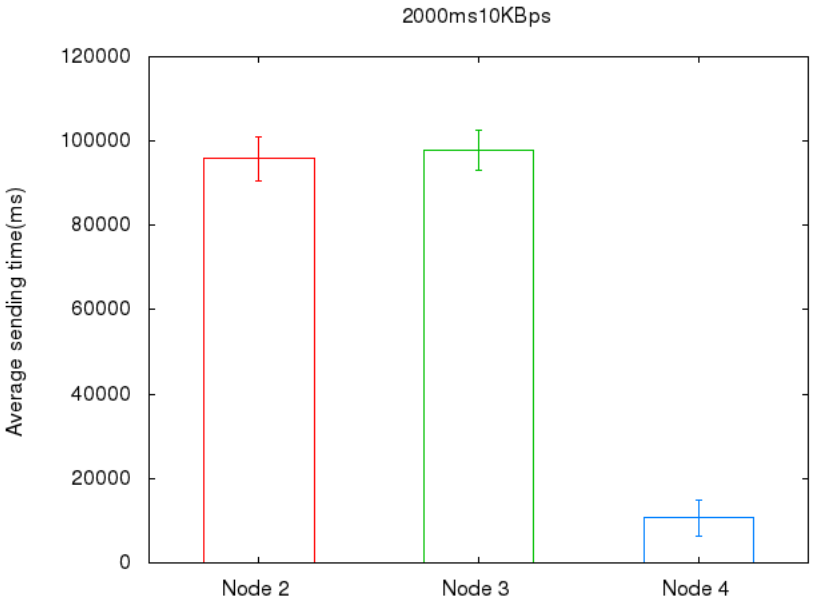


Figure 38: Time graph, timeout equal to 2000 and bandwidth of 10kBps

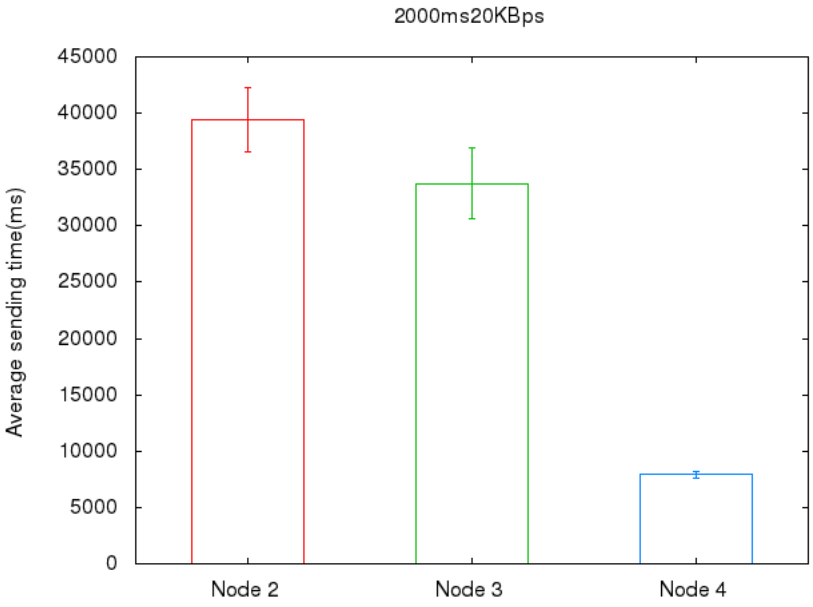


Figure 39: Time graph, timeout equal to 2000 and bandwidth of 20kBps

The result we got for this test also surprised us a bit. The number of successful messages has increased with quite a bit compared to a timeout of

500ms. Which is what we expected, but with result of 1000ms this might not have been the case. What is really strange is that the average time has dropped.

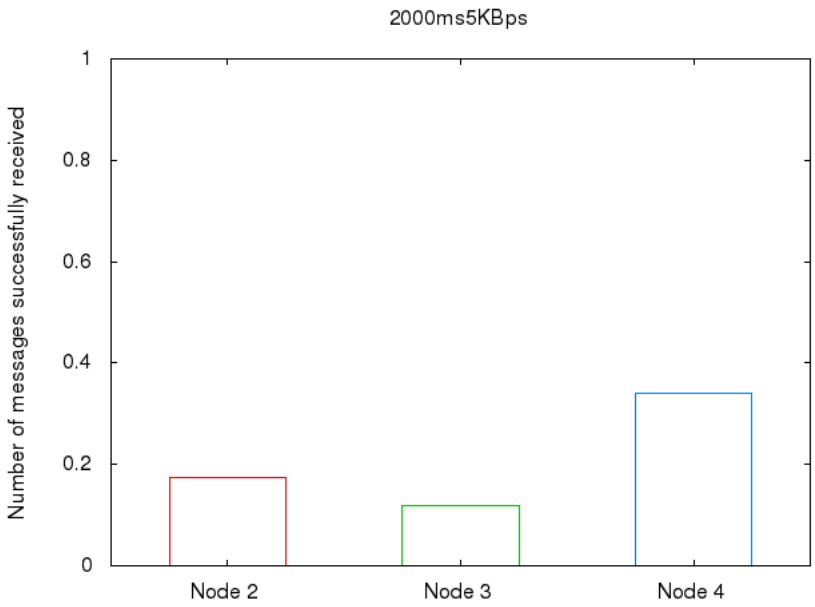


Figure 40: Message graph, timeout equal to 2000 and bandwidth of 5kBps

Here the result is a bit brighter than before, and we can see that more messages arrive because of the increased timeout.

Test case 4:

We expected more messages to arrive here compared to the previous tests.

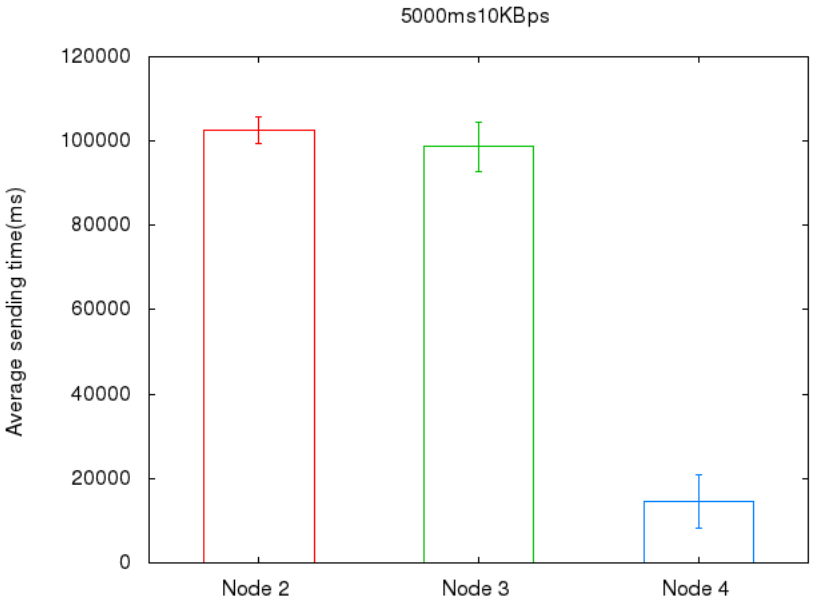


Figure 41: Time graph, timeout equal to 5000 and bandwidth of 10kBps

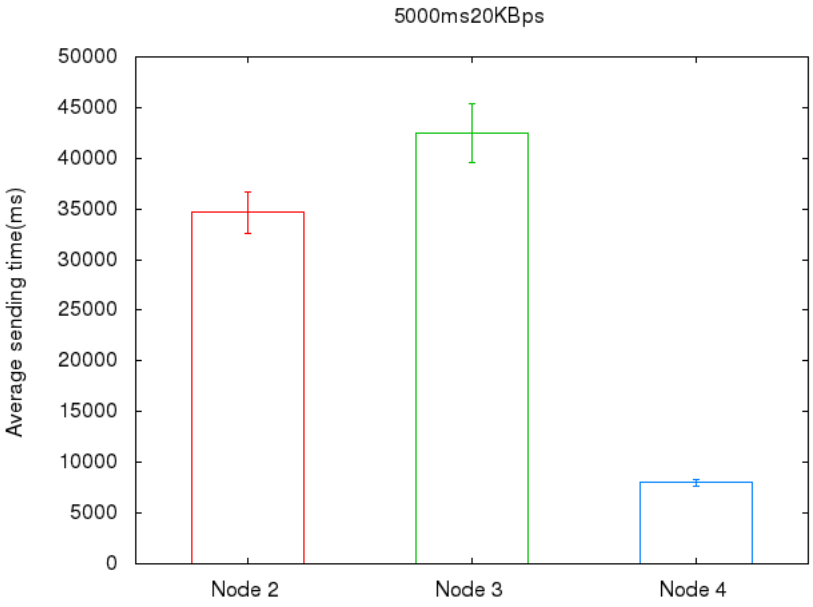


Figure 42: Time graph, timeout equal to 5000 and bandwidth of 20kBps

The story is not very different from what we expected. On average more messages arrive successfully compared to the previous three test cases. The time

has also increased slightly, but is again within the standard deviation on most bandwidths.

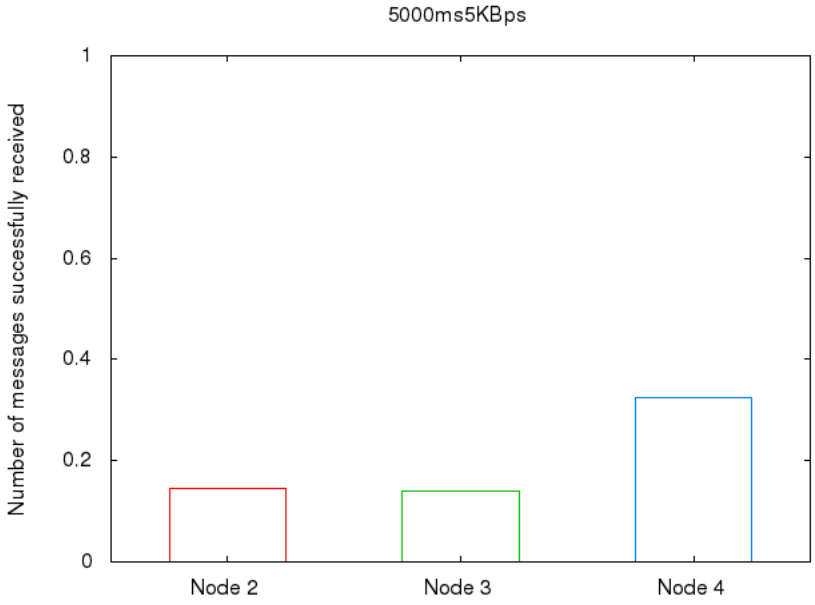


Figure 43: Message graph, timeout equal to 5000 and bandwidth of 5kBps

The results for successful messages on 5kBps is very similar to the 2000ms results, but is better than the first two tests.

Test case 5:

In this test we wanted to see how the ESB behaved with a large timeout.

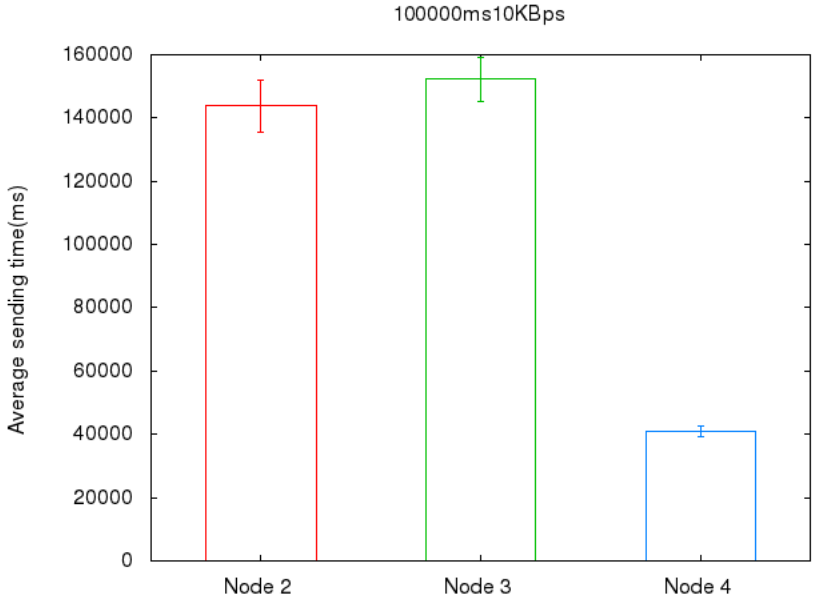


Figure 44: Time graph, timeout equal to 100000 and bandwidth of 10kBps

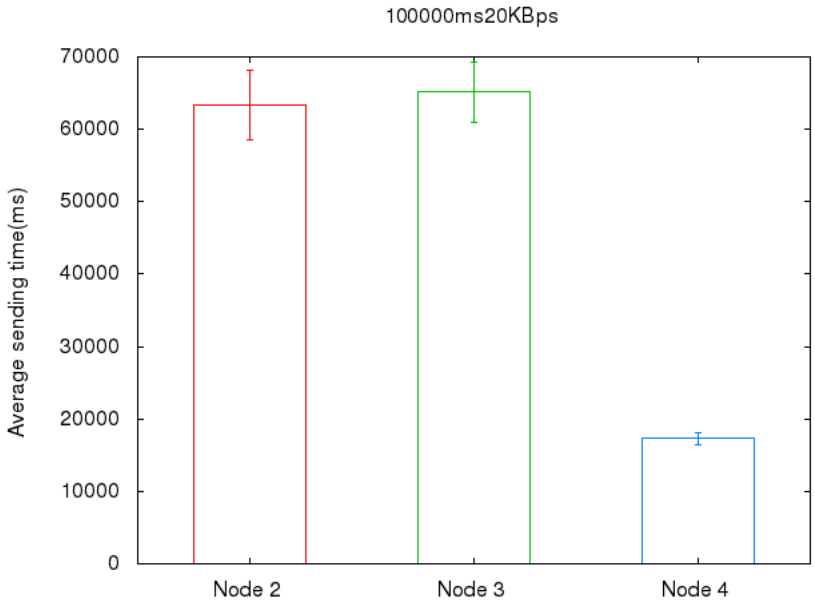


Figure 45: Time graph, timeout equal to 100000 and bandwidth of 20kBps

As we expected with such a large timeout more messages arrive successfully compared to the previous tests. The time has dramatically increased which is

a direct result of the higher number of successful messages. The few deviations that we see are most likely due to random fluctuations in the test suite.

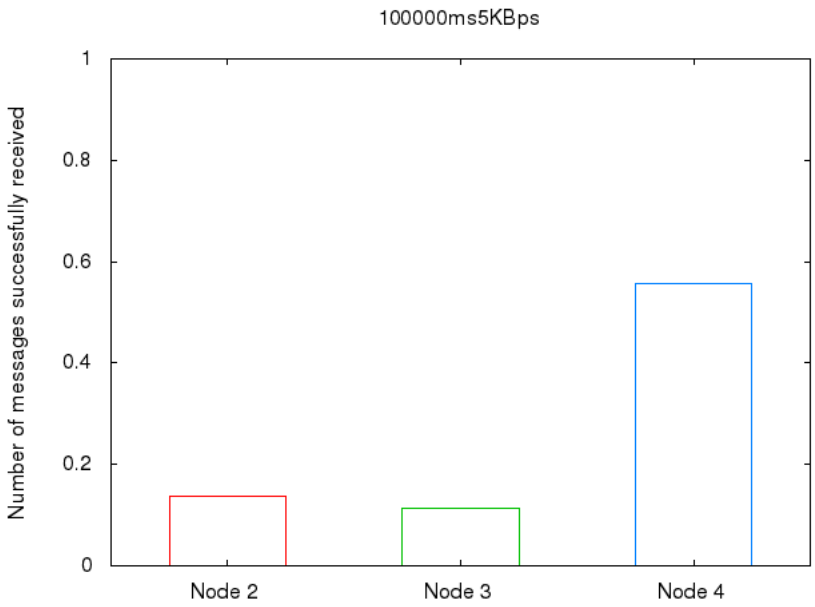


Figure 46: Message graph, timeout equal to 100000 and bandwidth of 5kBps

As with the previous test we can see an increased again, which is due to the timeout.

Test case 6:
Without the throttle mediator we expect that the results below is better with regard to number of successful messages, but worse with regard to time.

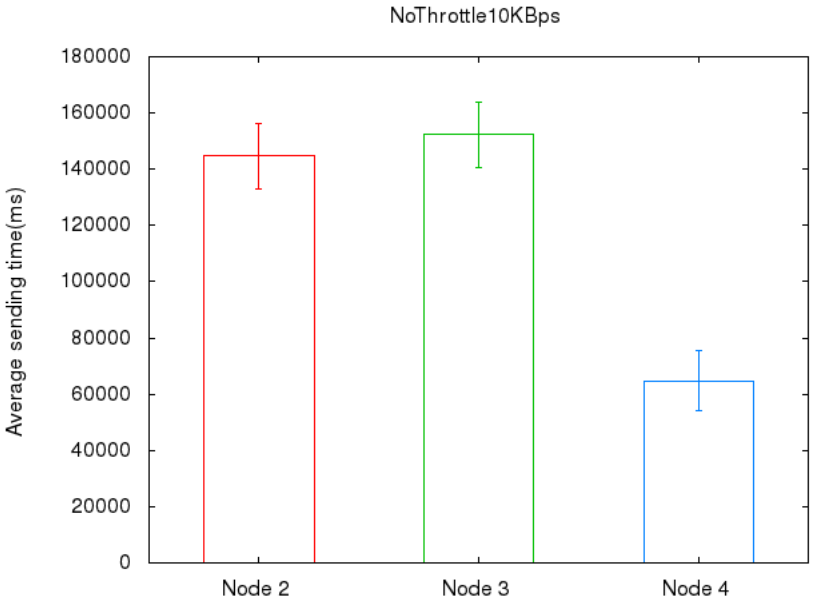


Figure 47: Time graph, no throttle mediator and bandwidth of 10kBps

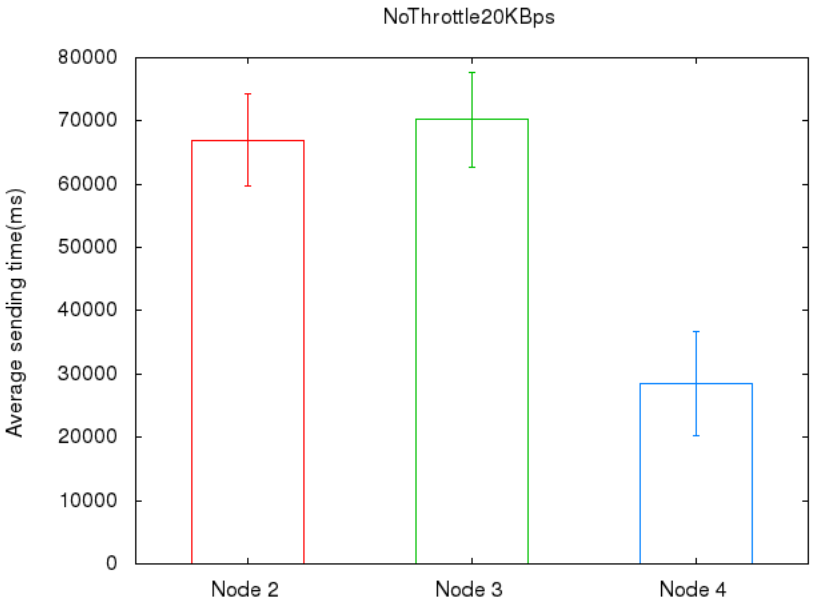


Figure 48: Time graph, no throttle mediator and bandwidth of 20kBps

As we expected without our throttle mediator, the time taken to receive messages back at the client is increased on all bandwidths where the bandwidth is below a certain threshold. Where the bandwidth is large enough, i.e. 40kBps,

the time is comparable to our other tests because the bandwidth is more than large enough.

The trend is also clear when it comes to successful messages, without our throttle mediator more messages arrive even on lower bandwidths. This is because the throttlemediator discards messages after the timeout, this statement is strengthened by the fact that if we compare no throttle to 100 000 ms timout, the latter performs better, managing to get more high priority messages successfully back, on all capacities (ignoring 1kBps and 40kBps).

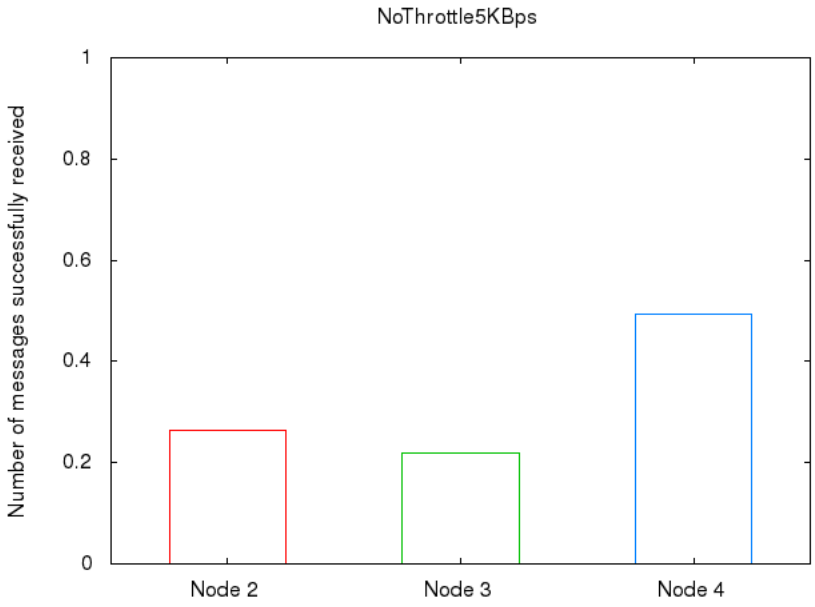


Figure 49: Time graph, no throttle mediator and bandwidth of 5kBps

In general, 1kBps was not enough to successfully get responses on requests, probably not enough for the SAML-communication or SSL handshakes either. On the other end, with more than enough bandwidth, that is 40 kBps, there are not any notable differences in any of the test cases. The more interesting statistics are found on the intermediate bandwidth capacities.

Because of lacks in the testing system, e.g. limited resources, the uncertainties regarding avarage times and responses received can be rather big. Even with this uncertainty we belive we can say something about the impact of the throttle mediator.

Checking for DiffServ: Running tests also produce "pcap"-files, these files contain network traffic data. Here we can check whether or not the diffserv field is set correctly, and it would seem it is.

8 Project Evaluation

During this last chapter before the conclusion, we will try to take a step back and look at the project. We will try to criticize were that is appropriate, and give our self a pat on the back when that is in order. We hope that after reading this, you will understand the problems we have faced and where we have gone wrong. And hopefully we can point out how we should have avoided those problems. This chapter is a summary of the process.

8.1 Task evaluation

Our task was very focused on research, and with that came a lot of freedom to choose which technologies to use, and to some degree what to actually implement. We did manage to settle on some requirements quite early, although most of them were not very strict. Even so, we felt this was not a problem and started designing, but in the later parts of the project we realized having such loose requirements might have led us to grasp over a bit much. Stricter prioritized requirements might have let us know what parts were more important than others, and we could have focused more on them. We realize we should have asked the customer for these stricter requirements on both what to use and what to implement.

Since the project was research focused from the customer side we got quite a lot of freedom when it came to the project. This freedom was not a hindrance for us, but we could have handled it better. As mentioned above the requirements we agreed on with the customer was a bit to loose, again here we should have realized that they gave us this freedom and we should have insisted on stricter requirements. When it came to testing the customer gave us the same freedom and again we should have used that freedom to write up some strict test requirements. In the end the freedom gave us all the choices, but we could have handled it better.

Overall, the task has been very interesting, and we are in general very happy with the result of it.

8.2 Team organization

The problem we had with the roles in the group, is that we did not manage to switch betweeen them during the project. This resulted in some instances where we could not proceed with something, because the one who knew the most about it was ill. This was something that we were quite wary of in the beginning of the project, but we did not follow it up with the same care. The reason behind this is partly that it was usually easier to simply ask the person in charge of that specific part, to explain what you did not understand. Another reason was that we worked together every day during the project, which probably gave us the false confidence that we would not need to share the information. The few early roadblocks that we did encounter during the start up, where we could have done something about it, were probably so small that we just carried on without thinking about it.

We feel that the flat structure we chose worked out quite nice. When we came to a big decision that one of us felt uneasy about taking full responsibility for, we talked about it in the group, and came to a mutual decision. There

are many reasons why this worked in our group, but a key enabler was the fact that we worked together Monday to Thursday. This close proximity made such decisions easy to approach, and agreement could quickly be made. If we had not had this work schedule, this sort of management might not have worked out the way it did.

We mentioned roles above, but we would also like to mention a bit about how that worked on a daily basis. Because we grew into certain roles as the project progressed, we also got some responsibilities. For instance, oneof us quickly became the main contact between the group and the supervisor, but having only one person handling that communication did not hinder use. In fact, the communication became quicker, because the supervisor could relate to one person and not everyone, and the fact that when someone in the group wanted to ask the supervisor about something, they could contact Magnus.

Luckily, we had very few conflicts in the group. There was some miscommunication which led to some disagreements, but there where very few of those. Among the few things that came up during this 15 week long project, was a miscommunication about when we were going to start working again after the Easter vacation. This little incident only lead to some stressful days, and the misunderstanding was cleared away.

As mentioned above, we tried to work together from Monday to Thursday from 10:00 to 16:00. This worked rather well during the whole project, except for some hiccups regarding the "early" start. We had some weeks where not all of us managed to get up in time, but after a meeting within the group we cleared away any bad air, and did not really experience any such hiccups after that.

8.3 Planning

In the first couple of weeks we spent a lot of time trying to understand the task and what we were supposed to do. We didn't plan the process very well. This was probably because we didn't know exactly what to plan for. What we did instead was to make daily agendas of what we should research.

After the first few weeks, we had managed to get a decent idea of what needed to be done, and so the more detailed planning began. We started by making a Gantt chart (ref:Appendix I - gantt.html) with the different work packages we needed to be complete by what dates. At this point we should have planned better and updated our gantt chart along the way. In the end we did keep most of the deadlines we set: we started implementation when intended, and we only went a week past the intended deadline for implementation (excluding some important bugfixes).

The biggest miss in the initial plan was probably that we intended to have the final report ready by April 16th, so that we could get detailed feedback on it before the final delivery. This ended up not happening because implementation required more resources than anticipated, and we prioritized the product before the report.

We also started making weekly Activity Plans (ref:J.3), instead of the daily agendas. The first two weeks of activity plans were very badly done. But after that we made more detailed and more accurate plans.

Work breakdown structures were also made. They started out somewhat inaccurate, but by the end of the design phase they had become more correct

and informative.

Time estimation on the different tasks in the activity plans were very difficult. Some tasks ended up taking more than twice or even three times as much time as anticipated, while other tasks ended up taking less than half of what was planned. But most of the time we were within 20% of the anticipated time, which we believe is pretty good. The activity plans proved to be the most useful planning tool for us. This despite the inacurracy in time estimation. The best effect of the activity plans was focus. We would look at the plan and see what the next task was. This kept us on course.

Towards the end of the project the routine of creating activity plans faltered. This was due to bug hunting and report feedback. We tried to create activity plans but they ended ut being a sort of checklist for report improvements. And while the bughunting tok priority towards the prototype meeting, updating the activity plans was forgotten.

The bughunting and code improvements after our prototype presentation has not been planned or tracked in any way. This is a very bad practize and we look back on it as a point where we have massive room for improvement.

TODO: why don't we include the "activity plans" from the weeks after easter? This shows the fact that we faltered in our routine, but managed to stay on target and complete the prototype and write the report!

8.4 Methodology

In this project we went against the current when it comes to modern software development methodology. Instead of going with the darling of the development world, SCRUM, we chose to go back and pick something that most would not. The waterfall model might not be the best fit for everyone, but for this project we think we got it right.

The first thing we knew was that most of the technologies was unfamiliar for everyone, even the customer, this meant that we had to invest a lot of time getting to know the different frameworks. Another thing was the research focus of the project, which demanded a certain investment into planning. All this lead us to the waterfall model, explained in section 5.2, which worked out quite well. We had a large planning phase, which included some head-scratching moments, but for the most part, we got through it. The implementation phase had some more problems, mostly with regards to time estimates and external dependencies. Had we gone for a more agile methodology, we might not have ended up with such a thorough design.

Although the previous paragraph does mention that we chose the waterfall model, we did not completely forget the agile world. Most of the implementation went according to a more agile development methodology, where we had weekly sprints, tried to have code reviews and used unit testing. We feel that this mixing of methodologies is some of the things we excelled at the most during this project. The waterfall model helped us with the planning and design of an unknown entity, and the agile implementation lead to cleaner and better code quality.

8.5 Meetings

When it came to meetings, we did a decent job. As mentioned before we had biweekly meetings with the supervisor, and weekly meetings with the customer over Skype. The meetings went smoothly, but we did not prepare well for most meetings which reflected in the length and content of the meetings. This often lead to having to take followup questions over email, which for the most part went well, but on some occasions we could definitely have benefited from better meeting preparation.

The distance to the customer never posed any real problems to the meetings, we never rescheduled any meetings, and even when the customer came to Trondheim, all went well. The only thing which could have caused a problem regarding distance was the problem of impromptu meetings, but the customer never said no to another meeting later in the week if we needed it, so even this did not cause a problem.

The meetings with the supervisor also went well. We had no problems scheduling meetings and the supervisor was very flexible when it came to the meetings. The meetings were often informal and the tone between us and the supervisor was good.

Other than the lack of preparation before the meetings, the meeting part of the project was good. If there is anything to draw from our experience around meetings, it is that proper preparation is worth doing.

8.6 Communication

Group communication

The communication inside the team worked well, because we were working in the same room most of the time. This contributed to the prevention of conflicts. We also had some "Team building" that helped us not get on each others nerves. Other than that we used SMS to keep in contact with each other outside of the university. This resulted in quite a good team spirit and there were no major mishaps regarding communication inside the group.

Supervisor communication

The overall communication with the supervisor has been as expected. Sometimes, it would have been nice with an answer to some of the emails about meetings. Typically we asked the supervisor for a meeting, decided time and place, and the supervisor didn't confirm the meeting time, but he showed up, so there wasn't really a problem. Other than that we had a good rapport with the supervisor and he always answered our questions. He was particularly good at helping us with the report, guiding us on how to lay it out and explaining what a good report should contain. It was very easy dealing with him as we could just send him an email or even meet him at his office.

For the most part our meetings with him went quite well, except for one little communication error which we did not present clear enough to him. In the start of the project we were not quite sure what development methodology we were going to use, and as stated earlier, we eventually went with a modified waterfall model. The supervisor recommended SCRUM and was quite supportive of that way of developing. The problem arose when we did not convey clearly to him that we had chosen waterfall, and some of the meetings ended with some confu-

sion because of this. But we took it up during a later meeting and straightened everything out.

The biweekly meetings with the supervisor worked well, and we could always count on some insight into the problems we had faced. We also received good feedback on the weekly reports, activity plans and schedules which we sent.

Customer communication
Since the customer was located in Oslo, we had quite a challenge when it came to communication. Early on, we decided together with the customer that we wanted to do weekly meetings over Skype. This worked out very well and we got lots of feedback over Skype. The customer did not mind us sending a lot of emails either, meaning that a lot of communication went over email, which worked out very well. We got feedback when we needed it and we resolved problems either over email or, if the subject needed some discussion, at the weekly meeting. The customer also gave us very good feedback on the report which indicated their level of commitment.

In addition to all this they also made several trips to Trondheim where we would have face to face meetings. This worked quite well, but we did not always prepare the way we should or could, and some of the meetings were quite short for a trip from Oslo to Trondheim. But this level of commitment from the customer really impressed us, and we are quite grateful that they gave us this opportunity.

8.7 Design phase

Since the project contained such a large design phase it is only natural that we elaborate on what that phase entailed.

We started the design phase with a vague idea about what we were going to create. With the help of the customer we got a little further and soon we were going strong. Because of the nature of the project we did not have a clear starting point. So in the beginning we followed every hint that the customer gave us and tried to use every framework that the customer said could help. This gave us a lot to do because we had to get familiar with a lot of frameworks and asses their usefulness for the project. We then came up with the design which you can see in the prestudy section 3.1 and 3.2 which we used as a spring board into the actual design.

After this initial design we first checked with the customer that the design was something like what they had in mind and then went forward with our design to come up with a more final version. Since we had gotten a little more confidence in the design we started putting more effort into the different frameworks that we wanted to use and developing a better image of what we could create.

The design phase went quite well, and the only real problem we had were problems related to unfamiliarity with the frameworks we decided to use. These problems subsided over time as our familiarity grew.

Most of what we decided during the design phase were possible, but some things were out of our reach. Among other things the design of the testing suite had to be scaled back quite a bit, but everything that we had to alter during

implementation were thoroughly discussed with the customer so that they had a saying in every alteration.

The design phase overall were quite helpful and since we initially had no idea about how the final design would look the large design phase really helped. We learned a lot during those weeks and we have a new understanding of what is required during design for a large scale project such as this.

8.8 Implementation phase

Because of all the research needed for this project we planned to start the development phase relatively late in the project. And we did manage to start it at the planned time.

On the server side of the project we quickly saw that most of the implementation would take less time than originally anticipated. That way we could start looking at the test suite earlier as well. However on the client side things went a little slower, so we put in more work hours to complete it in time.

Work on the Identity Server and OpenSAML did not go as planned. The IS was very badly documented, and alot of work hours was put into something that in the end was dropped. OpenSAML was used at some point, but was dropped towards the end because it was too slow to use in the client library. To replace the IS we ended up with a work around which can be used in testing, but should be replaced in a proper system. The IS' is mainly used for enforcement of security, which the customer said is not very important for this project. The work around was accepted by the customer and should not be a problem.

We ended up using a bit more resources than planned on the implementation, resulting in work on the final report mostly being pushed back to after the implementation. But we did manage to finish the implementation on time, with only some bug fixes and the work around done after our internal deadline.

If we had more time we would probably be able to implement some more functionality, especially on the ESB. But in the end we managed to implement the most important parts and get some positive results.

8.9 Overall Summary

All in all the project has been very interesting. We have had some great experiences and we are left with a much better understanding of what it takes to create a complex system of interacting parts.

We have learned a lot about staying in contact with a customer and have a new understanding of what it takes to communicate with an outside entity which may or may not have the same idea as you. For this project the customer was very helpful in every way, but we also understood the importance of an open dialog where nothing is hidden.

During early development we took activity plans quite lightly which is something that we realized later that we should not. The importance of clear prioritizes and things to do became quite obvious to us. We also fumbled a bit at the end with activity plans which could account for our slow progress at the end.

We had few problems within the group, but we quickly understood the importance of clear communication which is something that we definitely could get better next time.

We have also learned that using libraries and frameworks that other people have made can be both a blessing and a curse. As we have documented there has at least been two occasions where we had to abandon frameworks and libraries which were not well documented and also opposed to large of a performance impact. For future works consulting with more experienced persons would be very beneficial and should that not work at least have an understanding with the customer that this could become a problem later.

9 Conclusion

This section concludes our work on this project and gives a summary of our accomplishments and results. It also gives an overview of the future work of the prototype that we created.

9.1 Project accomplishments

The problem we set out to investigate was whether or not prioritization on the application level of the OSI model could be beneficial in networks with low bandwidth. We extended an ESB to accommodate changes necessary for prioritization on the server side and crated a custom client library to go with it.

What our results show is that prioritization on the application level is very viable. In our tests we show that there is a lot of improvement that can be made utilizing the network with just high priority messages instead of flooding it. Our results also indicates that having such a layer does not have to big of an performance impact.

Because of some drawbacks of our implementation we can't conclude with anything to definite, but as an approach to better utilize available network resources in a constricted bandwidth scenario have the application layer help could mean a great deal.

Going forward there are some things that could indeed be improved, but what we have done is shown that having prioritization on the application level could make a large difference.

9.2 Future Work

In this section we will discuss what can be worked on, and further improved in the future. Some things we did not have time to do, as well as some improvements we might have wanted, and some things that we knew would have to be made or modified later.

9.2.1 Server

In our MS Mediator, we use a dummy implementation of the MS Communicator, which just reads an XML-file with the needed data. Making an implementation that actually contacts a Monitoring Service, and use this in the mediator, is something that should be implemented in the future.

The throttling done in the ESB is relatively static, one configuration will work very well for some scenarios, but might not work as well for other ones. In the future, making it more dynamic might be desirable. The "Timeout" used in the ESB could be made dynamic by monitoring how long messages

needs to send to each endpoint and then varying the timeout after this. The message size should also be monitored so it could be used to decide when to preempt. Another thing to do might be to make and use a new implementation of the Message Processor instead of the built in SamplingMessageProcessor, retrieving a messages from the Prioritized Message Store dynamically instead of just once every predefined interval milliseconds could get you a long way. Also the Throttle mediator could be made more dynamic, for example by varying the now static variables based on perceived network load. The preempting can also be improved greatly by taking into account how long a message has been sent and which priority it has gotten.

If proper SAML authentication is implemented the IdentityServer proxys sequence would have to be modified as well.

9.2.2 Client

As mentioned in the changes-section (6.3), the components related to authentication on the client side were not implemented as desired due to the problems with the Identity Server. Naturally, this is an issue that should be adressed when a proper IS is present.

The use of HTTPS, which is a result of our wish to use the Identity Server, could also be made more modular. During our testing we did experience some problems with SSL handshaking having timeouts. This should not be big problems as that would almost guarantee that our messages during testing would also timeout.

Other then that there is little unfinished tasks in the client library. Althought there could always be better and more unit tests.

A Client User Guide

A.1 Intro

This is the user manual for the QoS client library. Here we will cover how to use the client library to communicate with our server implementation, in a way that properly set the diffserv value on the packages sent from the client to the server. This manual is intended to be as simplistic and understandable as possible.

First we will cover the steps one needs to take in order to be able to use our library. Then move on to the easiest way to use it, as well as how to use it with a listener pattern. This will be followed by a section covering the available settings in the library, and finally we will bring up some caveats of our implementation that is worth keeping in mind.

A.2 Required interfaces

One of the most important parts of all network communication is being able to catch and handle exceptions gracefully. In order for a client, the user of our library, to be notified of exceptions that occur they will have to implement the ExceptionHandler interface found in no.ntnu.qos.client.ExceptionHandler. This interface contains several methods, which are:

Listing 3: ExceptionHandler interface

```
1  /**
2   * URI is malformed/invalid
3   * @param e UnknownHostException
4   */
5  public void unknownHostExceptionThrown(UnknownHostException
       e);
6  /**
7   * Problem reading variables, input, streams or strings
8   * @param e IOException
9   */
10 public void ioExceptionThrown(IOException e);
11 /**
12  * Problem with the HTTP connection in the form of timeouts,
        too many retries, etc.
13  * @param e org.apache.httpcomponent.HttpException, cast to
       generic Exception for convenience.
14  */
15 public void httpExceptionThrown(Exception e);
16 /**
17  * Problems with the socket, invalid SSL port or socket
       closed from service due to capacity problems.
18  * @param e SocketException
19  */
20 public void socketExceptionThrown(SocketException e);
21 /**
22  * Input message is invalid or malformed.
23  * @param e UnsupportedEncodingException
24  */
25 public void unsupportedEncodingExceptionThrown(
       UnsupportedEncodingException e);
```

The most important of these is the IOException method. This is the exception that will be thrown (As a straightforward IOException, or as a subclass of it called NoHttpResponseException) whenever the connection is closed without receiving the full reply from the server. In addition to the normal occurrences of this exception it will also happen whenever the server decides to cut a connection for priority reasons.

It is worth noting that whenever an exception is thrown for a specific request, the response for that request is set to the name of the exception, so as to enable the client to find out which request has been terminated by an exception.

A.3 Using the library

Once you've implemented the ExceptionHandler interface the client library can be easily constructed using:

Listing 4: Constructing the library

```
1 QoSClient client = New QoSClientImpl(String username, String
      userrole, String password, ExceptionHandler this);
```

Once you have a valid instance of QoSClient sending any data will be as simple as:

Listing 5: Sending data

```
1 ReceiveObject replyObject = client.send(String soap, URI
      destination);
2 String reply = replyObject.receive();
```

The string you send has to be a valid SOAP message. The SOAP message has to contain a valid envelope with a body element, more on this in the caveats section.

The ReceiveObject you get back from the send method is a blocking string, which means that calling receive on it will block execution until a reply is available.

A.4 Using the library with listeners

After constructing the library as shown above, you are able to add listeners to it using:

Listing 6: Add listener

```
1     client.addListener(DataListener listener);
```

And remove them again using:

Listing 7: Remove listener

```
1     client.removeListener(DataListener listener);
```

The DataListener referenced here is the interface DataListener in the qos client library, it requires that you implement a single method:

Listing 8: The DataListener interface

```
1 /**
2  * Default receive method
3  * @param recObj SOAP data
4  */
5 public void newData(ReceiveObject recObj);
```

Which will be called whenever a ReceiveObject gets some reply data.

A.5 Change Credentials

If you for some reason wish to change the user credentials during execution, this can easily be done by calling:

Listing 9: Changing user credentials

```
1     client.setCredentials(String username, String role,
          String password);
```

A.6 Logging

The client library supports logging both to file and console, by default it only logs to console, and only warnings and above. To set whether to log to console you can call:

Listing 10: Turn logging to console on or off

```
1    client.setLogToConsole(boolean on);
```

To set logging to file:

Listing 11: Turn logging to file on or off

```
1    client.setLogToFile(boolean on);
```

To change the level of the logging between warning and above, or everything:

Listing 12: Switch between the two logging scopes

```
1    client.setFineLogging(boolean on);
```

A.7 Caveats

A.7.1 URI from client

It is assumed by the client library that the port of the URI is a valid SSL port that is capable of communicating using TLS. It does however nothing to validate the authority of the servers certificate and will accept any certificate.

A.7.2 SOAP from client

The client library requires that this is a valid SOAP envelope, with an element with the local name of "Body" one level inside the envelope. Note that all XML is case sensitive.

A.7.3 User credentials

User credentials are not checked for validity (beyond very basic sanity checking) until the library attempts to get a token.

For our implementation of the client server set, this doesn't matter much since no credential validation is ever done, but it might matter if the client library is extended to interact with an actual identity server. If this is done, both the SAML communicator as well as the SAML parser should be reimplemented.

A.7.4 Redundant token fetching

If two or more requests are sent to the same service-set at the same time and the token has not already been fetched for that service-set there is a high probability that the token will be fetched over the network several times before being stored in the credential storage. Meaning you will waste network bandwidth getting the same information several times.

A.8 Example code

A simple client that will send a soap containing "Hello World" to the service at "https://localhost:443/service/myService" and retry 4 times

Listing 13: A simple example client

```
1  public class ExampleClient implements ExceptionHandler {
2     final static int retry = 4;
3     public static void main(String[] args) {
4         URI destination = new URI("https://localhost:443/
              services/myService");
5         QoSClient client = new QoSClient("John", "Anon", "
              DoeIsMe", this);
6         String soap = "<?xml version=\"1.0\" ?><S:Envelope
              xmlns:S=\"http://schemas.xmlsoap.org/soap/envelope
              /\">" +
7                 "<S:Body>Hello World</S:Body></S:Envelope>";
8         ReceiveObject recObj = null;
9         int send = 0;
10        do{
11            recObj = client.send(soap, destination);
12            send++;
13        } while (recObj.receive().endsWith("Exception") &&
              send<=retry);
14        System.out.println(recObj.receive());
15    }
16
17    @Override
18    public void unknownHostExceptionThrown(
          UnknownHostException e) {
19        //Do nothing
20    }
21    @Override
22    public void ioExceptionThrown(IOException e) {
23        //Do nothing
24    }
25    @Override
26    public void httpExceptionThrown(Exception e) {
27        //Do nothing
28    }
29    @Override
30    public void socketExceptionThrown(SocketException e) {
31        //Do nothing
32    }
33    @Override
34    public void unsupportedEncodingExceptionThrown(
35            UnsupportedEncodingException e) {
36        //Do nothing
37    }
38 }
```

B Server Setup Guide

We have altered some source code which our project is dependent upon. That is why it is quite important that anyone wanting to use our setup follow

the steps below. Our ESB mediators will not work unless this is done properly.

First we have to download the ESB from wso2.org, and extract it, for this project we used version 4.0.3 found here: http://wso2.org/products/download/esb/java/4.0.3/wso2esb-4.0.3.zip

This version of the ESB uses httpcore-nio version 4.1.3, which does not support setting DiffServ in the IP header. To fix this we have to download its source code and make some modifications to it.

Now we need to retrieve the source of HTTPCore, this can be done by pasting the command in Listing:14 into a bash prompt. This will download the source compatible with WSO2 into a folder named "hc", this may take some time depending on your Internet connection.

Listing 14: Checkout HttpCore source

```
1 $ svn checkout http://svn.apache.org/repos/asf/
    httpcomponents/httpcore/tags/4.1.3/ hc
```

After the download has finished we have a working directory, of the version of HTTPCore which WSO2 ESB uses, and it is now time to apply our patch to enable support for traffic class. The instruction in Listing:15 describes how. Here "hc.diff" is a file containing our changes which svn can use to alter the working directory. The file "hc.diff" can be found in appendix I.

Listing 15: Apply HC patch

```
1 $ cd hc/
2 $ patch -p0 -i /path/to/hc.diff
```

Since we have now applied our patch we just need to compile HTTPCore, to do this we just copy-paste the commands from Listing:16 and let it compile.

Listing 16: Build HttpCore-NIO

```
1 $ cd hc/httpcore-nio/
2 $ mvn clean install
```

When the building is complete we can add the relevant jar, "hc/httpcore-nio/target/httpcore-nio-4.1.3.jar" to the WSO2 ESB. For the ESB to recognize it correctly it must have the correct name, and it must also have the correct data in the META-INF folder inside the jar. To fix this we follow the steps in Listing:17.

Listing 17: Create WSO2 compatible jars

```
1 $ cd /path/to/wso2esb/repository/components/plugins/
2 $ mkdir backup
3 $ cp httpcore-nio-4.1.3.wso2v2.jar backup/httpcore-nio
    -4.1.3.wso2v2.jar
4 $ mkdir build
5 $ cp /path/to/hc/httpcore-nio/target/httpcore-nio-4.1.3.jar
    build/httpcore-nio-4.1.3.jar
6 $ cp httpcore-nio-4.1.3.wso2v2.jar build/httpcore-nio-4.1.3.
    wso2v2.jar
```

```
$ cd build
$ unzip httpcore-nio-4.1.3.wso2v2.jar
$ zip -r httpcore-nio-4.1.3.jar META-INF
$ cd ..
$ cp build/httpcore-nio-4.1.3.jar httpcore-nio-4.1.3.wso2v2.
    jar
```

Java 1.6 only support setting DiffServ on IPv4, so to make Java actually set the DiffServ header we must set IPv4 as the preferred IP stack. This is done by adding the command line option -Djava.net.preferIPv4Stack=true when starting the Java program. This should be done with all clients as well as ESB. The ESB is usually started by running /path/to/wso2esb/bin/wso2server.sh, so we edit this file adding the line containing "-Djava.net.preferIPv4Stack=true" in Listing:18.

Listing 18: Changes made to wso2server.sh

```
while [ "$status" = "$START_EXIT_STATUS" ]
do
    $JAVACMD \
    -Xbootclasspath/a:"$CARBON_XBOOTCLASSPATH" \
    -Xms256m -Xmx512m -XX:MaxPermSize=256m \
    $JAVA_OPTS \
    -Dimpl.prefix=Carbon \
    -Dcom.sun.management.jmxremote \
    -classpath "$CARBON_CLASSPATH" \
    -Djava.endorsed.dirs="$JAVA_ENDORSED_DIRS" \
    -Djava.io.tmpdir="$CARBON_HOME/tmp" \
    -Djava.net.preferIPv4Stack=true \
    -Dwso2.server.standalone=true \
    -Dcarbon.registry.root=/ \
    -Dcarbon.xbootclasspath="$CARBON_XBOOTCLASSPATH" \
    -Djava.command="$JAVACMD" \
    -Dcarbon.home="$CARBON_HOME" \
    -Dwso2.transports.xml="$CARBON_HOME/repository/conf/mgt-
        transports.xml" \
    -Djava.util.logging.config.file="$CARBON_HOME/lib/log4j.
        properties" \
    -Dcarbon.config.dir.path="$CARBON_HOME/repository/conf"
        \
    -Dcomponents.repo="$CARBON_HOME/repository/components/
        plugins" \
    -Dcom.atomikos.icatch.file="$CARBON_HOME/lib/
        transactions.properties" \
    -Dcom.atomikos.icatch.hide_init_file_path=true \
    -Dorg.apache.jasper.runtime.BodyContentImpl.LIMIT_BUFFER
        =true \
    -Dcom.sun.jndi.ldap.connect.pool.authentication=simple
        \
    -Dcom.sun.jndi.ldap.connect.pool.timeout=3000  \
    org.wso2.carbon.bootstrap.Bootstrap $*

    status=$?
done
```

Now that the ESB is set up, and supporting DiffServ, we can add our own components to it. The first thing to add is a jar-file containing all the custom mediators and the custom message store. Copy the file "no.ntnu.qos.jar" found in appendix I to the folder /path/to/wso2esb/repository/components/lib/.

Next we add a base configuration for the ESB to use, extract "synapse-configs.zip" found in I into /path/to/wso2esb/repository/deployment/server/synapse-configs/. This configuration contains setup of mediator sequences to be used, and a simple sample service endpoint/proxy configuration.

Finally, before starting the ESB, we should add the template xml-files found in "mediator-configuration.zip" in appendix I to the folder /path/to/wso2esb/.

The ESB should now be ready and can be started by running the script:

```
1 $ ./path/to/wso2esb/bin/wso2server.sh
```

C MobiEmu Setup Guide

In this appendix we will show how to setup the MobiEmu framework to make it ready to run the tests from Chapter 7.

We will start by downloading NS3 which is required in order to run our tests. Just download NS3 from http://www.nsnam.org/release/ns-allinone-3.13.tar.bz2 in order to get the same version as we used and then follow the instructions at http://www.nsnam.org/docs/release/3.13/tutorial/html/getting-started.html#building-ns-3 in order to build and let NS3 configure itself.

Since this framework is quite nice and packages up everything before a system test all we need to do is unpack one of our run folders and we should be good to go. We have included a compressed folder which contains five compressed folders where each of these contains a test which we need to unpack in order to run.

After you have unpacked one of these tests we only have to add the ESB and GlassFish to be able to run the tests.

We will assume that you have unpacked one of our tests and created a folder named "system-test" which contains the whole experiment.

In order to do the next part you will need to have set up the ESB with our changes, if you have not done so, please see appendix B

Listing 19: Copy ESB and GlassFish into System test

```
1 $ cd /path/to/system-test/experiments/esb/
2 $ cp /path/to/esb/bin/ bin
3 $ cp /path/to/esb/dbscripts/ dbscripts
4 $ cp /path/to/esb/lib/ lib
5 $ cp /path/to/esb/repository/ repository
6 $ cp /path/to/esb/samples/ samples
7 $ cp /path/to/esb/tmp/ tmp
8
```

```
$ cd ..
$ cp /path/to/glassfish/ glassfish
```

Now we just have to add the testing client.

Listing 20: Adding the test client

```
$ cd /path/to/system-test/experiments/
$ mkdir EchoClient
$ cp /path/to/EchoClientClient.jar EchoClient/
```

Now we need to copy the file "synapse.xml" into the correct folder and we should be good to go. Copy the "synapse.xml" file from the folder you unpacked into "/path/to/system-test/experiments/esb/repository/deployment/server/synapse-configs/default/". This will ensure that the ESB is configured correctly with the same timeout as we have run with.

You may also need to change the path in "system-test-2.py" please have a look at 23 and change it to reflect your setup.

The last thing we need to do is edit the settings file and ensure that the "[ns3]" section points to the right path. In listing 22 we have included our setting file, which is configured the way we set things up. Edit the path under "[ns3]" to point to the path to NS3.

Now the setup should be completed and it should now be possible to run the framework. In order to do so run:

Listing 21: Run MobiEmu

```
$ cd /path/to/system-test
$ sudo su
# ./run.py run
```

You will now be running one of our system tests!

The rest of this appendix will explain the different variables and testing files that we use in our setup, it is not necessary to read this section if you only want to verify our tests.

Below is the full settings files for all of our system test, the comments within it is from the MobiEmu creator, but we will try to explain them all and highlight the ones which has a real effect on our tests.

Listing 22: Setting.cfg

```
#
# This configuration file contains the parameters for the
    experiments run by run.py.
#
# When an experiment starts, scripts are executed in the
    following order (for each repetition):
#
# 1. Scripts specified in config.init_scripts are executed
# 2. Virtual network devices are created
# 3. ns-3 is started
# 4. One lxc-container is started for each node in the
    experiment
```

```
10 # 2. In lxc: Any modules specified in the experiment are executed in parallell
11 # 3. In lxc: Wait for config.initial_wait
12 # 5. In lxc: Start experiment script
13 # 6. In lxc: Wait for config.experiment_wait
14 # 7. In lxc: Wait for config.shutdown_wait / 2. If the experiment is still running, attempt to kill it.
15 # 8. In lxc: Stop all modules
16 #
17 # This is repeated for every repetition of the experiment. Note that multiple experiments may be executed
18 # by separating them by a "," in the configuration.
19 #
20 # When run.py is run without parameters it attempts to estimate the total time it will take to execute
21 # the current configuration.
22 #
23 # Modules and experiment-scripts are passed all parameters in their configuration and in the general-section as environment variables.
24 # Topology scripts (ns-3 simulation scripts) are passed all configuration parameters as parameters to the script. E.g. --total_nodes=xxx
25 #
26 # Output is logged to core.log and node*.log
27
28 [general]
29 # total nodes in the experiment
30 total_nodes=4
31
32 # intial random seed
33 initial_random_seed=31
34
35 #list of experiments to run. Each experiment must match a config section
36 experiments=enoughBandwidth
37
38 # Number of times to repeat each configuration of the experiment
39 repetitions=10
40
41 # Time to run the experiment (in seconds)
42 experiment_duration=600
43
44 # Time to wait initially before starting the experiment, e.g. for routing protocols to converge and modules to start.
45 initial_wait=10
46
47 # Time to wait after the experiment before shutting down the emulator
48 shutdown_wait=30
49
50 # Config for ns3 script, used to generate the topology and connect to the virtual devices. The name must match a
```

```
    config section.
topology=system-test-2

# Process priorities for experiment and simulator scripts.
simulator_niceness=-20
experiment_niceness=19

# Enable or disable debug messages. This will also output
    all commands executed by run.py
show_debug_messages=False

# Set to True if the lxc-containers use chroot
use_chroot=False

# Script to call before starting. This script is executed
    before the modules.
init_scripts=set_long_queues.sh

[directories]
main=.
# where to store experiments when they are done
results=%(main)s/results

# where to store output from experiments while the
    experiment is running
dumps=%(main)s/dumps

# if general.use_chroot is true, this directory will be
    bound to MobiEmu within the lxc-container, relative
# to chroot_rootpoints
chroot_bindpoint=/mobiemu

# List of chroot root mountpoints, may have wildcards.
chroot_rootpoints=../../chroot/node?,../../chroot/node??

# lxc working directory when using chroot. This is also
    where all output will be stored. It should be
# set to an empty directory relative to the chroot
    environment. These directories should also be included
# in the [results_archiver]-section, so that they are
    archived after each experiment.

chroot_working_dir=%(chroot_bindpoint)s/dumps/

# Path to module scripts (must be available within the lxc
    container)
modules=%(main)s/modules

# Path to experiment scripts (must be available within the
    lxc container)
experiments=%(main)s/experiments

# Path to topology scripts
topologies=%(main)s/topologies
```

```
95
96  # Path to configuration file templates
97  configs=%(main)s/configs
98
99  [ns3]
100 # Path to ns-3
101 path=../../ns-allinone-3.13/ns-3.13/
102
103 [source_archiver]
104 # Before each simulation all files and directories listed
        here will be archived and put together with the results
105 include=settings.cfg run.py modules experiments topologies
        configs
106 exclude=
107
108 [results_archiver]
109 # Moves the results from the given directory and stores them
         in the directory specified in directories.results
110 include=dumps/*
111
112 [system-test-2]
113 # System-test-2 see report chapter 8 section 3 under Three
        clients message sending
114 #
115 # Parameters specified here are passed to the script. In
        addition, the special parameters
116 # --nodes, --seed and --duration, are set to the number of
        nodes, the current random seed
117 # and the experiment duration, respectively.
118 # When specifying multiple values separated by a "," the
        experiment will be repeated
119 # an extra time for each value.
120 dataRate=1KBps,5KBps,10KBps,20KBps,40KBps
121 #MTU needs to be defined
122 mtu=2304
123 # The ns-3 script. Must be in directories.topolgies.
124 script=system_test_2.cc
125
126 [enoughBandwidth]
127 #Load modules within lxc prior to loading ns3, but before
        starting experiment. The modules
128 #may have a configuration section with additional parameters
         which are passed to the module as
129 #environment variables.
130 #modules=manualrouting.py,manualarp.py,tcpdump.sh
131 modules=monitoring_service.py,manualarp.py,tcpdump.sh
132 #modules=tcpdump.sh
133
134 #experiment script to run within lxc. Automatically
        terminated (SIGTERM is sent) after
135 #%(experiment_duration + shutdown_wait/2)
136 experiment=system_test_2.py
137
138 [tcpdump.sh]
```

```
# shell environment variables can be used in filter
filter=
device=eth0

[manualarp.py]
arp_mac=00:16:3e:00:01:%0.2X
arp_ip=10.0.0.%s

[ipv4_multicast_route.sh]
device=eth0
[manualrouting.py]
[monitoring_service.py]
```

The most important variables and their meaning is described below.

- total_nodes=4 - This is the total number of nodes in the testing, this variable is passed to NS3 so it can use it and setup the right amount of nodes. Since we don't have dynamic tests this should be coordinated with the NS3 topology.
- initial_random_seed=31 - This seed is passed to all scripts which use random variables. In our testing we have no random variables so this should not be of great importance.
- repetitions=10 - The number of repetitions for each test. In our setup this means 10 repetitions for each bandwidth.
- experiment_duration=600 - Total duration for the experiment, this must be coordinated with the "system-test-2.py" file you can see in Listing:23.
- dataRate=1KBps,5KBps,10KBps,20KBps,40KBps - These are the different datarates that the experiment is run with. Each of these will be repeated "repetition" number of times.
- experiment=system_test_2.py - This is the experiment in "experiments" to run, please see Listing:23 for more information.

Next we will take a look at our testing file. This file is what starts the ESB, GlassFish and each of the clients. It is run inside its own LXC and as such needs to check which node it is so as to start the right application.

Listing 23: System-test-2.py

```
#!/usr/bin/env python

from os import getenv
from subprocess import Popen
from time import sleep

node_id = int(getenv('node_id'))
path = '/home/qos/server/mobiemu/system-test-2/experiments/'
gfSleep = 60
wso2Sleep = 190
experimentSleep = 320

```

```
13 if node_id == 1:
14     #This is the ESB/GlashFish node
15     #Start GlashFish:
16     print 'Starting GlashFish'
17     gf = Popen(['{0}glassfish/bin/./startserv'.format(path)])
18     #Wait for glassfish to start
19     sleep(gfSleep)
20     #Start ESB
21     print 'Starting WSO2'
22     wso2 = Popen(['{0}esb/bin/./wso2server.sh'.format(path)])
23     #Need to sleep to wait for experiment to finish
24     sleep(wso2Sleep + experimentSleep)
25     print 'Done with experiment, terminating GlashFish and
           WSO2'
26     wso2.kill()
27     gf.terminate()
28 elif node_id == 2 or node_id == 3 or node_id == 4:
29     #This is the client node
30     #Need to wait for GF and WSO2 to start
31     print 'Starting node 3, EchoClientClient'
32     sleep(gfSleep + wso2Sleep)
33     echo = Popen(['java', '-Djava.net.preferIPv4Stack=true',
           '-jar', '{0}EchoClient/EchoClientClient.jar'.format(
           path), '{0}client_{1}.config'.format(path, node_id -
           1)])
34     sleep(experimentSleep)
35     #Check if echo has terminated,
36     #poll() returns None if it hasn't terminated
37     echo.poll()
38     if not echo.returncode:
39         #Client has most likely crashed at this point
40         #as such we need to kill it, softly with this song...
41         echo.terminate()
```

There should really be nothing to special about this file. It first starts up GlassFish and then the ESB, each client sleeps until the ESB has started and then they start sending their messages.

- path = '/home/qos/server/mobiemu/system-test-2/experiments/' - This will need to be changed to reflect where it is run from, this has to be this way because it is run with root and it needs an absolute path.

The last file we will look at is the topology file, this defines the topology in NS3 and creates Tap-Bridges which we connect the LXCs to.

Listing 24: System-test-2 Topology

```
1 /* -*- Mode:C++; c-file-style:"gnu"; indent-tabs-mode:nil;
      -*- */
2 /*
3 * This program is free software; you can redistribute it and
      /or modify
4 * it under the terms of the GNU General Public License
      version 2 as
5 * published by the Free Software Foundation;
```

```
6  *
7  * This program is distributed in the hope that it will be
       useful,
8  * but WITHOUT ANY WARRANTY; without even the implied
       warranty of
9  * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See
       the
10 * GNU General Public License for more details.
11 *
12 * You should have received a copy of the GNU General Public
       License
13 * along with this program; if not, write to the Free
       Software
14 * Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA
       02111-1307  USA
15 */
16
17 // Network topology
18 // //
19 // //             ESB      Client Client   Client
20 // //              |         |       |       |
21 // //              ============================
22 // //                           LAN
23 // //
24
25
26 #include <iostream>
27 #include <fstream>
28
29 #include "ns3/core-module.h"
30 #include "ns3/csma-module.h"
31 #include "ns3/point-to-point-module.h"
32 #include "ns3/internet-module.h"
33 #include "ns3/ipv4-address-helper.h"
34 #include "ns3/stats-module.h"
35 #include "ns3/tap-bridge-helper.h"
36 #include "ns3/ipv4-global-routing-helper.h"
37
38 using namespace ns3;
39 using std::stringstream;
40 using std::string;
41
42 NS_LOG_COMPONENT_DEFINE ("QoS System test 1");
43
44 void printTime(int interval)
45 {
46     Ptr<RealtimeSimulatorImpl> impl = DynamicCast<
          RealtimeSimulatorImpl>(Simulator::GetImplementation
          ());
47     Time real_time = impl->RealtimeNow();
48
49     Time sim_time = Simulator::Now();
50
51     std::cout << "drift:" << real_time.GetMilliSeconds() <<
```

```
        ":" << sim_time.GetMilliSeconds() << ":" << (
        real_time.GetMilliSeconds() - sim_time.
        GetMilliSeconds()) << std::endl;
52      Simulator::Schedule(Seconds(interval), &printTime,
        interval);
53  }
54
55  int main (int argc, char *argv[])
56  {
57      CommandLine cmd;
58      uint32_t run_time= 200, seed = 1, n = 3, mtu = 0;
59      string runID;
60      string dataRate;
61      cmd.AddValue ("duration", "Duration of simulation",
        run_time);
62      cmd.AddValue ("seed", "Seed for the Random generator",
        seed);
63      cmd.AddValue ("runID", "Identity of this run", runID);
64      cmd.AddValue("datarate", "Data rate for LAN", dataRate);
65      cmd.AddValue("nodes", "Not used in this test", n);
66      cmd.AddValue("mtu", "MTU used for TapBridges", mtu);
67
68      cmd.Parse(argc, argv);
69
70      stringstream s;
71      s << "Duration: " << run_time << ", Seed: " << seed << "
        , runID: " << runID << ", DataRate: " << dataRate;
72      std::cout << s.str() << std::endl;
73
74      SeedManager::SetSeed (seed);
75      GlobalValue::Bind ("SimulatorImplementationType",
        StringValue ("ns3::RealtimeSimulatorImpl"));
76      GlobalValue::Bind ("ChecksumEnabled", BooleanValue (true
        ));
77
78      NodeContainer nodes;
79      nodes.Create(4);
80
81      CsmaHelper csma;
82      csma.SetChannelAttribute ("DataRate", StringValue (
        dataRate));
83
84      NetDeviceContainer csmaDevices;
85      csmaDevices = csma.Install (nodes);
86
87      TapBridgeHelper tapBridge;
88      tapBridge.SetAttribute ("Mode", StringValue ("UseLocal")
        );
89      tapBridge.SetAttribute ("Mtu", UintegerValue(mtu));
90
91      //Tap bridge setup for ESB
92      std::cout << "Adding tap bridge: tap-1\n";
93      tapBridge.SetAttribute ("DeviceName", StringValue ("tap
        -1"));
```

```
94      tapBridge.Install (nodes.Get(0), csmaDevices.Get(0));
95
96      //Tap bridge setup for client 1
97      std::cout << "Adding tap bridge: tap-2\n";
98      tapBridge.SetAttribute ("DeviceName", StringValue ("tap
            -2"));
99      tapBridge.Install (nodes.Get(1), csmaDevices.Get(1));
100
101     //Tap bridge setup for client 2
102     std::cout << "Adding tap bridge: tap-3\n";
103     tapBridge.SetAttribute ("DeviceName", StringValue ("tap
            -3"));
104     tapBridge.Install (nodes.Get(2), csmaDevices.Get(2));
105
106     //Tap bridge setup for client 3
107     std::cout << "Adding tap bridge: tap-4\n";
108     tapBridge.SetAttribute ("DeviceName", StringValue ("tap
            -4"));
109     tapBridge.Install (nodes.Get(3), csmaDevices.Get(3));
110
111
112
113     std::cout << "Starting simulation. Will run for " <<
            run_time << " seconds...\n";
114     Simulator::Schedule(Seconds(0), &printTime, 1);
115     Simulator::Stop (Seconds (run_time));
116
117     Simulator::Run();
118
119     Simulator::Destroy ();
120
121     std::cout << "Done.\n";
122 }
```

There should be very little which we could explain here, as NS3 in itself is quite complex. Therefore we refer you to the NS3[43] documentation if you would like to extend the topology.

D Result Parsing

In this apendix we will describe how to use the scripts provided to parse the results we get from testing with MobiEmu.

If tests are run with different bandwidth capacities we can use the script GroupResults.py like this:

```
1 $ python2 GroupResults.py /path/to/results/ /path/to/where/
    you/want/results/grouped/
```

This script will move the results from the first folder to the second, and group them in subfolders with the name of their bandwidth capacities. When choosing

[43] Documentation for NS3 http://www.nsnam.org/docs/release/3.13/tutorial/singlehtml/index.html

a folder to move them to we recommend choosing a subfolder of a general results folder, this way you can use the script parseall.sh like this:

```
$ ./parseall.sh "-m -t -p -g" /path/to/folder/containing/the
    /folder/you/moved/results/to/ "2 3 4" > AllResults.txt
```

Here the first argument "-m -t -p -g" is the optional arguments used for ParseResults.py. If '-g' is present it must be the last argument here. All graphs will be named after the folder names of where the results are, at the end the graphs are moved to the folder "graphs" in the script folder. The last argument "2 3 4" are the nodes to parse output from. "¿ AllResults.txt" is used to store the output in a file.

ParseResults works by entering a folder and looping over all the files at the bottom of that folder structure. It expects that the folder contains only similar runs, e.g. runs with speed 10KBps and timeout of 500ms. It then retrieves all the log files from each of the nodes from the commandline. It then calculates the average time taken with standard deviation and the number of successful messages received back at the client. It then outputs this information and can optionally create graphs of this information.

ParseResults can be run seperatly from the scripts mentioned above by running

```
$ python2 ParseResults.py -t -m -p -g nameOfGraph /path/to/
    folder/ 2 3 4
```

Here "-t" means calculate average time, "-m" means calculate successful messages, "-p" print result to console, "-g" followed by nameOfGraph means we want graphs, and "2 3 4" are the nodes to extract results from. Should you need any help the "-h" option alone should be quite helpful.

E Raw Results

E.1 500ms

———-10KBps,———
Percentage of messages received for node2.log : 0.326
Percentage of messages received for node3.log : 0.322
Percentage of messages received for node4.log : 0.54
Average time for received messages(in ms) for node2.log : 100905 deviation: 3699 (3%)
Average time for received messages(in ms) for node3.log : 105443 deviation: 3140 (2%)
Average time for received messages(in ms) for node4.log : 11510 deviation: 7046 (61%)

———-1KBps,———
Percentage of messages received for node2.log : 0.001
Percentage of messages received for node3.log : 0.002
Percentage of messages received for node4.log : 0.0
Average time for received messages(in ms) for node2.log : 276284 deviation: 0 (0%)

Average time for received messages(in ms) for node3.log : 297896 deviation: 490 (0%)
Average time for received messages(in ms) for node4.log : 1 deviation: 0 (0%)

———-20KBps,———
Percentage of messages received for node2.log : 0.613
Percentage of messages received for node3.log : 0.598
Percentage of messages received for node4.log : 0.973333333333
Average time for received messages(in ms) for node2.log : 33529 deviation: 2934 (8%)
Average time for received messages(in ms) for node3.log : 38329 deviation: 2731 (7%)
Average time for received messages(in ms) for node4.log : 6999 deviation: 806 (11%)

———-40KBps,———
Percentage of messages received for node2.log : 1.0
Percentage of messages received for node3.log : 1.0
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 18660 deviation: 589 (3%)
Average time for received messages(in ms) for node3.log : 18725 deviation: 562 (3%)
Average time for received messages(in ms) for node4.log : 1723 deviation: 557 (32%)

———-5KBps,———
Percentage of messages received for node2.log : 0.132
Percentage of messages received for node3.log : 0.162
Percentage of messages received for node4.log : 0.296666666667
Average time for received messages(in ms) for node2.log : 156465 deviation: 7519 (4%)
Average time for received messages(in ms) for node3.log : 174120 deviation: 5640 (3%)
Average time for received messages(in ms) for node4.log : 58477 deviation: 8710 (14%)

E.2 1000ms

———-10KBps,———
Percentage of messages received for node2.log : 0.345
Percentage of messages received for node3.log : 0.353
Percentage of messages received for node4.log : 0.496666666667
Average time for received messages(in ms) for node2.log : 102174 deviation: 4103 (4%)
Average time for received messages(in ms) for node3.log : 102160 deviation: 3481 (3%)
Average time for received messages(in ms) for node4.log : 14107 deviation: 7884

(55%)

———-1KBps,———
Percentage of messages received for node2.log : 0.002
Percentage of messages received for node3.log : 0.002
Percentage of messages received for node4.log : 0.0
Average time for received messages(in ms) for node2.log : 285404 deviation: 145 (0%)
Average time for received messages(in ms) for node3.log : 279749 deviation: 7 (0%)
Average time for received messages(in ms) for node4.log : 1 deviation: 0 (0%)

———-20KBps,———
Percentage of messages received for node2.log : 0.602
Percentage of messages received for node3.log : 0.628
Percentage of messages received for node4.log : 0.98
Average time for received messages(in ms) for node2.log : 38944 deviation: 2722 (6%)
Average time for received messages(in ms) for node3.log : 33844 deviation: 2596 (7%)
Average time for received messages(in ms) for node4.log : 7607 deviation: 548 (7%)

———-40KBps,———
Percentage of messages received for node2.log : 1.0
Percentage of messages received for node3.log : 1.0
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 18573 deviation: 590 (3%)
Average time for received messages(in ms) for node3.log : 18622 deviation: 577 (3%)
Average time for received messages(in ms) for node4.log : 1623 deviation: 601 (37%)

———-5KBps,———
Percentage of messages received for node2.log : 0.14
Percentage of messages received for node3.log : 0.141
Percentage of messages received for node4.log : 0.293333333333
Average time for received messages(in ms) for node2.log : 164201 deviation: 7064 (4%)
Average time for received messages(in ms) for node3.log : 179312 deviation: 5050 (2%)
Average time for received messages(in ms) for node4.log : 47926 deviation: 8053 (16%)

E.3 2000ms

———-10KBps,———
Percentage of messages received for node2.log : 0.371
Percentage of messages received for node3.log : 0.38
Percentage of messages received for node4.log : 0.676666666667
Average time for received messages(in ms) for node2.log : 95884 deviation: 5181 (5%)
Average time for received messages(in ms) for node3.log : 97958 deviation: 4777 (4%)
Average time for received messages(in ms) for node4.log : 10661 deviation: 4270 (40%)

———-1KBps,———
Percentage of messages received for node2.log : 0.001
Percentage of messages received for node3.log : 0.0
Percentage of messages received for node4.log : 0.0
Average time for received messages(in ms) for node2.log : 279428 deviation: 0 (0%)
Average time for received messages(in ms) for node3.log : 1 deviation: 0 (0%)
Average time for received messages(in ms) for node4.log : 1 deviation: 0 (0%)

———-20KBps,———
Percentage of messages received for node2.log : 0.623
Percentage of messages received for node3.log : 0.643
Percentage of messages received for node4.log : 0.993333333333
Average time for received messages(in ms) for node2.log : 39455 deviation: 2837 (7%)
Average time for received messages(in ms) for node3.log : 33749 deviation: 3139 (9%)
Average time for received messages(in ms) for node4.log : 7921 deviation: 315 (3%)

———-40KBps,———
Percentage of messages received for node2.log : 1.0
Percentage of messages received for node3.log : 1.0
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 18928 deviation: 560 (2%)
Average time for received messages(in ms) for node3.log : 18856 deviation: 560 (2%)
Average time for received messages(in ms) for node4.log : 1646 deviation: 606 (36%)

———-5KBps,———
Percentage of messages received for node2.log : 0.175
Percentage of messages received for node3.log : 0.12
Percentage of messages received for node4.log : 0.34
Average time for received messages(in ms) for node2.log : 173645 deviation: 5618 (3%)

Average time for received messages(in ms) for node3.log : 171221 deviation: 5603 (3%)
Average time for received messages(in ms) for node4.log : 54031 deviation: 10797 (19%)

E.4 5000ms

———-10KBps,———
Percentage of messages received for node2.log : 0.391
Percentage of messages received for node3.log : 0.36
Percentage of messages received for node4.log : 0.676666666667
Average time for received messages(in ms) for node2.log : 102483 deviation: 3215 (3%)
Average time for received messages(in ms) for node3.log : 98766 deviation: 5868 (5%)
Average time for received messages(in ms) for node4.log : 14599 deviation: 6431 (44%)

———-1KBps,———
Percentage of messages received for node2.log : 0.003
Percentage of messages received for node3.log : 0.002
Percentage of messages received for node4.log : 0.0
Average time for received messages(in ms) for node2.log : 287978 deviation: 75 (0%)
Average time for received messages(in ms) for node3.log : 282528 deviation: 27 (0%)
Average time for received messages(in ms) for node4.log : 1 deviation: 0 (0%)

———-20KBps,———
Percentage of messages received for node2.log : 0.662
Percentage of messages received for node3.log : 0.637
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 34649 deviation: 2050 (5%)
Average time for received messages(in ms) for node3.log : 42473 deviation: 2907 (6%)
Average time for received messages(in ms) for node4.log : 8015 deviation: 307 (3%)

———-40KBps,———
Percentage of messages received for node2.log : 1.0
Percentage of messages received for node3.log : 1.0
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 18553 deviation: 555 (2%)
Average time for received messages(in ms) for node3.log : 18476 deviation: 575 (3%)
Average time for received messages(in ms) for node4.log : 1599 deviation: 545

(34%)

———-5KBps,———
Percentage of messages received for node2.log : 0.146
Percentage of messages received for node3.log : 0.141
Percentage of messages received for node4.log : 0.323333333333
Average time for received messages(in ms) for node2.log : 173342 deviation: 6162 (3%)
Average time for received messages(in ms) for node3.log : 172908 deviation: 5539 (3%)
Average time for received messages(in ms) for node4.log : 59416 deviation: 9063 (15%)

E.5 100000ms

———-10KBps,———
Percentage of messages received for node2.log : 0.619
Percentage of messages received for node3.log : 0.628
Percentage of messages received for node4.log : 0.903333333333
Average time for received messages(in ms) for node2.log : 143825 deviation: 8231 (5%)
Average time for received messages(in ms) for node3.log : 152367 deviation: 6942 (4%)
Average time for received messages(in ms) for node4.log : 41008 deviation: 1603 (3%)

———-1KBps,———
Percentage of messages received for node2.log : 0.0
Percentage of messages received for node3.log : 0.002
Percentage of messages received for node4.log : 0.0
Average time for received messages(in ms) for node2.log : 1 deviation: 0 (0%)
Average time for received messages(in ms) for node3.log : 260191 deviation: 30 (0%)
Average time for received messages(in ms) for node4.log : 1 deviation: 0 (0%)

———-20KBps,———
Percentage of messages received for node2.log : 0.919
Percentage of messages received for node3.log : 0.93
Percentage of messages received for node4.log : 0.98
Average time for received messages(in ms) for node2.log : 63400 deviation: 4797 (7%)
Average time for received messages(in ms) for node3.log : 65118 deviation: 4158 (6%)
Average time for received messages(in ms) for node4.log : 17285 deviation: 795 (4%)

———-40KBps,———
Percentage of messages received for node2.log : 1.0

Percentage of messages received for node3.log : 1.0
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 18793 deviation: 554 (2%)
Average time for received messages(in ms) for node3.log : 18890 deviation: 554 (2%)
Average time for received messages(in ms) for node4.log : 1610 deviation: 627 (38%)

———-5KBps,———
Percentage of messages received for node2.log : 0.138
Percentage of messages received for node3.log : 0.114
Percentage of messages received for node4.log : 0.556666666667
Average time for received messages(in ms) for node2.log : 202807 deviation: 5644 (2%)
Average time for received messages(in ms) for node3.log : 208866 deviation: 2777 (1%)
Average time for received messages(in ms) for node4.log : 83343 deviation: 5149 (6%)

E.6 NoThrottle

———-10KBps,———
Percentage of messages received for node2.log : 0.703
Percentage of messages received for node3.log : 0.652
Percentage of messages received for node4.log : 0.796666666667
Average time for received messages(in ms) for node2.log : 144833 deviation: 11652 (8%)
Average time for received messages(in ms) for node3.log : 152233 deviation: 11479 (7%)
Average time for received messages(in ms) for node4.log : 64787 deviation: 10614 (16%)

———-1KBps,———
Percentage of messages received for node2.log : 0.001
Percentage of messages received for node3.log : 0.0
Percentage of messages received for node4.log : 0.0
Average time for received messages(in ms) for node2.log : 283573 deviation: 0 (0%)
Average time for received messages(in ms) for node3.log : 1 deviation: 0 (0%)
Average time for received messages(in ms) for node4.log : 1 deviation: 0 (0%)

———-20KBps,———
Percentage of messages received for node2.log : 0.933
Percentage of messages received for node3.log : 0.939
Percentage of messages received for node4.log : 0.903333333333
Average time for received messages(in ms) for node2.log : 66971 deviation: 7305 (10%)
Average time for received messages(in ms) for node3.log : 70191 deviation: 7401

(10%)
Average time for received messages(in ms) for node4.log : 28471 deviation: 8251 (28%)

———-40KBps,———
Percentage of messages received for node2.log : 1.0
Percentage of messages received for node3.log : 1.0
Percentage of messages received for node4.log : 1.0
Average time for received messages(in ms) for node2.log : 18024 deviation: 581 (3%)
Average time for received messages(in ms) for node3.log : 18078 deviation: 579 (3%)
Average time for received messages(in ms) for node4.log : 1536 deviation: 514 (33%)

———-5KBps,———
Percentage of messages received for node2.log : 0.264
Percentage of messages received for node3.log : 0.218
Percentage of messages received for node4.log : 0.493333333333
Average time for received messages(in ms) for node2.log : 180684 deviation: 12765 (7%)
Average time for received messages(in ms) for node3.log : 192730 deviation: 10337 (5%)
Average time for received messages(in ms) for node4.log : 133092 deviation: 12597 (9%)

F NS3 Problems

When trying to set up the test we wanted, illustrated in section 3.5, we encountered some strange problems which we could not solve in time for this project. Below is an outline of the problem and a possible solution sketched out by the creator of MobiEmu.

The problem seem to stem from NS3 and how it ”installs” the different abilities to each node in the network. In listing 25 we have tried to illustrate the problem.

Listing 25: This code snippet does not work

```
1  NodeContainer net1 (esb, r);
2  NodeContainer net2 (r, client);
3  NodeContainer all (esb, r, client);
4  NodeContainer shortCut (esb, client);
5
6  PointToPointHelper p2p;
7  p2p.SetDeviceAttribute ("DataRate", StringValue (
       constDataRate));
8  //pointToPoint.SetChannelAttribute ("Delay", StringValue ("2
       ms"));
9
10 NetDeviceContainer esbToRouterDevices;
11 esbToRouterDevices = p2p.Install (net1);
```

```
12
13 p2p.SetChannelAttribute ("DataRate", StringValue (dataRate))
       ;
14 //pointToPoint.SetChannelAttribute ("Delay", StringValue ("2
       ms"));
15
16 NetDeviceContainer routerToClientDevices;
17 routerToClientDevices = p2p.Install (net2);
18
19 TapBridgeHelper tapBridge;
20 tapBridge.SetAttribute ("Mode", StringValue ("UseLocal"));
21 tapBridge.SetAttribute ("Mtu", UintegerValue(mtu));
22
23 //Tap bridge setup for ESB
24 std::cout << "Adding tap bridge: tap-1\n";
25 tapBridge.SetAttribute ("DeviceName", StringValue ("tap-1"))
       ;
26 tapBridge.Install (esb, esbToRouterDevices.Get(0));
27
28 //Tap bridge setup for router
29 std::cout << "Adding tap bridge: tap-2\n";
30 tapBridge.SetAttribute ("DeviceName", StringValue ("tap-2"))
       ;
31 tapBridge.Install (r, esbToRouterDevices.Get(1));
32
33 //Tap bridge setup for router
34 std::cout << "Adding tap bridge: tap-3\n";
35 tapBridge.SetAttribute ("DeviceName", StringValue ("tap-3"))
       ;
36 tapBridge.Install (client, routerToClientDevices.Get(1));
```

When we try to run this code inside each LXC we do not get the communication that we expect to see. What happens instead is that only the nodes coming from the same ”NodeContainer” get to talk to each other. We can then induce communication through the two other nodes if we change which ”NodeContainer” we use when we install the tap bridges. The strange thing is that there is not much which would indicate this inside the source code.

The solution which was illustrated to us by the creator of MobiEmu was to create all the LXCs with two network connections, then inside NS3 create twice as many tap bridges and connect all this up. We did not have time do this as this would require much more knowledge about LXC, we would have to alter MobiEmu substantially to create all the extra tap bridges and we would need to change the NS3 scripts. In addition, this solution was not at all guaranteed to work, which would mean that we could put down many hours without any results. We mentioned in the testing chapter (ref:7.1.1) that we decided, together with the customer, that this would take too long, and that there was too little time left in the project.

G List of used software

- Git version 1.7.x

- OpenJDK Java version 1.6.023
- Eclipse Indigo 3.7.x
- JUnit version 4.x
- NS3 version 3.13
- WSO2 ESB 4.0.3
- Axiom version 1.2.11 - Note that our server code must use the same version of axiom as the ESB.
- HTTPCore version 4.1.4
- Commons-logging version 1.1.1
- MobiEmu

  Python 2.7.2

  uml-utilities 20070815

  lxc 0.7.5

  Bridge-utils 1.5

  MobiEmu was installed with all dependencies, for more see https://code.google.com/p/mobiemu/ for all of MobiEmu requirements.

H Work Breakdown Structure

WBS to be completly implemented later, it is also attached under (I)

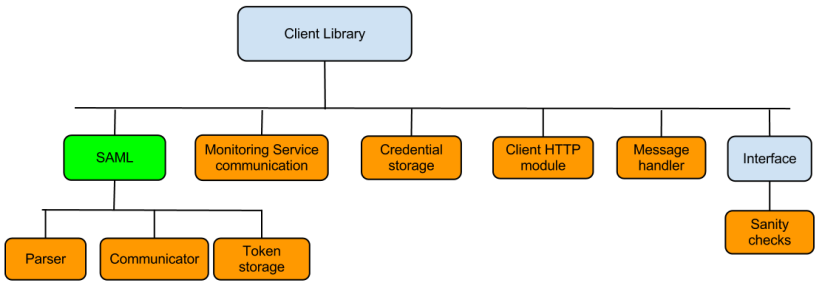


Figure 50: WBS-Client
The work break down structure for the client library.

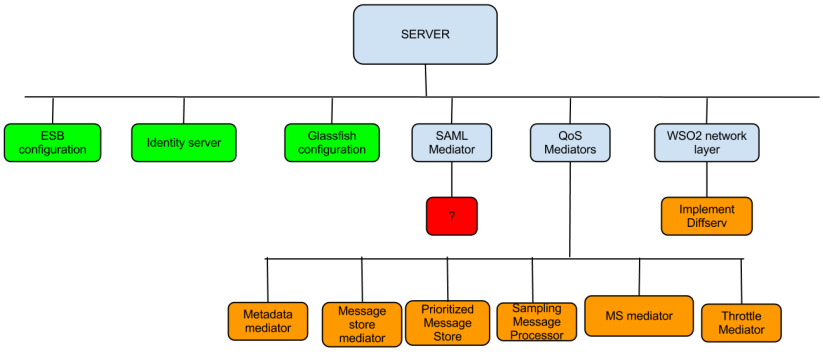


Figure 51: WBS-Server
The work break down structure for the server.

I File Attachments

Files are found in: fileAttachments.zip
Or at: https://github.com/magnuskiro/it2901/ path/to/raw/file

- bachelor-QoS.pdf

  Introduction to the assignment and Quality of Service(QoS) support for Web services in military networks.

- risklist.pdf

  The full risk list attached in it's full glory.

- gantt.html

  Our gantt chart in it's full form.

- ClientClassDiagram.png

  The class diagram describing our classes and their metadata.

- EchoClientClient.jar

  The client we have used for our testing.

- Client.config

  An example configuration for the Echo client.

- TestClient.java

  The source code for the Echo client.

- EchoServiceLargeReply.war

  A simple service which echoes responses back and pads them with 10Kb of text.

- hc.diff

  A diff file which can be applied to the HTTPCore source to apply the changes for DiffServ support.

- no.ntnu.qos.jar

  The server side, neatly packed into a jar ready for deployment in an ESB near you.

- synapse-configs.zip

  The commented Synapse configuration files, the values may not be correct, but the comments are.

- mediator-configuration.zip

  The necessary configuration files for the ESB using our test setup.

- Test-Case-1.tar.gz

  Necessary files for Test Case 1.

- Test-Case-2.tar.gz

  Necessary files for Test Case 2.

- Test-Case-3.tar.gz

  Necessary files for Test Case 3.

- Test-Case-4.tar.gz

  Necessary files for Test Case 4.

- Test-Case-5.tar.gz

  Necessary files for Test Case 5.

- Test-Case-6.tar.gz

  Necessary files for Test Case 6.

Glossary

LaTeX A document preparation system for the TeXtypesetting program http://www.latex-project.org/. 25

Agile methods A group of software development methodologies based on iterative and incremental development http://en.wikipedia.org/wiki/Agile_software_development. 22

Apache Synapse A lightweight and high-performance Enterprise Service Bus http://synapse.apache.org/. 40

Bandwidth Available or consumed data communication resources https://secure.wikimedia.org/wikipedia/en/wiki/Bandwidth_(computing). 4

COTS Commercially available Off-The-Shelf often used to talk about services which the customer wants to use server side https://secure.wikimedia.org/wikipedia/en/wiki/Commercial_off-the-shelf. 15

DiffServ Differentiated services, a field in the IPv4 header http://www.networksorcery.com/enp/rfc/rfc2474.txt. 4

Gantt Chart A type of bar chart that illustrates a project schedule http://en.wikipedia.org/wiki/Gantt. 23

Git A free and open source, distributed version control system http://www.git-scm.com. 25

GitHub A web-based hosting service for software development projects that use the Git version control system http://www.github.com. 25

GlassFish An application server written in Java http://glassfish.java.net/. 4

HTTP Hypertext Transfer Protocol. The foundation of data communication on the World Wide Web http://www.w3.org/History/19921103-hypertext/hypertext/WWW/Protocols/HTTP/AsImplemented.html. 16

HTTPComponents A toolset of low level Java components focused on HTTP and associating protocols http://hc.apache.org/. 27

IP address A numerical label assigned to each device connected to the Internet. 43

JUnit A testing framework for the Java programming language http://junit.org/. 25

LXC Linux Containers, http://lxc.sourceforge.net/. 55, 107

Mediator A component in WSO2 ESB which can be used to work on incoming or outgoing messages that passes through the ESB http://synapse.apache.org/Synapse_QuickStart.html. 8

Message SOAP message https://secure.wikimedia.org/wikipedia/en/wiki/SOAP#Message_format. 13

Middleware In the report middleware will refer to the program we are making. Other distinctions should be made explicitly in the text.. 4

MobiEmu Mobility Emulator, A framework for emulating mobile ad-hoc networks with Linux containers and ns-3.. 106

Monitoring Service Monitoring Service, a service that provides bandwidth monitoring, running on the same server as the Tactical Router.. 9

NS3 A network simulator http://www.nsnam.org/. 6

OpenSAML A set of open source C++ Java libraries to support developers working with SAML. https://wiki.shibboleth.net/confluence/display/OpenSAML/Home/. 10

Packet IP packet refers to the format to which a data transmitted over the IP protocol has been formatted tohttp://en.wikipedia.org/wiki/IPv4#Packet_structure. 4

Packet sniffer description. 12

Pcap pcap is short for Packet capture which in our text this usually refers to a program which captures the traffic on a given socket. https://secure.wikimedia.org/wikipedia/en/wiki/Pcap. 14

Proxy A proxy server is a server that acts as an intermediary for requests from clients seeking resources from other servers http://en.wikipedia.org/wiki/Proxy_server. 9

Quality of Service Quality of Service refers to several related aspects of telephony and computer networks that allow the transport of traffic with special requirements http://en.wikipedia.org/wiki/Quality_of_service. 3

SAML Security Assertion Markup Language https://secure.wikimedia.org/wikipedia/en/wiki/SAML. 4

Scrum An agile software development methodology http://en.wikipedia.org/wiki/Scrum_(development). 22

SOAP A lightweight protocol intended for exchanging structured information in the implementation of web services in computer networks http://www.w3.org/TR/soap12-part1/#intro. 4

Tactical router A Multi-topology router used in military networks. 4

Token A SAML token from some form of identity server, possibly with additional meta data.. 8

TOS Type of Service, a field in the IPv4 header, now obsolete and replaced by diffserv http://en.wikipedia.org/wiki/Type_of_Service. 4

Waterfall model A sequential design process often used in software development, in which development is supposed to proceed linearly through the phases of requirements analysis, design, implementation etc http://en.wikipedia.org/wiki/Waterfall_development. 16, 22

WBS Work Breakdown Structure. An oriented decomposition of a project into smaller components http://en.wikipedia.org/wiki/Work_breakdown_structure. 23

Web Service A software system designed to support interoperable machine-to-machine interaction over a network http://www.w3.org/TR/2004/NOTE-ws-gloss-20040211/#soapmessage. 4

WS-Security An extension to SOAP to apply security to web services. 4

WSO2 ESB An Enterprise Service Bus built on top of Apache Synapse. http://wso2.com/products/enterprise-service-bus/. 4

XACML eXtensible Access Control Markup Language https://secure.wikimedia.org/wikipedia/en/wiki/Xacml. 4

XML eXtensible Markup Language. A markup language defining a set of rules for encoding documents in a format readable for both humans and machines. http://www.w3.org/TR/REC-xml/. 27

XP Extreme programming is a type of agile software development http://en.wikipedia.org/wiki/Extreme_programming_practices. 22

References

[1] Frank Trethan Johnsen, Trude Hafsøe, Mariann Hauge (FFI), and Øyvind Kolbu (University of Oslo). Cross-layer quality of service based admission control for web services. test.

J Attachments

This appendix is a compilation of all our additional documents from the project process. This includes weekly reports, schedules and activity plans among other thing.

J.1 Risk List

Category	Description	Likelihood (1-9)	Impact (1-9)	Importance (C*D)	Preventive actions	Remedial actions	comments
communication	Miscommunication with the customer	6	5	30	Confirm any and all changes or decissions about the project explicitly with the customer	Costly and time consuming changes to the project	
communication	Conflicts within the group	3	5	15	Beer	More beer	
design	Design is too complicated	5	8	40	Redesign with simpler ideas and less functionality.	drop functionality and make things work.	
design	Design is too simplistic	3	4	12	Specify more.	add functionality	
exterior	Illness	5	4	20	Eat healthy, sleep enough, be well clothed.	Stay home and sleep a lot to get better.	Probably not going to become a problem but, you never know.
exterior	Disruptive facilities	5	2	10	Book isolated rooms	take a break and find a new location to work	
exterior	End of the world	0.000001	10	0.00001	Sacrifice goats	None, it won't happen before december, and we'll be done in may	to be removed later. ("The hell it is!" ~Stig Tore)
group	Inability to work under pressure	4	5	20	Know who and make sure they don't get stressed out.	calm people down and take a break.	
group	Team unfamiliar with the type of project	7	2	14	Time and research	Put more hours in to the project to familiarise ourselves more with the project type.	
group	Inefficient team structure	1	3	3	Evaluate pros and cons for the given structure. And see if it is necessary to create a more elaborate structure for the group.	Restructure the team and assign roles and responsibility areas	
organization	Lack of Room. No work space for us.	6	5	30	Book rooms in time and possibly work from home.	Find an alternative room on showing up at Gløs. The backup plan is to be at Drivhuset in the red room.	This has been a bit of a problem as you can't book a room for five weeks at a time Monday through Thursday between 1000 and 1600.
planning	Cascading delays	5	9	45	Stress mastering and beer to calm the nerves.	Efficient time planning. Ultimately drop functionality to complete necessities.	
planning	Optimistic scheduling	5	8	40	Regularly evaluate the schedules and make changes as necessary	**Overtime for everybody!!!**	
planning	Paperwork overhead is too big	4	9	36	Use more time on paperwork throughout the project.	Cut down on the paperwork and focus on the product.	
planning	Project too large in required effort or code size	6	6	36	Minimize the project and cut off features and components that is not needed.	Minimize the project and cut off features and components that is not needed.	
planning	Too coarse-grained requirements	6	5	30	Work with the customer to specify requirements better	Communicate with the customer to get a new set of must have requirements.	
planning	Incomplete schedule	4	7	28	Regularly evaluate the schedules and make changes if necessary	Add elements to the schedule and insert extra empty timeslots for unforeseen work.	
planning	Additional requirements turn up	7	4	28	Make sure all requirements are found before starting	Overrule the requirements that came later as optional.	
planning	Schedule slips without being discovered	3	7	21	Find up to date information about the course, project and deadlines and share them in the group, so all the members will remember.	Reschedule and make up for lost time.	
planning	Faulty planning	3	6	18	Make sure we properly research things before we decide anything	Improvise or bang head into the wall	
planning	Miss deadlines	2	4	8	Follow the plan and make sure we are ahead. Plan buffers.	Use planned buffer time to cath up. Use the weekend if necessary.	
tech	Integration with external libraries more complicated than expected	7	7	49	Prestudy	Re schedule and use more time then expected. Buffer zones are to be used if this happens.	
tech	Reimplementation due to faulty design	5	6	30	Use time on the design process and make sure the design is right.	Skip functionality and work overtime.	
tech	Poor code-quality in external libraries	5	6	30	Try to only use well-tested libraries, stay away from the highly experimental ones. Write code ourselves.	Find an alternative or create it your self.	
tech	Failure to implement chosen technologies	3	9	27	Proper research into the technologies we are using and a proper understanding of those	Acquire knowledge and ask questions	This could be very bad if it should occur, but with proper research and a good understanding it should not be a problem

tech	External libraries not suited for project	5	5	25	Research library content and usage.	Find an alternative library or implement the necessary code.	
tech	Unfamiliarity with the core technology of the design	8	3	24	Research and training.	Research and training. Ask experts for help.	
tech	Reliance on unfinished software	3	8	24	Be smart, unstable releases is catgorized as "Do not use!"	Make sure the relied on software is tested and implemented first.	
tech	Unfamiliar software or hardware environments	5	3	15	Time and research	Use the buffer zones.	
tech	Hardware failure	2	5	10	Maintain and take care of equipment, keep backups of important stuff	Acquire and set up new, or fix old, equipment as soon as possible	proper use of Git should minimize loss of work
tech	Broken codebase	1	8	8	Use Git (distributed as opposed to sentralised SVN). Keep one or more testing branches, which are merged with the Master branch only after having passed a full and rigourous test suite	Don't panic	Probably not going to occur, as we use Git and will at all times do development against a testing branch
tech	Can't get Identity Server to work	3	7	21	Do proper research around our alternatives and comprehensive evaluation of WSO2's Identity Server	Talk to the customer to come to some agreement	

J.2 Weekly Reports

J.3 Activity Plans

Activity plan!	week - 6							
Resource Rx=x people on activity		Work per resource:	22		Actuall work per resource:	9.66666666666667		
	Plan					Follow-up		
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work(hrs)	Status(%)	Comment
Architecture Planning	Research SAML	R2	24	06.02.12	10.02.12	1,5	5%	Not much work was done as it was extended into next week
Architecture Planning	Research WSO2 mediator	R1	12	06.02.12	07.02.12	0	0%	Research into TOS made us research some of the mediators, but that work was separated
Architecture Planning	Research WSO2 GlassFish setup	R1	12	07.02.12	10.02.12	0	30%	Nr 8 was more important Was worked on the week before
Architecture Planning	Research into metadata	R2	12	06.02.12	07.02.12	4	100%	This item could easily be joined with the item under.
Architecture Planning	Decide what metadata should be sent and what should be stored	R2	24	07.02.12	10.02.12	4	100%	Everyone worked together on this one, so the hours are quite nice
Architecture Planning	Client library architecture design	R2	12			10	50%	
Architecture Planning	Research WS-Security	R2	24			0	0%	We decided that other activities was more important than this so this was pushed back.
Architecture Planning	Research possible alternatives for setting TOS field in WSO2 ESB	R1	12	06.02.12	07.02.12	40	70%	Lots of extra time due to researched possibilities not working out. Some hours was the week before, with R2.

Activity plan!	week - 7							
Resource Rx=x people on activity		Work per resource:	12		Actuall work per resource:	11.333333333333		
	Plan					Follow-up		
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work(hrs)	Status(%)	Comment
Architecture Planning	Research SAML	R2	24	13.02.12	16.02.12	10	25%	As the codebase is extremely poorly documented much work has to be done here, but only one person has been working on it.
Architecture Planning	Research WSO2 mediator	R1	12	13.02.12	16.02.12	8	100%	Used slightly less hours, but two people worked on it.
Architecture Planning	Research WSO2 GlassFish setup	R1	12	13.02.12	16.02.12	4	90%	Managed to set up statically.
Architecture Planning	Client library architecture design	R2	12			30	100%	
Architecture Planning	Research possible alternatives for setting TOS field in WSO2 ESB	R2	12	13.02.12	14.02.12	16	100%	:-D

Activity plan!	week - 8							
Resource Rx=x people on activity		Work per resource:	24.6666666666667		Actuall work per resource:	21.4166666666667		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work(hrs)	Status(%)	Comment
Client Library	Sequence diagram	R2	24	20.02.12	21.02.12	10.5	100%	Boy did we miss the mark on this estimate!
Client Library	Extend textual use cases	R1	6	22.02.12	22.02.12	2	100%	Was already fairly complete
Client Library	Research Apache Axiom	R1	6	20.02.12		7	80%	Remaining work is related to OpenSAML, and how the two should be used together
Meetings	Meeting preparations	R6	12	20.02.12	21.02.12	6	100%	One person was missing so that was some time lost, we also had some time issues
Meetings	Customer meeting	R6	3	21.02.12	21.02.12	3	100%	Had a good meeting with the customer which answered many questions and we presented many documents to the documents
Meetings	Meeting summary, and documentation	R1	3	21.02.12	21.02.12	4	100%	The meeting was longer then usual, and a lot was discussed. Which in turn made the meeting summary longer, therefore taking more time.
Project management	Weekly report	R3	6	23.02.12	23.02.12	6		
Project management	Activity Plan	R3	6	23.02.12	23.02.12	6		
Project management	Unplanned activities	R6	12	20.02.12	24.02.12	24		
Report	Team Structure	R1	6	20.02.12	23.02.12	6	100%	
Report	Software project life cycle	R1	6	22.02.12	23.02.12	6	100%	
SAML	OpenSAML research	R1	18	20.02.12		16	80%	
Server	Update Server WBS	R1	4	20.02.12	21.02.12	2	100%	
Server	Sequence diagram	R2	24	20.02.12		22	60%	Since two of the mediators has some characteristics which we don't know yet we could not complete them yet.
Server	Document server mediators	R1	8	22.02.12	23.02.12	6	100%	This also went quicker than we expected because there were two persons working on it.
Server	Update server use cases	R1	4	22.02.12	22.02.12	2	100%	Since we only had to update names and some sentences there wasn't much to do and we got it done before the planned time

Activity plan!	week - 9							
Resource Rx=x people on activity		Work per resource:	26.33333333		Actual Work per resource:	20.0833333		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work(hrs)	Status(%)	Comment
Client	Client to library interface design	R1	6	27.02.12	27.02.12	4	100%	
Client	Client class diagrams	R3	36	28.02.12	01.02.12	15	100%	Missed again, by a LOT!
Report	Integrate server documentation into report	R3	4	01.03.12	29.02.12	6.5	100%	
Report	Integrate client documentation into report	R3	4	01.03.12				This items was posponed to next week
Report	Compile test suite documentation	R2	12	29.02.12		13	90%	Most of the documentation is completed, but there could still be more specific test cases
SAML	OpenSAML-Axiom integration	R2	24	27.02.12	29.02.12	21	100%	We have decided that it is best to use OpenSAML for all client XML-stuff
Server	Server sequence diagrams	R2	12	29.02.12	28.02.12	1	100%	This task ended up being much shorter because we'll probably be able to use built in functionality for integrating IS.
Server	ESB and IS integration	R2	24	27.02.12		6	10%	This activity will most likely be postponed because we can't do much without a client to test against.
Server	Update server documentation	R2	8	27.02.12	29.02.12	13	100%	Not many updates as such, but added some new documentation on classes to implement
Planning	Planning of next week	R6	18	01.03.12	01.03.12	15	100%	Magnus was not here.
Various	Unscheduled activities	R6	10	27.02.12		26		Lots of extra work on report that was not explicitly planned for.

Activity plan!	week - 10							
Resource Rx=x people on activity		Work per resource:	24.83333333		Actual Work per resource:	20.66666666		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work (hrs)	Status(%)	Comment
WSO2 Network Layer	Set up Apache synapse, HTTPComponents and WSO2 so we can make changes	R2	12	05.03.12	05.03.12	1	100%	Way easier than anticipated
WSO2 Network Layer	Compile WSO2 with modified Apache Synapse	R2	6	06.03.12	05.03.12	11	95%	This took some more time than anticipated because it ended up also including documentation which we didn't factor in during planing
WSO2 Network Layer	Modify Apache Synapse and HTTPComponents	R2	6	06.03.12	05.03.12	8	95%	Most modifications are done, but we might want to change some more and push it upstream. We have now made a diff file and started to try to push it upstream
Server Documentation	Finalize Server documentation for Midterm report	R2	6	05.03.12	06.03.12	9	100%	
Server Implementation	Metadata Mediator	R2	2	08.03.12	08.03.12	12	100%	
Server Implementation	Prioritized message store	R2	2	08.03.12	08.03.12	2	100%	
Server Implementation	MS mediator	R2	2	08.03.12				
Client Documentation	Client report introduction	R1	3	05.03.12	05.03.12	2	100%	
Client Documentation	Update client use cases	R1	3	05.03.12	05.03.12	1	100%	
Client Documentation	Integrate Client documentation	R2	7	05.03.12	07.03.12	6	100%	
Client Documentation	Update Client documentation	R2	4	05.03.12	07.03.12	14	100%	
Client Implementation	Client implementation start up	R3	12	07.03.12	08.03.12	8	100%	
Client Documentation	Update client WBS	R2	1	05.03.12	05.03.12	1	100%	
Report	Update report	R1	12	05.03.12	08.03.12	26	100%	note that we have "update report based on feedback" as it's own task
Client Implementation	Write JavaDoc for Client interfaces	R2	12			5	75%	
Client-Server implementation	MS communicator	R2	2			0	0%	Delayed until next week!
Report	Update report based on feedback	R6	12	08.03.12	09.03.12	2	30%	
Meetings	Plan FFI meeting and supervisor meeting	R6	6	05.03.12	05.03.12	3	100%	
Meetings	Meeting with FFI	R6	4	08.03.12	08.03.12	3	100%	
Meetings	Meeting with supervisor	R6	4	09.03.12	09.03.12	3	100%	

Activity plan!	week - 10							
Resource Rx=x people on activity		Work per resource:	24.83333333		Actual Work per resource:	20.66666666		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work (hrs)	Status(%)	Comment
Meetings	Meeting summary and documentation	R1	3	08.03.12	08.03.12	1	100%	Short meetings mean short meeting summaries.
Various	Unscheduled Activities	R6	10			2	20%	
	Create activities plan	R3	9		08.03.12	3	100%	
	Create Weekly report	R3	9		08.03.12	1	100%	

Activity plan!	week - 11							
Resource Rx=x people on activity		Work per resource:	23		Actual Work per resource:	16.03333333		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work (hrs)	Status(%)	Comment
Client implementation	Credential/Token storage system	R1	10	12.03.12		12	60%	
Client implementation	MS Communicator + RouteInfo	R1	6	12.03.12		5	100%	
Client implementation	Start Parser implementation	R1	12			8	25%	
Client implementation	Recieve Object	R1	10					Delayed until next week
Client	Update all developers on inner workings	R3	3	12.03.12	12.03.12	2	100%	
Client	Research thread pools	R3	8		12.03.12	3	100%	
Server implementation	Get patch for HC accepted	R2	4			2.5	100%	There were much less changes needed doing than we anticipated so this was done ahead of time.
Client-Server implementation	Design MS interface	R2	1	12.03.12	12.03.12	1	100%	
Client-Server implementation	MS implementation	R2	8	12.03.12	12.03.12	3	100%	
Server implementation	MS Mediator	R2	4	13.03.12	13.03.12	3	100%	
Server implementation	SAML mediator	R1	6	12.03.12	12.03.12	8.5	100%	This tok some more time than anticipated because of how hard it is to integrate Axiom with OpenSAML, also we decided that this mediator should do more than originally planned which caused more work do be needed to be doing
Server implementation	Throttle mediator	R2	24	13.03.12		3	5%	
Server implementation	Get patch accpeted for Synapse	R2	12			0.2	100%	We discovered that we don't need to patch Synapse =D, some more hours on unscheduled instead, to make the diffserv mediator.
Various	Unscheduled Activities	R6	24			39		
	Create activities plan	R4	4	15.03.12	15.03.12	4		
	Create Weekly report	R2	2	15.03.12	15.03.12	2		

Activity plan!	week - 12							
Resource Rx=x people on activity		Work per resource:	21.33333333		Actual Work per resource:	23.16666666		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work (hrs)	Status(%)	Comment
Client	Interface completion	R1	6	18.03.12		6	70%	
Client	Sequencer	R1	6	20.04.12		6	70%	
Client	Saml/soap parser	R2	24	19.03.12		30	40%	Turns out to be a lot more complex than initially assumed, mostly looking into it this week.
Client	DataObject	R1	6	19.03.12		6	80%	
Client	Recieve Object	R1	10	21.03.12	21.03.12	5	100%	
Client	Token Object	R1	6	20.03.12		6	70%	Waiting for the diffserv and priority value to finish this class
Client	HttpComponent Core	R1	12			12	90%	
Server implementation	Throttle mediator	R2	36	19.03.12		16	100%	
Server implementation	Configure WSO2	R2	10	19.03.12		6	10%	We will most likely have to do more of this in order to get the testing up and running
Meeting	FFI meeting planning	R6	3	19.03.12	19.03.12	2	100%	Only R4
Meeting	FFI meeting	R6	3	20.03.12	20.03.12	3	100%	
Various	Unscheduled Activities	R6	0			35	100%	Started Setting up NS3 tests, tests for the client library. Also testing, code cleaning and testing of client.
	Create activities plan	R4	4			4	100%	
	Create Weekly report	R2	2			2	100%	

Activity plan!	Week - 13							
Resource Rx=x people on activity		Work per resource:	23.33333333		Actual Work per resource:	20.83333333		
	Plan				Follow-up			
Work package	Activity	Resource	Planned Work(hrs)	Start	Finish	Actual Work (hrs)	Status(%)	Comment
Client implementation	QoSclient	R1	4			4		
Client implementation	Sequencer	R1	3			2		
Client implementation	Token object	R1	2			1		
Client implementation	data object	R1	3			4		
Client implementation	MessageHandler (HttpComp.)	R1	6	22.03.12		15	95%	Needs testing and logging of exceptions
Client implementation	SAML parsing and communication	R2	32			18	75%	
Client implementation	Test classes	R2	12	27.03.12		4	50%	
Client implementation	Sanity checker	R1	6	29.03.12	29.03.12	8	100%	
Code review	Review of code and merging into master	R2	12	26.03.12	27.03.12	10	100%	
Meeting	Meeting with FFI	R6	3	27.03.12	27.03.12	3	100%	
Meeting	Prepare for meeting with FFI	R6	6	26.03.12	26.03.12	3	100%	
Meeting	Meeting with advisor	R6	3	26.03.12	26.03.12	6	100%	
Testing suite	Getting NS3 up and running	R2	22	26.03.12		21	50%	
Testing suite	Creating testing client	R2	10	26.03.12		6	100%	
Testing suite	Create remaining system-tests	R2	10	26.03.12				
Various	Unscheduled Activities	R6	0			15		Writing and proof reading of the meeting summary, one hour total. ConfigManager, 3 hours.
Various	Create activities plan	R4	4			4		Not activity plan for next week, but some work was done on the next one
Various	Create Weekly report	R2	2			1		

J.4 Schedules

Week #	**3**			
Wednesday		**18-Jan**		
From	To	# Hours	Name	Comments
11:30	16:00	4:30	Jørgen	We created an agenda for the day, and started working on that to try to get started on the planning around the project
11:30	16:00	4:30	Magnus	----------||----------
11:30	16:00	4:30	Ola Martin	----------||----------
11:30	16:00	4:30	Håvard	----------||----------
11:30	16:00	4:30	Stig Tore	----------||----------
0:00	0:00	0:00	Jan	Spent the day at the hospital
Thursday		**19-Jan**		
From	To	# Hours	Name	Comments
10:00	14:00	4:00	Magnus	Meta planning, bookkeeping, reading templates, discussions.
10:00	14:00	4:00	Jørgen	----------||----------
10:00	14:00	4:00	Stig Tore	----------||----------
10:00	14:00	4:00	Håvard	----------||----------
10:00	14:00	4:00	Jan	----------||----------
10:00	14:00	4:00	Ola Martin	----------||----------

Week #	4			

Monday		23-Jan		
From	To	# Hours	Name	Comments
10:00	12:00	2:00	Jørgen	Worked on our views on the assignement and getting ready for the customer meeting tomorrow
10:00	12:00	2:00	Magnus	Worked on our views on the assignement and getting ready for the customer meeting tomorrow
12:00	15:00	3:00	Magnus	Work on the Preliminary Report; doc branch, added files, created report structure. And reading documentation.
12:00	14:00	2:00	Jørgen	Researching SAML, Java Sockets and how Diffserv works
10:00	15:00	5:00	Stig Tore	Preparing meeting, questions. Researching and pondering DiffServ implementations and issues.
10:00	16:00	6:00	Håvard	----------||----------
14:00	16:00	2:00	Jørgen	Reading different papers sent to us by FFI regarding what they have done previously
10:00	16:00	6:00	Ola Martin	Reading different papers sent to us by FFI and some articles on different standards.
10:00	16:00	6:00	Jan	Read papers from FFI, and researched DiffServ, SAML etc

Tuesday		24-Jan		
From	To	# Hours	Name	Comments
10:00	12:00	2:00	Magnus	Meeting with FFI.
12:00	14:00	2:00	Magnus	Meeting minute translation and perfection. Reading documentation on WSO2. Discussing metadata
10:00	12:00	2:00	Ola Martin	Meeting with FFI.
12:00	16:00	4:00	Ola Martin	Looking at WSO2 ESB, SOAP, SAML and XACML.
10:00	12:00	2:00	Stig Tore	Meeting with FFI.
12:00	16:00	4:00	Stig Tore	Research of WSO2 ESB, SOAP, SAML and the possibilities and limitations of them.
10:00	12:00	2:00	Jørgen	Meeting with FFI.
12:00	16:00	4:00	Jørgen	Looking at WSO2 ESB and evaluating if it suite our needs, researching SAML, XACML and how they are used and how we would use them
10:00	12:00	2:00	Håvard	Meeting with FFI.
12:00	16:00	4:00	Håvard	Looking at WSO2 ESB, SAML and XACML. Reading papers sent from FFI
10:00	12:00	2:00	Jan	Meeting with FFI.
12:00	14:00	2:00	Jan	Discussion after meeting, researching WSO2 ESB

Wednesday		25-Jan		
From	To	# Hours	Name	Comments
10:30	14:00	3:30	Stig Tore	WSO2 Mediators and architecture research, also what Jørgen said.
14:00	16:00	2:00	Stig Tore	Further research.
10:00	14:00	4:00	Jørgen	Started the day by going over what the meeting yesterday was about. Started to write the group note for today and then started looking at WSO2 and configuration of it.
10:00	13:00	3:00	Magnus	Meting minute translation and formalization. Discussion about architecture
13:00	16:00	3:00	Magnus	Project planning, organizing, writing documents. discussion.
10:00	16:00	6:00	Håvard	Repetition of what we found out during yesterdays meeting, further reading on WSO2
14:00	16:00	2:00	Jørgen	Reading up on WSO2 trying to figure out how to configure as a dynamic proxy
10:00	16:00	6:00	Ola Martin	Reading about WSO2 ESB, installed it and fiddled with it.
10:00	16:00	6:00	Jan	Repetition from yesterday, reading about WSO2 ESB

Thursday		26-Jan		
From	To	# Hours	Name	Comments
10:00	15:00	5:00	Magnus	Documentation, templates, reports, research on technical solutions.
10:00	16:00	6:00	Jørgen	Started the day by answering an email from the client, then went on to work on research on WSO2, task definition and a technical glossary.
10:00	16:00	6:00	Håvard	Started work on the preliminary report

Week #	**4**			
10:00	16:00	6:00	Ola Martin	Looked more into WSO2-ESB, resolved some problems found some new ones.
10:30	16:30	6:00	Jan	Created template for the status reports, wrote the report for week 4, template for WBS in Planner
Friday		**27-Jan**		
From	To	# Hours	Name	Comments
12:00	12:30:00	0:30	Jan	Meeting with supervisor
12:00	12:30	0:30	Ola Martin	Meeting with supervisor
12:00	12:30	0:30	Magnus	Meeting with supervisor

Week #	5			
Monday		**30-Jan**		
From	To	# Hours	Name	Comments
10:00	12:00	2:00	Ola Martin	Discussed a few things, and looked a bit more on Apache Synapse
14:00	16:00	2:00	Ola Martin	Work on preliminary report, mostly reading it.
10:00	16:00	6:00	Jørgen	Working on preliminary report, writing Task definition, project methodology and Team organization
10:00	16:00	6:00	Håvard	More work on the preliminary report
10:00	16:00	6:00	Stig Tore	Document work, editing, reviewing, etc etc.
10:15	16:00	5:45	Jan	Worked on the preliminary report
11:00	16:00	5:00	Magnus	Documentation and report work.
Tuesday		**31-Jan**		
From	To	# Hours	Name	Comments
10:00	13:30	3:30	Magnus	Customer meeting and meeting report work.
10:00	12:00	2:00	Ola Martin	Customer meeting ang Server side architecture model
14:00	15:30	1:30	Ola Martin	Server side architecture doc
10:00	13:30	3:30	Stig Tore	Customer meeting, proofreading docs, report, etc. Researching possibility of using proxy client side.
14:00	15:30	1:30	Stig Tore	
10:00	14:00	4:00	Jørgen	Started the day with a meeting with the customer, then went onto writing about alternative solutions and the preliminary report
10:00	14:00	4:00	Jan	Meeting with the customer, wrote on preliminary report and risk list
14:00	15:30	1:30	Jørgen	Worked on alternative solutions documents and tools.
10:00	15:30	5:30	Håvard	Further work on the report
Wednesday		**1-Feb**		
From	To	# Hours	Name	Comments
10:30	11:30	1:00	Jørgen	Worked on time plan
10:30	14:30	4:00	Ola Martin	Worked on Server side architecture, some synapse research and some work on the report
11:30	13:30	2:00	Jørgen	Worked on alternative solutions, preliminary report and did some administrative work
13:30	14:30	1:00	Jørgen	Worked on the preliminary report and created an intro to the report
10:00	14:30	4:30	Håvard	Worked on the report
10:00	15:30	5:30	Magnus	Work on the preliminary report, Latex implementation and research.
14:00	16:00	2:00	Stig Tore	Work@Home(Sick) Further research into proxy implementational possibilities.
10:15	16:00	5:45	Jan	Worked on time plan and preliminary report
Thursday		**2-Feb**		
From	To	# Hours	Name	Comments
12:00	15:30	3:30	Jan	Preliminary report
10:00	13:30	3:30	Stig Tore	Client-side architecture outline, related discussion.
11:00	15:00	4:00	Ola Martin	Work on preliminary report, mainly architecture.
11:00	15:30	4:30	Magnus	Preliminary report, and other documents, sent to the right people.
10:30	14:30	4:00	Håvard	Work on the preliminary report
10:00	15:00	5:00	Jørgen	Work on the preliminary report

Week #	6			

Monday		6-Feb		
From	To	# Hours	Name	Comments
10:30	12:00	1:30	Ola Martin	Preliminary report, moved things around.
10:00	15:00	5:00	Magnus	Computer setup and report work.
10:30	15:30	5:00	Stig Tore	Work on report.
10:00	15:30	5:30	Håvard	Final work on preliminary report
10:00	15:30	5:30	Jan	Finished the preliminary report

Tuesday		7-Feb		
From	To	# Hours	Name	Comments
10:00	14:00	4:00	Jørgen	Worked on new WBS, discussing design overview and writing textual WBS. Also some research into Axis 2
10:00	16:00	6:00	Ola Martin	Worked on new WBS, discussing design overview. Research Synapse, Axis2 and ActiveMQ concerning diffserv.
10:00	15:30	5:30	Stig Tore	Preparation for meeting wednesday, extending risk list.
10:00	16:00	6:00	Håvard	Extended the risk list, and prepared for wednesdays meeting
14:00	16:00	2:00	Jørgen	Research into ActiveMQ, WSO2 and Axis 2
10:00	13:45	3:45	Jan	Worked on WBS
10:00	15:00	5:00	Magnus	Report improvements and documentation. Meeting preparations. Risk list improvements

Wednesday		8-Feb		
From	To	# Hours	Name	Comments
10:00	13:30	3:30	Stig Tore	FFI meeting, meeting minutes, etc.
14:30	16:00	1:30	Stig Tore	Looking into OpenSAML.
10:00	16:00	6:00	Jan	Meeting with FFI, glossary, gained access to virtual machine
10:00	16:00	6:00	Håvard	Meeting with FFI, etc.
10:00	16:00	6:00	Ola Martin	FFI meeting. Research on implementing diffserv.
10:00	16:00	6:00	Jørgen	FFI meeting. Research on implementing diffserv.
10:30	16:30	6:00	Magnus	FFI meeting. Meeting summary and report improvements.

Thursday		9-Feb		
From	To	# Hours	Name	Comments
10:00	12:00	2:00	Magnus	Planning and work on the preliminary report.
10:30	14:00	3:30	Stig Tore	client use cases, weekly report, TR description.
10:15	14:00	3:45	Jan	weekly report, glossary, groupt meeting report
10:30	14:00	3:30	Ola Martin	Further research on diffserv impl, some progress.
10:00	14:00	4:00	Jørgen	Further research on diffserv impl, some progress.
10:30	14:00	3:30	Håvard	Client use cases, risk-list, typo-hunting

Friday		10-Feb		
From	To	# Hours	Name	Comments
10:00	11:00	1:00	Magnus	Supervisor metting and preparation for that.
10:30	11:30	1:00	Jørgen	Supervisor metting and preparation for that. Replying to some mailinglist and researching the reply.
10:30	11:30	1:00	Ola Martin	Supervisor metting and preparation for that. Replying to some mailinglist and researching the reply.
10:15	11:30	1:15	Jan	Supervisor meeting

Week #	7			
Monday		**13-Feb**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Ola Martin	Looked even further into the depths of synapse.
10:00	15:30	5:30	Jørgen	More research into Synapse and how we could do the DiffServ dance
10:00	15:00	5:00	Magnus	Report updates(Software life cycle) and week planning.
10:00	15:00	5:00	Jan	Researched OpenSAML
10:30	16:00	5:30	Stig Tore	Looking into possible client side network functionality.
10:00	16:00	6:00	Håvard	Looked at client architecture and data flow
Tuesday		**14-Feb**		
From	To	# Hours	Name	Comments
		0:00	Stig Tore	Work@Home, adverse reaction to C2H5OH intake.
10:00	15:30	5:30	Håvard	Skype-meeting with customer, some more work on data flow and use cases
10:00	16:00	6:00	Ola Martin	Meeting with FFI and
10:00	16:00	6:00	Jørgen	More research into DiffServ, may have found a solution to the problem with lots of help from the mailinglist. Server side use case. Research into WSO2 Identity server
10:00	13:30	3:30	Magnus	Report improvements, FFI-meeting and meeting summary writing.
10:00	14:00	4:00	Jan	Skype meeting with FFI, figuring out OpeSAML
Wednesday		**15-Feb**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Stig Tore	Detailed client architecture.
11:00	16:00	5:00	Håvard	Detailed client architecture.
10:00	16:00	6:00	Ola Martin	Rewarding research on Server arcitecture, and some dataflow diagrams
10:00	16:00	6:00	Jørgen	Rewarding research on Server arcitecture, and some dataflow diagrams
10:30	16:00	5:30	Jan	OpenSAML
10:00	16:00	6:00	Magnus	Report work and research about svg files in latex. Architecture discussion.
Thursday		**16-Feb**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Stig Tore	Axiom research, Drawing orginizational chart, report.
10:00	16:00	6:00	Håvard	Started research on Apache Axiom. Weekly report, team organisation chart
11:00	16:00	5:00	Ola Martin	ESB-glassfish setup, reports & Team organization chart.
10:00	16:00	6:00	Magnus	Work on the report, software life cycle, team organization, charts.
10:00	16:00	6:00	Jørgen	Work on Synapse mediators, researching throttle posibilities in WSO2, activity plan and less
10:00	16:00	6:00	Jan	Continued with OpenSAML

Week #	8			

Monday		20-Feb		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Håvard	Research on Apache Axiom
10:00	15:00	5:00	Jan	OpenSAML, now I'm getting somewhere
10:00	12:00	2:00	Jørgen	Work on server sequence diagram
12:00	13:00	1:00	Jørgen	Research ESB IS SAML integration
13:00	14:30	1:30	Jørgen	Work on server sequence diagram
14:30	16:00	1:30	Jørgen	Meeting preperation
10:30	15:15	4:45	Magnus	Team Structure and organization.
10:00	16:00	6:00	Ola Martin	Work on server documentation and meeting preparation
10:30	15:00	4:30	Stig Tore	Client Sequence description and diagrams

Tuesday		21-Feb		
From	To	# Hours	Name	Comments
10:00	11:00	1:00	Stig Tore	FFI Meeting
11:00	14:00	3:00	Stig Tore	Sequence Diagrams
14:00	15:30	1:30	Stig Tore	Vague tech research stuffs.
10:00	11:00	1:00	Jørgen	Meeting with customer
11:00	12:30	1:30	Jørgen	Sequence Diagrams
12:30	15:00	2:30	Jørgen	Research WSO2 setup and Sequence diagram
10:00	15:00	5:00	Ola Martin	Meeting, research on wso2 setup.
10:00	15:00	5:00	Magnus	FFI Meeting, and meeting summary.
10:00	11:00	1:00	Jan	FFI Meeting
11:00	14:00	3:00	Jan	SAML research
10:00	15:00	5:00	Håvard	Meeting, sequence-diagrams and a bit more axiom research

Wednesday		22-Feb		
From	To	# Hours	Name	Comments
10:30	16:00	5:30	Magnus	Report work. Restructured and written some more. Discussed and decided hov the glossary should be.
10:30	16:00	5:30	Stig Tore	Fixing some sequence diagrams, latexizing glossary, learning basic LaTeX
11:00	16:00	5:00	Håvard	Sorting and latexifying glossary
10:00	16:00	6:00	Jørgen	Research identity server
10:00	16:00	6:00	Ola Martin	Research identity server, sequence diagrams, ++
10:00	16:00	6:00	Jan	OpenSAML, some LaTeX discussion and research

Thursday		23-Feb		
From	To	# Hours	Name	Comments
10:00	15:00	5:00	Stig Tore	Activity plan, documentation, preliminary client to lib interface implementation pondering, panic about time moving too damned fast
11:00	16:00	5:00	Ola Martin	Server mediator documentation, activity plan.
10:00	16:00	6:00	Jørgen	Work on activity plan, weekly report, sequence diagrams and writing textual description of server mediators
10:30	16:00	5:30	Magnus	Finished writing about software project life cycle and team organization. Proof read it and improved the report in som e other minor ways
10:00	16:00	6:00	Jan	OpenSAML
10:00	16:00	6:00	Håvard	Weekly report, activity plan

Week #	9			

Monday		27-Feb		
From	To	# Hours	Name	Comments
10:00	13:00	3:00	Jørgen	Research around ESB and IS integration
10:00	14:00	4:00	Stig Tore	Client to client library interface
14:00	16:00	2:00	Stig Tore	Ehhh, stuffs? Team building!
10:30	15:30	5:00	Ola Martin	Some IS research and some updating of different server documents
10:30	15:30	5:00	Håvard	Research on OpenSAML and Axiom
13:00	15:30	2:30	Jørgen	Updating different server documentation
10:00	15:00	5:00	Magnus	Report work. Changed all pictures to png(It's better). Added some more figures. Started thinking about the contents of testing. Started looking at the requirements for the midterm report so that we have all that worked out in time.
10:00	15:00	5:00	Jan	OpenSAML & Axiom

Tuesday		28-Feb		
From	To	# Hours	Name	Comments
11:00	16:00	5:00	Stig Tore	Class diagramsies.
10:00	16:00	6:00	Håvard	Research on OpenSAML and Axiom
11:00	13:00	2:00	Jørgen	Work on test suit documentation
14:00	16:00	2:00	Jørgen	Work on test suit documentation
11:00	16:00	5:00	Ola Martin	Work on test suit and server documentation
10:30	13:30	3:00	Magnus	Work on the report.
14:30	16:00	1:30	Magnus	Work on the report.
10:00	14:00	4:00	Jan	OpenSAML & axiom

Wednesday		29-Feb		
From	To	# Hours	Name	Comments
11:00	15:30	4:30	Magnus	integrated the server documentation in to the report. added sequence diagrams. changes lables.
10:00	15:30	5:30	Jørgen	Worked on updating the server documentation and making it ready for inclusion in the midterm report. Also worked on the test suits
10:00	15:30	5:30	Ola Martin	----------||----------
10:00	16:00	6:00	Jan	Report editing
10:30	15:30	5:00	Håvard	finished with axiom, worked on client class diagrams
10:30	15:30	5:00	Stig Tore	Client class diagrams

Thursday		1-Mar		
From	To	# Hours	Name	Comments
10:30	15:30	5:00	Ola Martin	Work on documentation of system testing and classes. And planning.
10:00	15:30	5:30	Håvard	weekly report
10:30	16:00	5:30	Jan	Work on report
11:00	16:00	5:00	Stig Tore	Planning for next week, finalizing some client documentation, etc

Week #	10			

Monday		5-Mar		
From	To	# Hours	Name	Comments
10:30	14:30	4:00	Jørgen	Worked on compiling and changing the WSO2 source
10:30	16:00	5:30	Håvard	Client introduction, meeting agenda
10:00	16:30	6:30	Stig Tore	Minor edits to class diagrams, report and sequence diagrams. Use cases are updated and signed off on. WBS for client brought up to date. Some knowledge transfer for report writing.
9:30	15:00	5:30	Ola Martin	Worked on compiling and changing the WSO2 source and updating the server documentation
14:30	16:30	2:00	Jørgen	Updating server documentation and creating meeting agenda for tomorrow
11:00	16:30	5:30	Jan	Finished first draft of the midterm report

Tuesday		6-Mar		
From	To	# Hours	Name	Comments
10:00	16:30	6:30	Magnus	Back from illness. Integrated the testing part of the report. Fixed some other small things in the report.
10:00	16:00	6:00	Håvard	started writing client component description, proof-reading/typo-hunting report
10:00	16:00	6:00	Jørgen	Wrote install guide for WSO2 and changed document for server
10:00	16:00	6:00	Ola Martin	Wrote install guide for WSO2 and changed document for server
10:00	11:15	1:15	Jan	Proof-reading of report
14:00	16:00	2:00	Jan	Restructured glossary in report and ironed out some kinks
20:00	22:00	2:00	Jan	Nitpicking on the report

Wednesday		7-Mar		
From	To	# Hours	Name	Comments
10:00	12:00	2:00	Jørgen	Mostly administrative work, but also some work on server documentation
10:00	16:00	6:00	Stig Tore	Update testing.tex, some minor report stuff. Getting report done!
12:00	16:00	4:00	Jørgen	Started coding mediators!
11:00	16:00	5:00	Håvard	finished updating client description, hunted for more typos and bad sentences in the testplan
11:00	16:00	5:00	Jan	Finished final draft of midterm report
10:00	16:00	6:00	Ola Martin	Metadata mediator!
13:30	16:00	2:30	Magnus	worked on the report.

Thursday		8-Mar		
From	To	# Hours	Name	Comments
11:00		13:00	Magnus	Meeting preparations for the supervisor meeting. Meeting with FFI, the weekly report. updating the gantt diagram
10:00	16:00	6:00	Stig Tore	Desperate search for room, client meeting, interface writing and stuffs.
10:00	16:00	6:00	Håvard	looking for rooms, client meeting, initial client implementation
10:00	16:00	6:00	Jan	Meeting with FFI, polishing report

Friday		9-Mar		
From	To	# Hours	Name	Comments
11:30	12:30	1:00	Magnus	Meeting with the supervisor and minor work on the report.
11:30	12:30	1:00	Jørgen	Supervisor meeting

Individual			
Date	# Hours	Name	Comments
06.03.12	1:00	Ola Martin	Compiled Synapse eclipse project for extending the ESB

Week #	11			

Monday		12-Mar		
From	To	# Hours	Name	Comments
12:15	16:15	4:00	Magnus	Fixed footnotes in the report, and continued with the feedback from FFI
10:30	16:00	5:30	Stig Tore	Thread Pool research, and getting everyone updated on client workings
10:00	16:00	6:00	Jørgen	Started the day by updating the HC patch, then started to update the XML template and used the rest of the day to work on SAML mediators
10:00	16:00	6:00	Ola Martin	Made MSComm, updated metadata mediator
10:00	16:00	6:00	Håvard	started implementation of client side msCommunicator, read up a bit on java threading

Tuesday		13-Mar		
From	To	# Hours	Name	Comments
11:30	16:30	5:00	Magnus	Getting up to speed on code and preparing work for Wednesday. Code quality seems good so far. Client is a bit behind schedule?
10:00	16:00	6:00	Håvard	worked on various parts of the client, among other things, creating missing classes from the class diagram.
10:00	16:00	6:00	Ola Martin	MSMediator, started ThrottleMediator, making code work with esb.
10:00	16:00	6:00	Jørgen	Finally got SAMLMediator to work also did some changes to the HC patch
20:30	22:30	2:00	Stig Tore	There is something wrong with my TuesdayImpl I say Tuesday. getUp() and it throws exceptions and reboots my sleep cycle! Added some initial testing stuff for the client Token manager.
15:15	16:00	0:45	Jan	Headaches!

Wednesday		14-Mar		
From	To	# Hours	Name	Comments
10:00	12:00	2:00	Jørgen	Refactor serverside mediators
10:00	16:00	6:00	Stig Tore	JUnit testing, run green, yay! HttpComponents booo!!!!
10:00	16:00	6:00	Ola Martin	Using mediators in ESB required lots of fixing and debugging.
12:00	16:00	4:00	Jørgen	More refactoring work and testing our mediators with WSO2
12:30	16:00	3:30	Jan	SAML parser
10:30	16:00	5:30	Håvard	various work on client code

Thursday		15-Mar		
From	To	# Hours	Name	Comments
10:00	11:30	1:30	Jørgen	Some code clean-up, made SAML mediator more resistant to errors in SOAP, also updated PPD to give a better error when there is no default client
11:00	16:00	5:00	Stig Tore	HttpComponent, weekly report stuff.
10:00	16:00	6:00	Ola Martin	Code cleanup, setup WSO2, diffservmediator, Found out patching synapse not needed
11:30	16:00	4:30	Jørgen	Some code clean up, more setup of WSO2, creation of DiffServ mediator, discovered that we don't need to patch Synapse
10:30	16:00	5:30	Håvard	weekly report and activity plans
10:30	16:00	5:30	Jan	Rewrote SAML generator, worked on the parser

Individual			
Date	# Hours	Name	Comments
14.03.12	5:00	Magnus	Fixed the last sutff from FFI-feedback. looked a bit at the client side. Will continue looking at the client side and think about stuff for the reflection part of the report.

Week #	12			
Monday		**19-Mar**		
From	To	# Hours	Name	Comments
8:00	9:15	1:15	Magnus	Merge client changes done earlier this morning. And pushed changes to repository for client and doc. Read the weekly report from last week
11:00	16:00	5:00	Håvard	worked on dataobject and some other code stuff
10:00	16:00	6:00	Ola Martin	ThrottleMediator+dataobjects
10:00	16:00	6:00	Jørgen	ThrottleMediator+dataobjects
10:00	16:00	6:00	Jan	
Tuesday		**20-Mar**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Håvard	various work on the client
10:00	14:00	4:00	Stig Tore	HttpCore SSL
15:00	16:00	1:00	Stig Tore	HttpCore and etc.
10:00	11:00	1:00	Jørgen	Meeting with FFI
11:00	12:00	1:00	Jørgen	Throttle mediator
12:00	16:00	4:00	Jørgen	Configure ESB and update code in relation to this configuration
10:00	16:00	6:00	Ola Martin	@see Jørgen
10:00	12:00	2:00	Magnus	FFI meeting and meeting summary.
12:00	16:15	4:15	Magnus	Client library coding. Interface and setCredentials chaing ++
10:00	11:00	1:00	Jan	Meeting with FFI
11:00	17:00	6:00	Jan	Trying to figure out the Identity Server
Wednesday		**21-Mar**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Jørgen	Worked on NS3 and getting our emulated network environment up and running
10:00	16:00	6:00	Ola Martin	Worked on NS3 and getting our emulated network environment up and running
10:00	16:00	6:00	Håvard	worked on the client
10:00	16:00	6:00	Stig Tore	ReceiveObject and related
10:30	16:30	6:00	Magnus	Client testing and improvements on the inner workings.
10:00	16:00	6:00	Jan	Identity server
Thursday		**22-Mar**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Stig Tore	Surprisingly little, trying to help wrap our heads around fetching saml tokens. and report.
10:00	14:00	4:00	Ola Martin	NS3 :(
10:00	15:00	5:00	Jørgen	----------||---------- :(
15:00	16:00	1:00	Jørgen	Activity plan, weekly report and supervisor meeting document
10:15	15:00	4:45	Magnus	Client implementation and testing. A bit on all the open tasks in client.
15:00	16:00	1:00	Magnus	Activity plan, weekly report and supervisor meeting document
10:00	16:00	6:00	Håvard	updatded the client class diagram, come client code-stuff, weekly report
10:00	16:00	6:00	Jan	Still figuring out the IS, all WSO2 tutorials are somewhat broken, makes it harder
Individual				
Date		# Hours	Name	Comments
19.03.12		5:30	Magnus	Client coding. Started with the interface and continued with various other classes and added code according to the class diagram.
19.03.12		4:00	Stig Tore	HttpComponent (nightmare)Core

Week #	13			

Monday		26-Mar		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Ola Martin	Supervisor meeting, looked at client interface, general help.
10:00	16:00	6:00	Jørgen	Worked on NS3 scripts to try and make them work with P2P and TapBridges
10:00	16:15	6:15	Magnus	Supervisor meeting, preparations for the customer meeting code review.
11:00	16:15	5:15	Stig Tore	HttpCoreIssues (Entity type)
11:30	16:00	4:30	Håvard	supervisor meeting, some client code and generally being very sleepy
10:15	16:00	5:45	Jan	supervisor meeting, further research on IS

Tuesday		27-Mar		
From	To	# Hours	Name	Comments
10:00	10:45	0:45	Magnus	FFI meeting
10:45	11:45	1:00	Magnus	Code review of server and pulling coen to testing and master.
11:45	13:30	1:45	Magnus	Work on the client library.
14:30	16:30	2:00	Magnus	Client implementation
10:00	16:00	6:00	Stig Tore	HttpCore, MessageHandlerImpl, ExceptionHandler, etc.
10:00	10:45	0:45	Jørgen	FFI meeting
10:45	16:00	5:15	Jørgen	Work with NS3 and GlassFish. Also wrote the meeting summary.
10:30	16:00	5:30	Håvard	work on the client library
10:00	16:00	6:00	Ola Martin	FFI meeting, NS3 Glassfish, testclient.
10:00	16:00	6:00	Jan	FFI meeting, IS

Wednesday		28-Mar		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Stig Tore	Message handler, logging, implementation of logging.
10:00	15:00	5:00	Ola Martin	Test Client, SOAPAction header, documentation.
10:00	16:00	6:00	Håvard	Sequencer, communicating of receiveobject ++
10:00	16:00	6:00	Magnus	A bit report, a lot of Client.
10:00	16:00	6:00	Jørgen	Worked on NS3 for a little while then worked on report
10:00	16:00	6:00	Jan	IS

Thursday		29-Mar		
From	To	# Hours	Name	Comments
10:15	16:00	5:45	Magnus	
10:30	16:00	5:30	Stig Tore	Sanity Checker (not completely happy with the simplicity of it)
10:00	16:00	6:00	Ola Martin	NS3, activity plan. Test client.
10:00	15:00	5:00	Jørgen	Worked some on the report and some on NS3
10:00	16:00	6:00	Håvard	

Week #	15			

Tuesday		10-Apr		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Stig Tore	Polish, Token-dataobject integration, logging.
11:30	16:00	4:30	Håvard	Poking the client
14:00	16:00	2:00	Magnus	Client code and minor improvements on the report.
20:00	22:30	2:30	Magnus	Client tests.
10:00	16:00	6:00	Ola Martin	Got test client and test service to work. Some placeholder SAML work
10:00	16:00	6:00	Jørgen	Created system-test-2, created new service for testing and worked on client

Wednesday		11-Apr		
From	To	# Hours	Name	Comments
6:00	8:00	2:00	Magnus	Client tests. Fixing and implementation.
10:00	16:00	6:00	Stig Tore	Saml parser, proper exception handling for message handler.
10:00	15:00	5:00	Ola Martin	Test client, and bugfixing server.
10:00	16:00	6:00	Jørgen	Working on test client, bugfixing server and some work on NS3
10:00	16:00	6:00	Håvard	Various work on client and tests

Thursday		12-Apr		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Håvard	more work on client and tests, updated client class diagram
10:00	16:00	6:00	Ola Martin	Testclient, client, testing, Server setup document
10:00	16:00	6:00	Magnus	Report work.
12:30	16:00	3:30	Stig Tore	Report, bug hunt.
10:00	16:00	6:00	Jørgen	Bug hunting
10:00	16:00	6:00	Jan	Identity Server

Friday		13-Apr		
From	To	# Hours	Name	Comments
10:00	14:00	4:00	Magnus	Supervisor meeting and report work.
10:00	14:00	4:00	Håvard	Supervisor meeting, test result analysis, and attempts to find a bug
10:00	14:00	4:00	Stig Tore	See above
10:00	14:00	4:00	Jørgen	Supervisor meeting, and bug hunting
10:00	14:00	4:00	Jan	Supervisor meeting, and IS

Saturday		14-Apr		
From	To	# Hours	Name	Comments
11:00	17:00	6:00	Magnus	Report work.
10:00	17:00	7:00	Håvard	bug hunting
12:30	17:00	4:30	Stig Tore	
11:30	17:00	5:30	Ola Martin	Server setup manual, some trying to get IS to work.
10:00	17:00	7:00	Jørgen	Server updating and bug hunting
11:00	17:00	6:00	Jan	IS

Sunday		15-Apr		
From	To	# Hours	Name	Comments
11:30	16:00	4:30	Magnus	Report work.
10:30	16:00	5:30	Håvard	worked on the report
		0:00	Stig Tore	
10:30	16:00	5:30	Ola Martin	Bug hunting
10:30	16:00	5:30	Jørgen	Bug hunting
10:30	16:00	5:30	Jan	IS

Individual			
Date	# Hours	Name	Comments
4/9/2012	4:30	Stig Tore	Runnableization, Minor coding, XML stuff
4/9/2012	2:00	Magnus	Student section of the report.
4/9/2012	5:00	Jørgen	Worked on NS3
4/10/2012	5:00	Jan	IS

Week #	**16**			
Monday		**16-Apr**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Magnus	FFI-meeting + summary.
10:00	16:00	6:00	Stig Tore	FFI+Bug stuff
10:00	12:00	2:00	Jørgen	Meeting preparation for FFI meeting
10:00	14:00	4:00	Jørgen	FFI meeting
14:00	16:00	2:00	Jørgen	Work on server side
10:00	16:00	6:00	Ola Martin	FFI meeting /w preparations, some server/testing work
10:30	16:00	5:30	Håvard	FFI meeting /w preparations, some client work
10:00	16:00	6:00	Jan	FFI meeting /w preparations, OpenSAML on client side
Tuesday		**17-Apr**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Ola Martin	Work on server manual, /w more
10:00	16:00	6:00	Stig Tore	
12:00	13:30	1:30	Magnus	Work on the report, todo elements.
14:30	16:30	2:00	Magnus	Work on prestudy - report. + sending stuffs to the Aupervisor
10:30	16:00	5:30	Håvard	Worked on the report
10:00	16:00	6:00	Jørgen	Worked some on the server SAML mediator, then on some of the Parsing scripts used with the results
10:00	16:00	6:00	Jan	Worked on the client side OpenSAML integration
Wednesday		**18-Apr**		
From	To	# Hours	Name	Comments
10:30	16:30	6:00	Håvard	report work, some client code assistance
10:30	16:30	6:00	Ola Martin	Client and server code fixing, SAML
10:30	16:30	6:00	Magnus	Work on the report
10:00	16:00	6:00	Jørgen	Work on the report
10:00	16:00	6:00	Jan	OpenSAML in client, getting it to work with the server
Thursday		**19-Apr**		
From	To	# Hours	Name	Comments
10:00	16:00	6:00	Stig Tore	Report, etc
10:00	16:00	6:00	Ola Martin	Client fixing, report consulting.
10:30	16:00	5:30	Håvard	report, client fixes, scratching head and beard
10:00	16:00	6:00	Jørgen	Work on the report

Week #	17			

Monday		23-Apr		
From	To	# Hours	Name	Comments
11:00	16:00	5:00	Håvard	report work
11:00	16:30	5:30	Ola Martin	Report work, fixed a bug
13:00	16:00	3:00	Magnus	Work on the report, minor rewrites and proof reading.
11:00	16:30	5:30	Stig Tore	Report, report
10:00	16:00	6:00	Jørgen	Work on the report
10:00	16:00	6:00	Jan	Work on the report

Tuesday		24-Apr		
From	To	# Hours	Name	Comments
10:30	16:00	5:30	Magnus	Worked on the report
11:00	16:00	5:00	Håvard	Worked on the report
10:30	16:00	5:30	Ola Martin	Report work, test client and service, changes.
10:00	16:00	6:00	Jørgen	Work on the report
10:30	16:00	5:30	Jan	Worked in the report

Wednesday		25-Apr		
From	To	# Hours	Name	Comments
11:00		13:00	Magnus	More report work...
10:00	16:00	6:00	Ola Martin	More report work..
10:00	16:00	6:00	Stig Tore	Writers block!!!
11:00	16:00	5:00	Håvard	work work work (on report)
10:00	16:00	6:00	Jørgen	Work on the report
10:30	16:00	5:30	Jan	Report working

Thursday		26-Apr		
From	To	# Hours	Name	Comments
10:30	17:00	6:30	Magnus	Supervisor feedback on the report. + medthodology update, risk section update, + file restructuring
10:00	16:00	6:00	Ola Martin	Work on report, mainly evaluation.
10:00	16:00	6:00	Jørgen	Work on the report
11:30	16:00	4:30	Håvard	Work on the report
10:00	16:00	6:00	Jan	Report writing

Friday		27-Apr		
From	To	# Hours	Name	Comments
11:00	12:00	1:00	Magnus	Supervisor meeting. ++
10:00	16:00	6:00	Stig Tore	Abstract, javadoc, meeting, etc.
10:30	16:00	5:30	Ola Martin	Supervisor meeting. Javadoc, activity plans and schedules. And more report work
10:30	16:00	5:30	Håvard	Supervisor meeting, working on the report
10:00	16:00	6:00	Jørgen	More work on the report plus supervisor meeting
10:00	16:00	6:00	Jan	Still working on report, supervisor meeting