Quality of Service - FFI
IT2901 - Group 7

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April 18, 2012

Abstract

TODO ...

Contents

List of Figures

List of Tables

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 have planned the work for the project, how we have organized our group and what development methodology we have chosen 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 wants 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

[1] Please see (D) - Quality of Service (QoS) support for Web services in military networks

or little support for this cooperation on the application level which is what we were tasked to do. For us this assignment will 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 are two senior researchers at the Norwegian Defence Research Establishment(FFI) [2] working in the SOA division. They had this to say about FFI.

> *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]

This cours is considered to be the Bachelors project, the main project that finishes a bachelor degree. 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 which counts very positive.

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 could come in handy. And everyone have extensive experience with Java.

[2] Forsvarets Forskningsinstitutt (FFI) - [http://www.ffi.no/]

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

1.5 Supervisor

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

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* 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 that we started out to design. After that follows *Implementation* which should give the necessary details about our code and how the system works deeper down.

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 test. The ability to reproduce our whole testing setup should also give you the confidence that we have in our results. *Results* will give you our interpretation of the results that we have gotten from the system test and should also shed light on the initial problem we set out to investigate.

Finally we will wrap up with *Conclusion* and *Project Evaluation* 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.

After the main part of the report we have some appendixes that elaborate the work process and results of the project. These are:

[TODO: write about the appendixes that will be included in our report.]

At the far end of the report we have added some attachments. These are not directly linked to our report. But they are our notes, plans, and summaries that have been created throughout the project.

[TODO: make sure the right appendixes are included at the end of the report. - weekly reports - schedule - meeting summaries. - activity plans - gantt chart - risk list. - ...]

2 Task Description and Requirements

Our task is 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 must 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.

2.1 Description

Our assignment is 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. Currently 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

[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]

[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

change in the future and our middleware should 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 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 does not require any prototypes along the way, just a working piece of software by the end of the project, so the deadline we have set for the prototype is self-imposed.

The customer has not given us many strict requirements, but instead they have suggested a few things that we could do. Given this freedom, we decided that we should 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.

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[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/]

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

—

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	-

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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 is one that requires quite a lot of prestudy before we can 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.

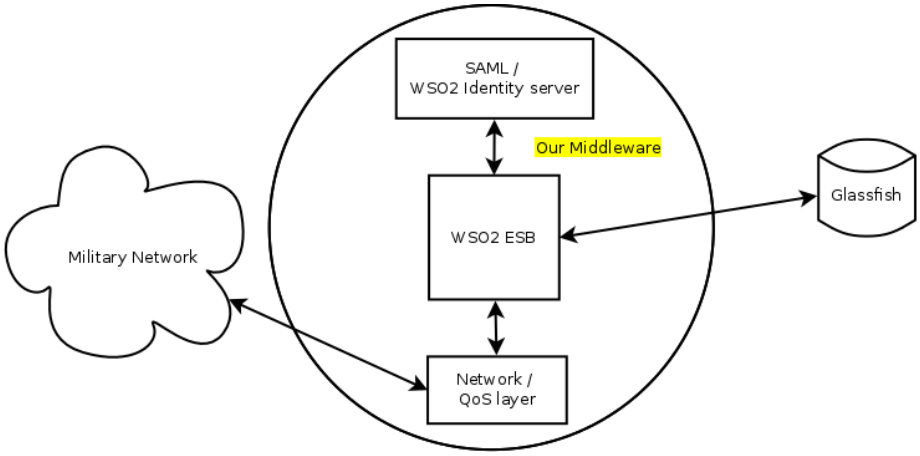


Figure 1: Basic server architecture
This shows our initial thoughts of how the servers side architecture wold look like. This has been changed later in the project.

3.1 Server side Architecture

The server side architecture consists of several components, the WSO2 ESB, the WSO2 Identity Server, the Tactical Router and the GlassFish server. Most

of them are visible in the initial architechture shown in figure 1. All of these components are already available, so what we will have to make is 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 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).

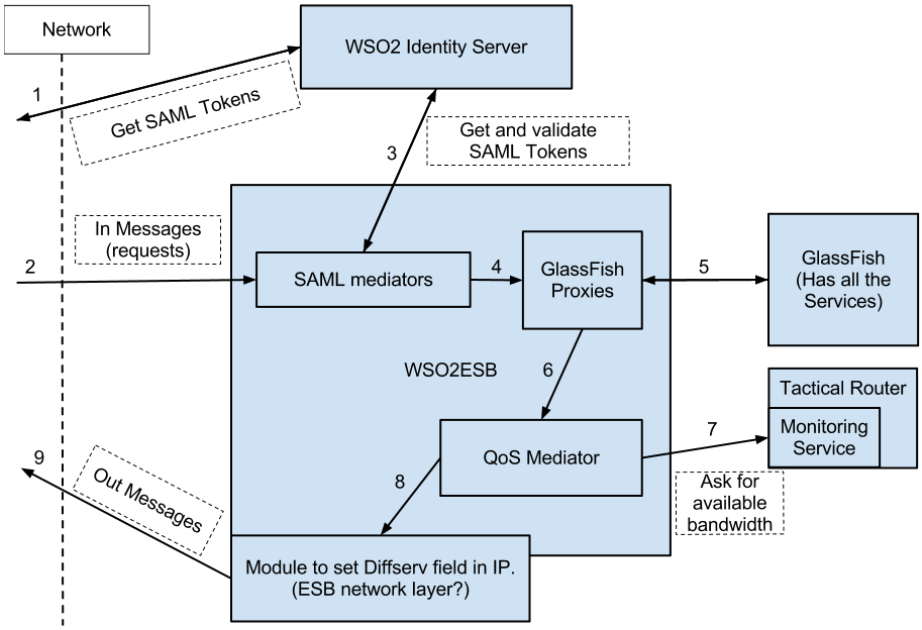


Figure 2: The Server side Architecture
This is the overall design of our implementation of the server side. It shows the modules in the server and the flow in the system.

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

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

[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

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.

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.

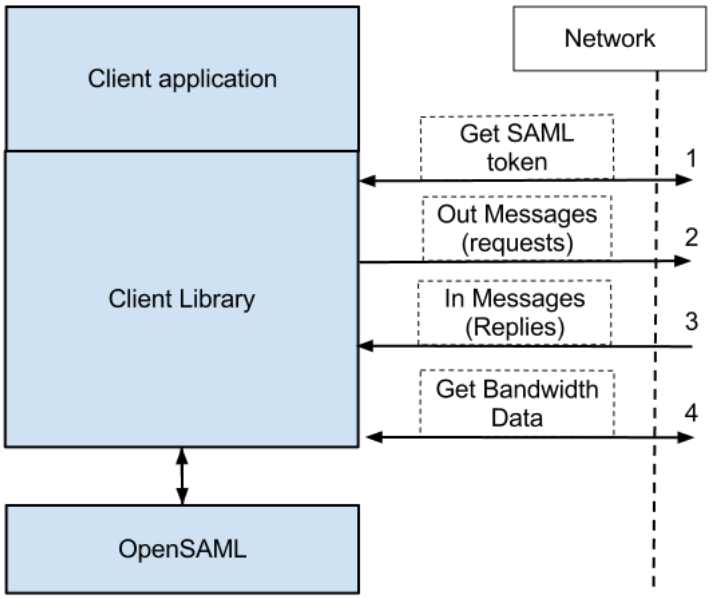


Figure 3: The Client side Architecture
The client architecture shows the basic thought of how the system should look like and the communication to and from the client library.

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.

[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/]

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 (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 to 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. 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 will 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.

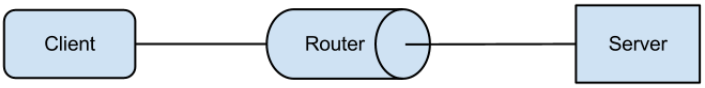


Figure 4: Simple message sending
One client communicates with one server through one router.

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(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 is 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.

Prioritizing messages:
In this test we want to test the ESB's ability to prioritize messages. The scenario

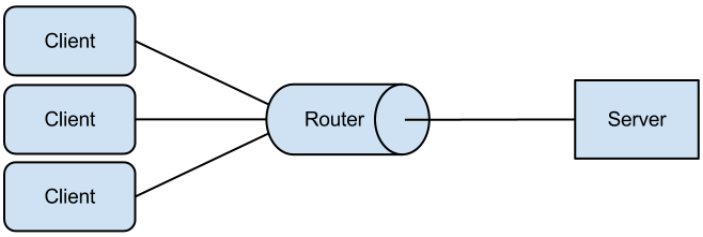


Figure 5: Three clients message sending
Three clients communicate with the same server through the same router. One of the clients will have a higher priority than the two others, in order to test the servers ability to prioritize.

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 sending 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 and the result can be performed and 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 value 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.

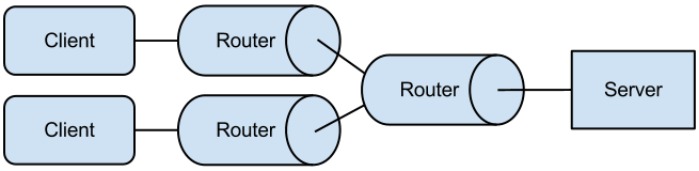


Figure 6: Two Clients with different paths
Two clients communicating with the same server, but with different paths.

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

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

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.

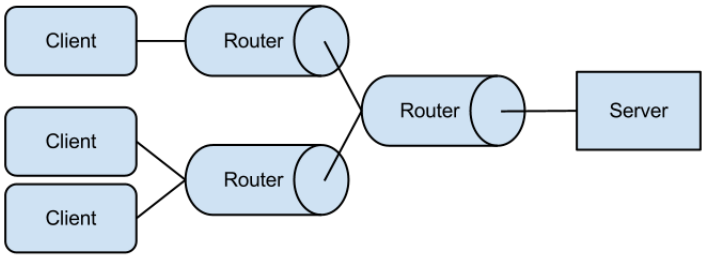


Figure 7: Tree Clients where two are competing
Three clients communicate with the same server, but only two of them share the path.

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. 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 initialisation 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 sending 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.

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 had to be done, 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

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

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

Our initial thoughts on the process was way of. At first we thought we could use scrum methodically and have weekly sprints. And most importantly start coding at once. This was before we really figured out what our task was. And the implications the task had on our approach to a solution.

When the Task Description and Requirements(2) became apparent we had to radically rethink our approach to the whole development approach and process.

The task required us to research a lot before we could design our system. And the design was essential for us to be able to implement a solution to the given task. We ended up with a waterfall like approach. Our project life cycle is described in section 5.2.

The gantt [TODO: ref the gantt chart**??**] chart is the result of the process planning. In short terms the plan consists of four parts: research, design, implementation, documentation. In practice we found out how to solve the task before we designed our solution. Then we coded and set up the system and tested it. And then everything was documented in the documentation phase.

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 organize ourselves and how we split roles and tasks among the team members. We have a flat team structure[25] and have

[24] Hypertext Transfer Protocol

[25] 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

shifted our focus accordingly over to team communication.

4.1.1 Team Structure

We already know each other coming into the project so we have chosen a flat organisational structure (Fig:8), with no intervening levels of management, since all decisions within the team will more or less be made by all the members together either way. Relying on the entire group for decisions will both involve and invest everyone in the project and will work well with our already existing group dynamic.

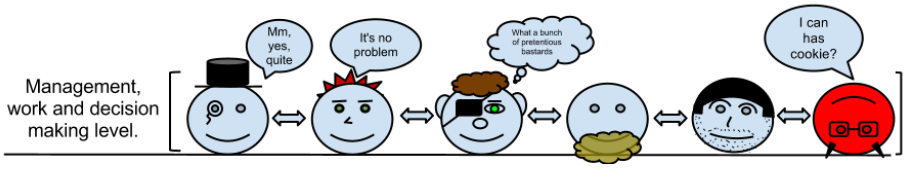


Figure 8: Team Organization chart
It was made during lunch, but the general principle still remains, that the structure is flat.

As the structure shows in the chart (Fig:8), there is no difference in what responsibility level anyone have, or what role one has. 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 anticipate that the time for this project probably won't be sufficient for any role changes, and therefore we have to keep people focused on the task they have been assigned. The efficiency of the current task relies 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've chosen to focus on tasks. The task will to some degree still represent areas of responsibilities, and since tasks will be spread across several group members, we don't run the risk of a single missing member crippling the entire group. Instead the remaining member(assigned) to a task will be able to pick of the slack. This, together with thorough documentation of a members knowledge, will just about eliminate the problems associated with an absent group member.

Further, the team structure and the distribution of responsibility gives us the chance to define how we want to deal with task and their priority. The work flow that we have makes us prioritise tasks continuously and 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 choose a task we consider the person's interest, experience and existing knowledge. Most times the tasks fall naturally to one person that has worked with similar tasks earlier in the project. Other times there is more of

with decision making. [http://en.wikipedia.org/wiki/Flat_organization]

lottery, where the task has no prerequisites. Often we rely on a person's initiative to take a task or we easily delegate them with a question, "Can someone do that?". Task delegation and sharing the work load has not been a problem so far in the project.

4.1.2 Team communication

We decided that we will work together from 10 to 16, Monday through Thursday every week, with allowed exceptions for lectures and such. Group members can 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 we can either take some time off now and then, or have more time for the exams in May.

We will 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* 4.1.1. It describes the general structure and the ideal situation and delegation. But to make this work in practice roles are unconsiously delegated to different people. A person then ends up with a role loosely based on the first delegation of a task. The first person to do that task has more experience then other people, so next time that task, or a similar one has to be delegated it is delegated to the same person as last time, sinse that will be more efficient.

Jan - IS, Jørgen - NS3, Ola - rooms, Magnus - Report, Stig - client.

4.2 Risk Assessment

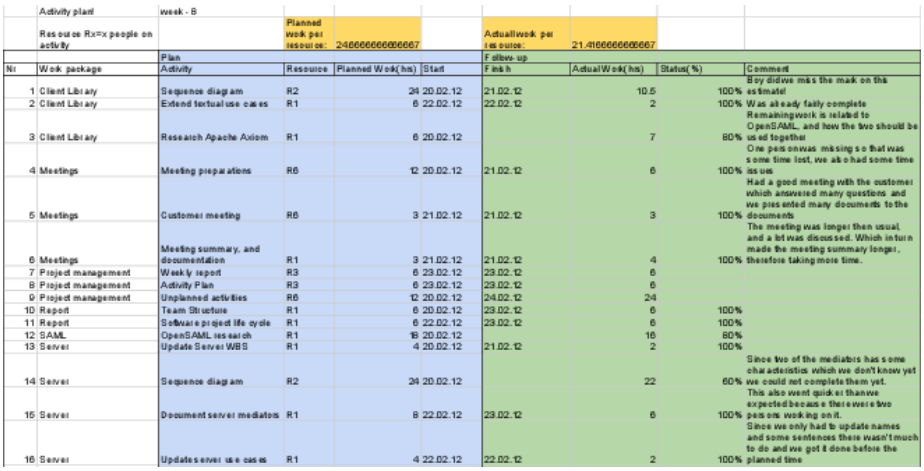
This is where we elaborate the risks in this project. And the immediate threats of our progression. In combination with what we see as likely misunderstandings and conflicts that will occur.

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.

The activity plans(Fig:9) now have the role of our day to day summaries and work progress. We update the activity plan as we go along. This way we have a complete overview of tasks and work hours that are planned this week. As we update the activity plan we have an overview of the work done this week and where we have missed with our time estimation.

As we can see in the weekly report (Fig:10) the staus report has a standard setup. We created a template early in the project so that we could reuse it later



	Activity plan	week - 8						
	Resource Rx=x people on activity		Planned work per resource:	24666666666667		Actual work per resource:	21.416666666667	
		Plan				Follow-up		
Nr	Work package	Activity	Resource	Planned Work(hs)	Start	Finish	Actual Work(hs)	Status(%)	Comment
1	Client Library	Sequence diagram	R2	24	20.02.12	21.02.12	10.5	100%	Boy did we 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%	Remaining work 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 person was 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 than we 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 fiugre displays the structure of our activity plans. It's meant as an overview. See the attachments for full weekly reports.

and reduce work. In the process of creating the template we put some thought in to 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 Process Evaluation

Project management documented: Possible deviations and how they have been handled.

5 Development Methodology

We did not follow any established development methodology, such as Scrum[26] or XP[27], as this project required more planning and configuration of existing solutions, than actual coding. We therefore chose a mix of the Waterfall model[28] and Agile methodss[29], 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 is a research project, the customer will act more as an advisor than a customer, and will have more suggestions and advice than demands and requirements. We have been given a clear understanding of what the final

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

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

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

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

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

product should be, and we have a list of requirements that should be met. Other than that, we are relatively free regarding how we go about solving the problem. Because of this, a single methodology, like Scrum, won't work for us, as it requires us to be in close and frequent contact with the customer, presenting a prototype every other week and continue development based on the customers feedback and demands.

As mentioned, this is a project that requires quite a lot of planning before any programming can be done. This necessitates that we start 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 ensure that the plannning is done thoroughly to minimize the ammount of trial and error during the later implementation phase.

As the project progresses we'll be switching to a more agile development method, in order to allow iterative development and facilitate any necessary changes that may turn up as code is produced, as opposed to waterfall-coding, where we have to strictly follow our plans. Agile also lets us use the flat organisational structure we have chosen, which we believe will greatly help cooperation within the team.

5.1 Project Organization

We have devided the project tasks in to work packages. These packages are represented in a WBS[30] (A). The schedule for the project is represented in a Gantt Chart[31] (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 (D).

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	13d 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 in attachments: (D)

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. With the agile method

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

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

there is elements that suits us better then 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[32]. Individuals and interactions are strongly connected with the organization of our team (4.1). The flat team structure force us to have a good dialog among the group members. This increase 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 is to make sure that we produce a product that the customer wants. To achieve this part of the agile manifesto we have meetings with the customer every week and have frequent email correspondence to iron out the bumps of our product. The frequent communication with the customer helps us to create a more precise and consistent system with better documentation. The main part of the communication with the customer is for the benefit of the project and constant improvement. The constant improvement and iterative work flow is a central part of the agile method.

5.3 System Technology

We intend to do a test driven development in order to achieve high quality code. This will give us something to test while we are working, and it will also give us a great way to tell if some new piece of code gets in the way of previously written code. For this purpose we will use JUnit[33] as the testing framework. We will also be doing periodical code reviews approximately every two weeks of development, synchronized with a code/feature freeze where we make sure everything works. As the customer wanted extensive testing of the middleware, we agreed to do testing on the network emulator NS3, as we have someone in the group already familiar with it. The advantage of using NS3 will be extensive testing, but also a great deal of empirical and verifiable data, which the customer can also use to evaluate the product.

We will use Git[34] and GitHub[35] to handle our file repository, although Google Docs will be used for easy sharing and collaboration of schedules, meeting minutes, and reports. Even though the course set us up to use Subversion (SVN)[36], we decided against this as Git gives us more options to develop code which will not greatly affect other parts of the code base before we decide to integrate it. To this extent we have decided that we should take advantage of Git's built in support for 'branches' as much as possible. The argument for using Google Docs is that we have the possibility of editing a document together and easy sharing of documents. Delivered reports will be created with LaTeX[37],

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

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

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

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

[36] Subversion - A version control system

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

which we prefer over standard word processors. Our GitHub repository is open to the public, and the software will be released as open source, most likely under the Apache License.[38] In some places we are forced to use the ASF, like the changes we have done to Apache HTTPComponents and Apache Synapse, but as the licenses allows for derived works to be licensed under a different license we are free to chose a different one. The Apache License version 2.0 is also compatible with the GPLv3 so there is no problem for us in using either. We argreed to use the Apache2 license. FFI could not find any negativities for them in the license so we decided to use it.

Each of us is free to choose his own IDE[39] for programming. Because we are using Git, there should be no problem in using the IDE of our choice, and this gives us the added advantage that each person can use the tool which he is most comfortable with. We will stick to the standard Java Coding Conventions.

Since we were so free to choose which tools we wanted to use we decided that this list should be quite lightweight. However the list compiled should be an indication of what is needed for the project. Some of the tools were chosen by us as is and other were demanded by needs of other components. All tools used can be upgraded, downgraded or dropped during the course of this project. The final report will contain the official list as such this list is not in any way final. Our final report will also contain a list with supported tools tested with the final product.

- Git version 1.7.x
- Java version 1.6.x
- Free choice of IDE
- 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

6 Design

6.1 Client Side

This chapter will introduce the design and architecture of the client side 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.

[38] http://www.apache.org/licenses/LICENSE-2.0.html
[39] IDE - Integrated Development Environment

The class diagram is a usefull addition when understanding the architecture of the client library and it's 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 components: The client application, the client library and the Monitoring Service. Additionally, the library makes use of some external components to do some of it's 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 prioritization it should have.

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[40] 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 componentsy.

6.1.4 Use Cases

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

1. Client software connects to the library interface

[40] XML - eXtensible Markup Language

2. Client delivers its credentials
3. Credentials are passed from the interface to the sequencer.
4. Credentials are sanitized 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:

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.

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 ReturnObject 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

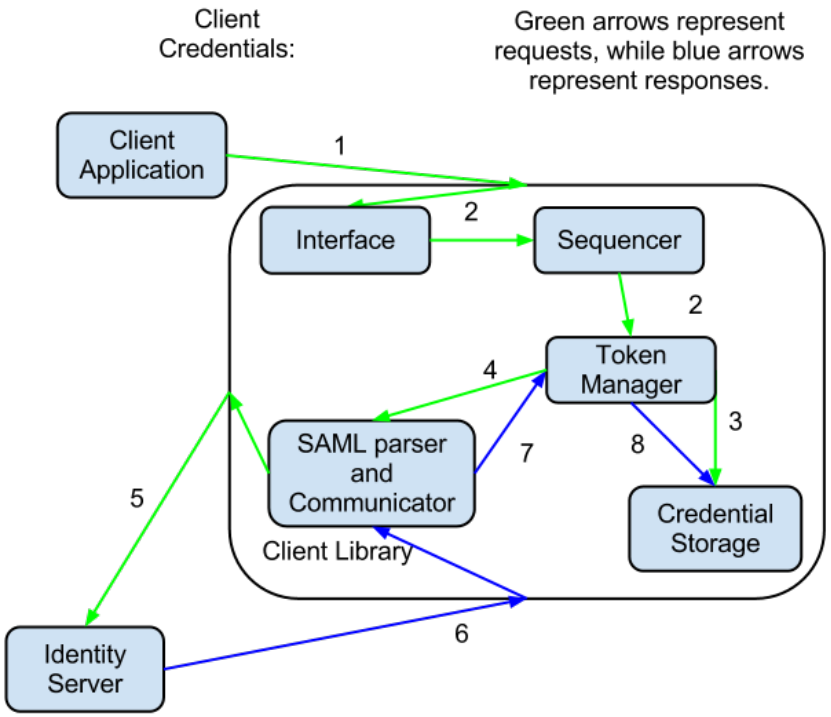


Figure 12: Client Credentials Flow
This figure describes how the client credentials are sent through the client library and through the system in general.

6.1.5 Data Flow

Client credentials (Visualized in Fig.12)

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 comunicator 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
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.13)

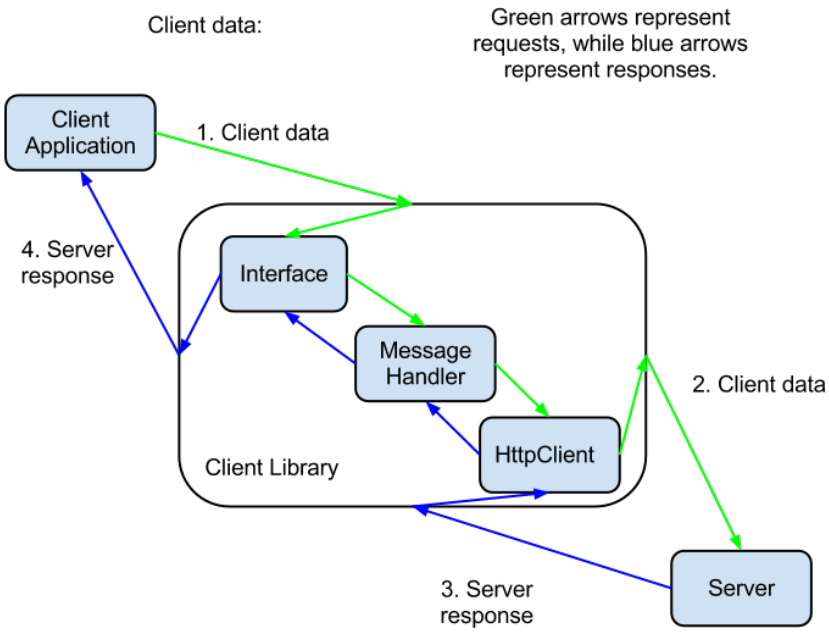


Figure 13: Client Data Flow
This is the message sequence. It describes the route the individual mesages takes throguth the system.

1. The client generates data and sends it to the library via API/Interface
2. The library does its magic, and sends the data to the server
3. The server sends a response to the library
4. The library passes the response to the client

6.1.6 Architecture

All the following sub paragraphs in this subsection are parts of the client library which is shown in figure 14.

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.

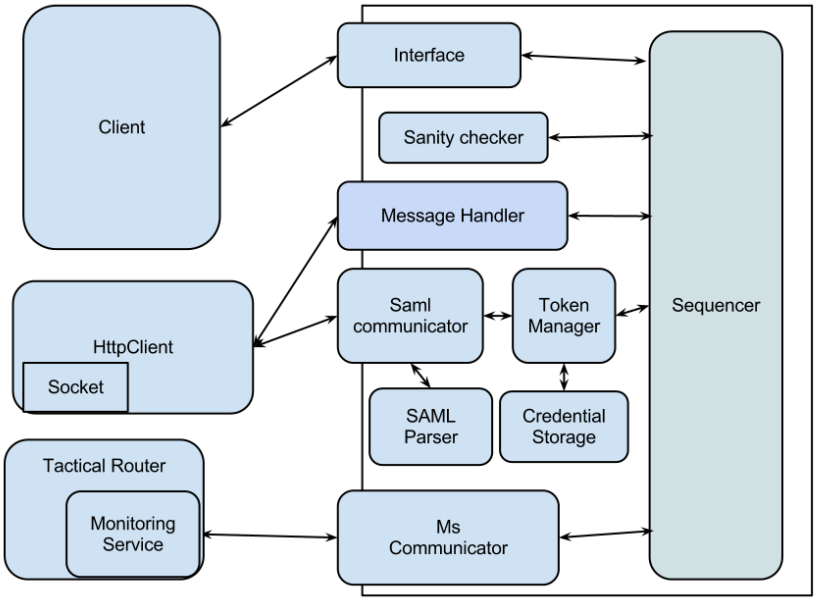


Figure 14: Detailed Client Architecture
This describes in detail the sctructure of the client library.

Sanity checker
This module is simply there to do some easy verification of data that comes from the client, to make sure that it isn't faulty in any obvious way (e.g: Data that isn't xml, or credentials that are empty).

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

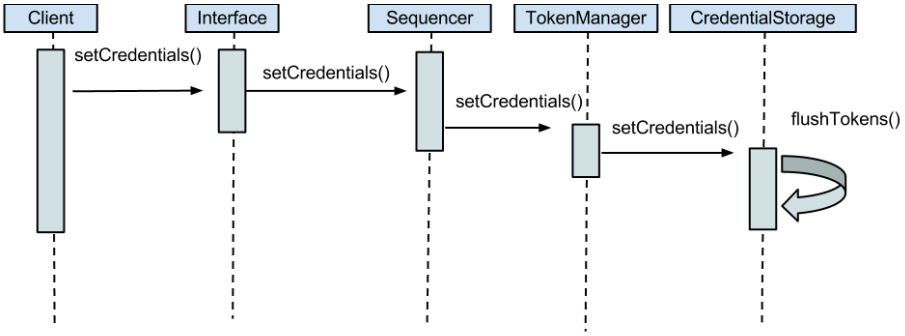


Figure 15: Accept client info
This describes how client credentials are set in the client library.

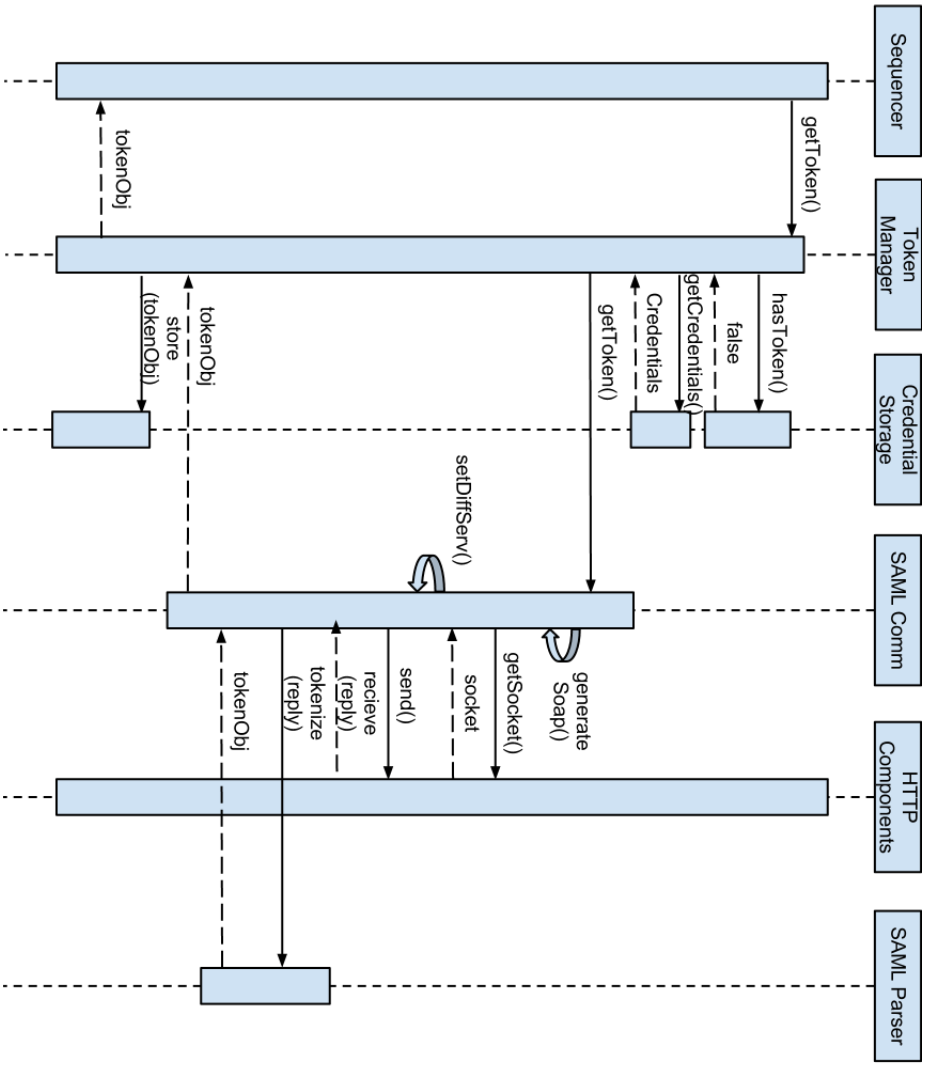


Figure 16: Getting non-stored token
This describes how the client library gets a token and stores it when there is no stored token in the library already.

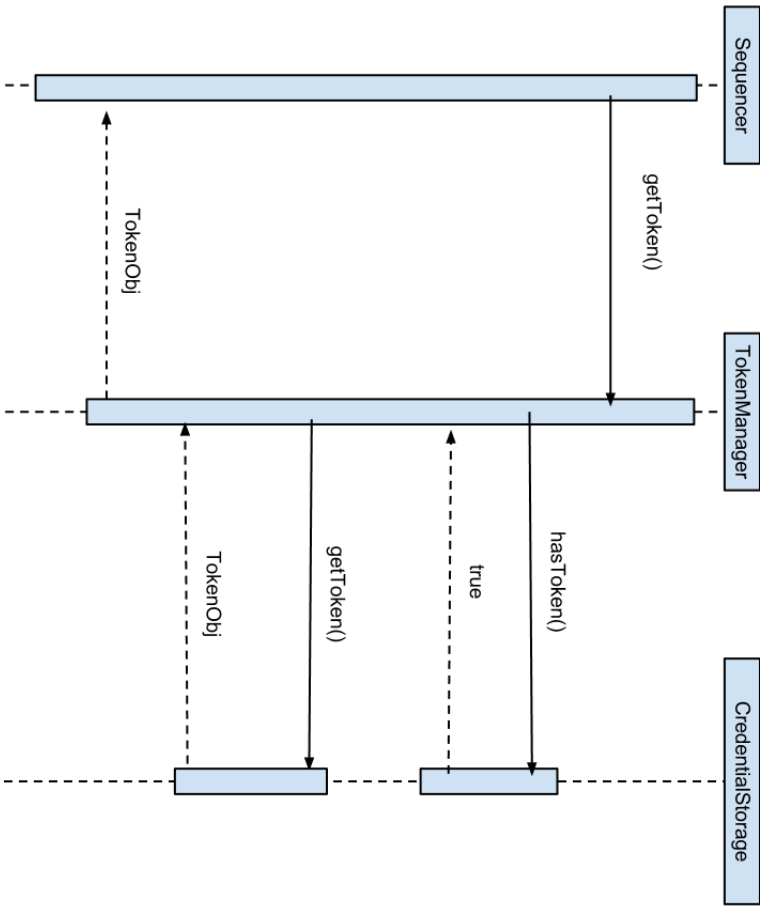


Figure 17: Getting stored token
When a token exists we return the token without creating a new one.

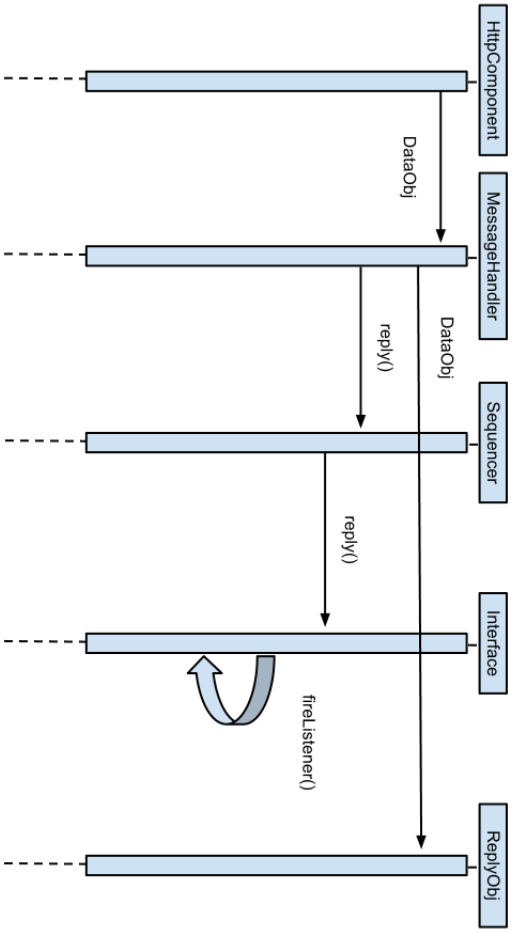


Figure 18: Receive reply
This is how the client library sends a reply to the client.

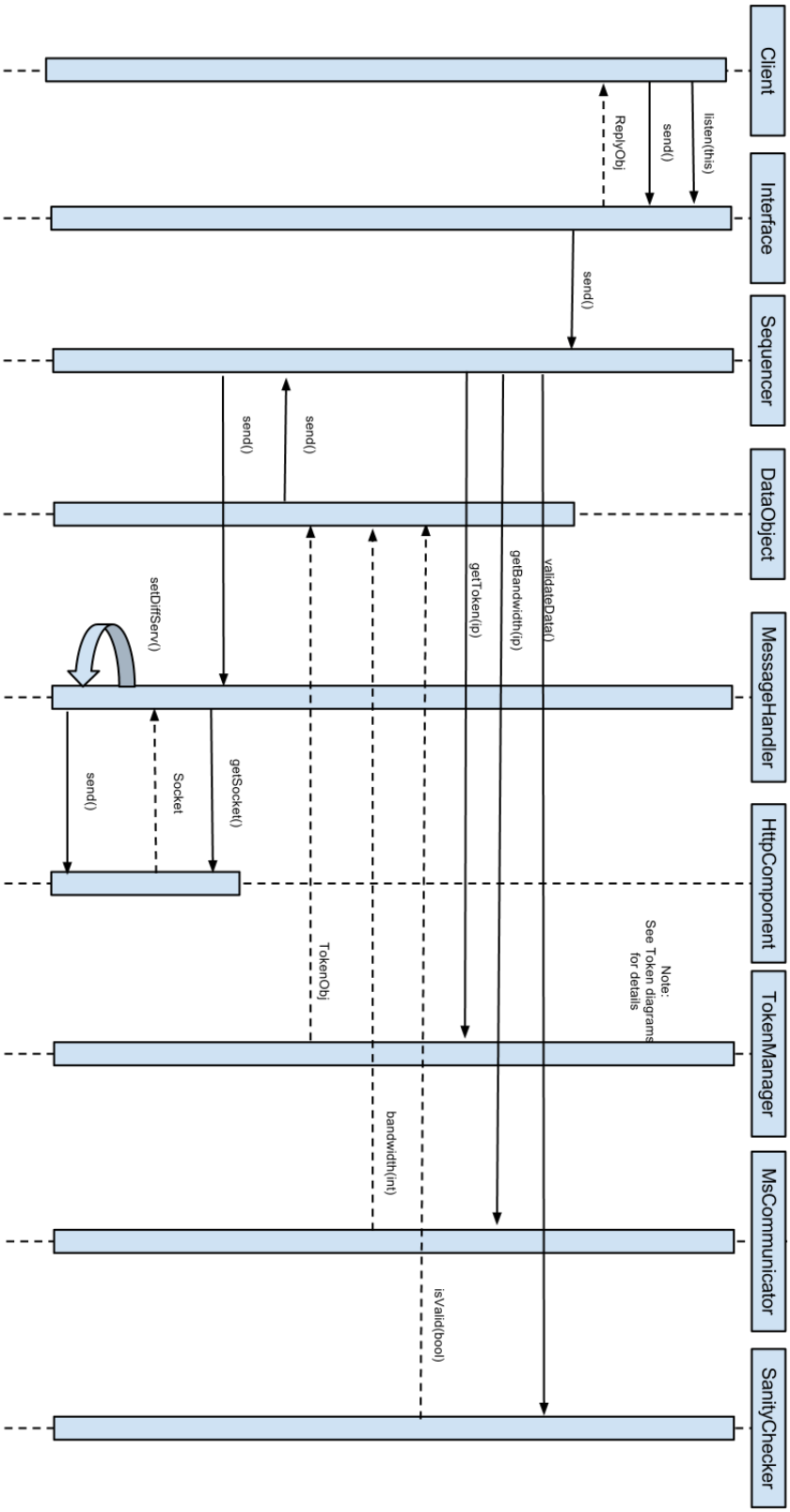


Figure 19: Send data
This diagram describes how data is sent through the client library.

6.2 Server Side

In this chapter we are going to introduce the design, configuration and modification that we are going to do 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 thoughts about the 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 good system overview. 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. The last section, 6.2.8 will depict how we have modified the framework to be able to meet our requirements, with this section you should be able to tell what modifications were needed and how we have altered those pieces.

6.2.1 Introduction

The server side architecture consists of several components, the WSO2 ESB, the WSO2 Identity Server (IS) the Monitoring Service and the GlassFish server. The GlassFish server is not necessary to modify, the MS is something we must assume exist in the network, and in the IS we only have to configure it to work with the ESB. The ESB is what we have to modify, configure and extend to meet the requirements set.

The ESB will be used to implement QoS for the web services. To do this, it will have to communicate with the IS and 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, and the IS. 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 ESB source code to allow for setting the diffserv field 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 for SAML authentication
Actors: Client, Enterprise service bus(ESB) and Identity server(IS)
Main

1. Client sends a SOAP message to ESB containing credentials
2. ESB mediates the message to the IS

3. IS fetches SAML Token
4. IS sends the message to ESB
5. ESB adds metadata to SOAP message
6. ESB sends the message back to the client

Extensions:

3a. Invalid credentials

4a. IS returns error message

6a. ESB sends error message to client

Precondition:

- There exists a connection between the client and the ESB

Title: Request mediation
Actors: Client, ESB, GlassFish
Main

1. Client sends SOAP message with SAML Token to ESB proxy
2. ESB authenticates SAML Token(See Authentication use case)
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
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 the address of 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
Actors: ESB
Main

1. ESB acquires QoS information (by magick)
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

Title: Authenticate SAML token
Actors: ESB, IS
Main

1. ESB sends SAML token to IS
2. IS authenticates the token
3. IS sends verification to ESB

Extensions:

2a. SAML token is not valid.

3a. IS sends error to ESB

Precondition:

- Request Mediation

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[41]. 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.

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.

Service Request :
To follow this flow, follow the green arrows in figure 20. The ESB receives a request message from a Client, it is then authenticated or, if not, an error is sent back to the client. If it is not authenticated the flow stops, otherwise the message is sent to the SAML mediator, and then to the send mediator which sends it to the service endpoint on the GlassFish server, and the flow is over.

Service Response:
To follow this flow, follow the blue arrows in figure 20. The ESB receives a response message from the Service, it is then sent through a sequence of mediators, first the Metadata mediator, and then the Store mediator. The Store

[41] Apache Synapse - An enterprise service bus

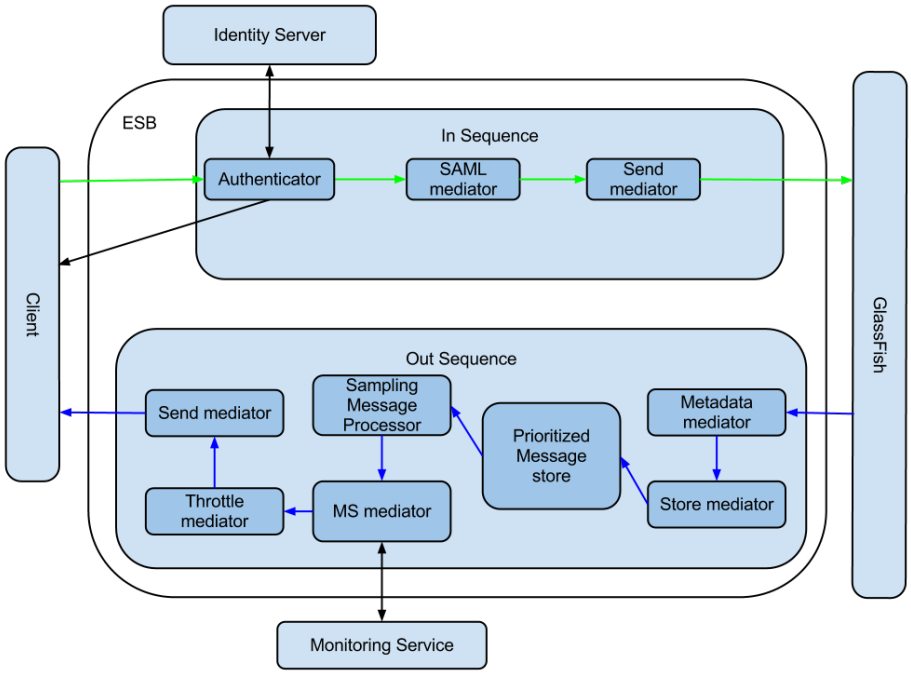


Figure 20: Server Data Flow
This diagram displays how the date flows through the server side.

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 MS 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 21.The ESB receives a request (from a Client) directed at the Identity Server (IS), the ESB relays this message to the IS. The ESB receives the response from the IS, and sends it through a mediator sequence consisting of the Priority mediator and the Send mediator. The send mediator sends the response to the Client.

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 extensions we make to the ESB, and then a short description of the built-in mediators we will use.

Custom mediators:

SAML mediator:
This mediator retrieves the user role from the SAML authentication and set this

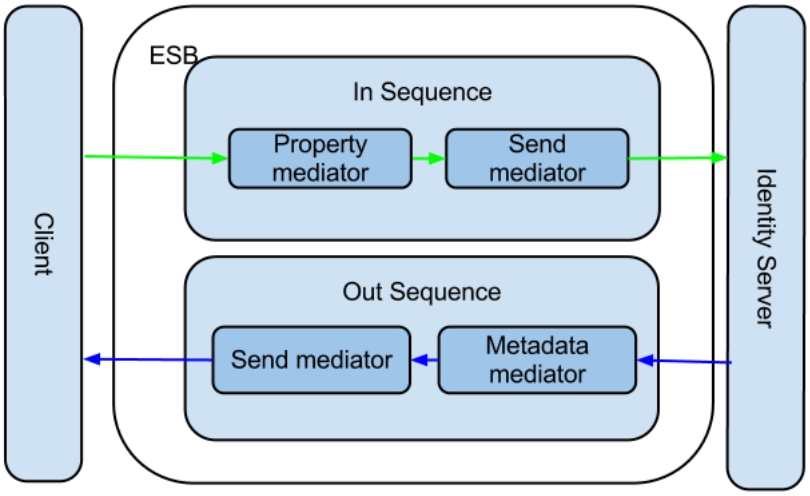


Figure 21: SAML Authentication Flow
This describes the flow of an authentication request.

as a property in the message context. The service is retrieved from the endpoint reference and set as another property.

SendBack mediator:
This mediator sends a SAML authentication error message back to the client. After the error is sent to the client, the message is forwarded to the Drop mediator. We are not quite sure if this mediator is needed or not, as it is difficult to determine this before having at least some other parts of the system ready for testing.

Metadata mediator:
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 6.2.8).

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.

MS mediator:
This mediator retrieves the IP address[42] of the receiving client from the endpoint

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

reference in the message context. It sends this IP address to the Monitoring Service and gets the IP address of 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.

Throttle mediator:
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. This mediator does not have a companion sequence diagram as of the midterm report. The reason behind this is currently a lack of possibility to test the mediator, this will however be remedied when we start to implement the mediators. Once we are more sure of what this mediator will be capable of, we will make a sequence diagram for it.

Built in Mediators:

Drop mediator:
This is a built in mediator that drops the message, preventing further processing.

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

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 MS mediator.

6.2.6 Sequence Diagrams

This section contains some sequence diagrams which you can use to get a more in depth look into the code and methods used in the mediators above.

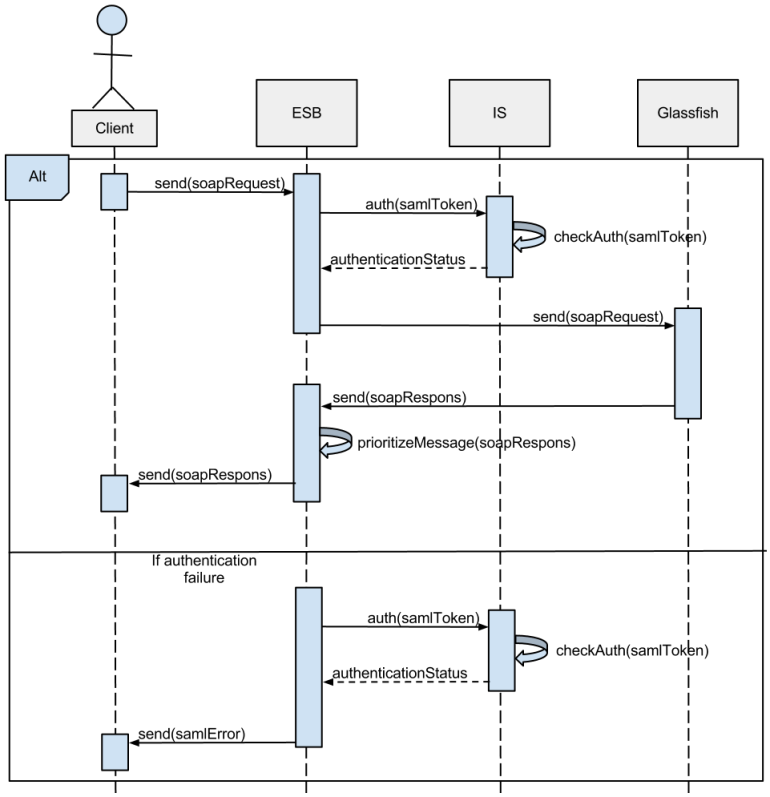


Figure 22: System-level sequence diagram
This high level diagram shows how the client communicates with web services through the ESB.

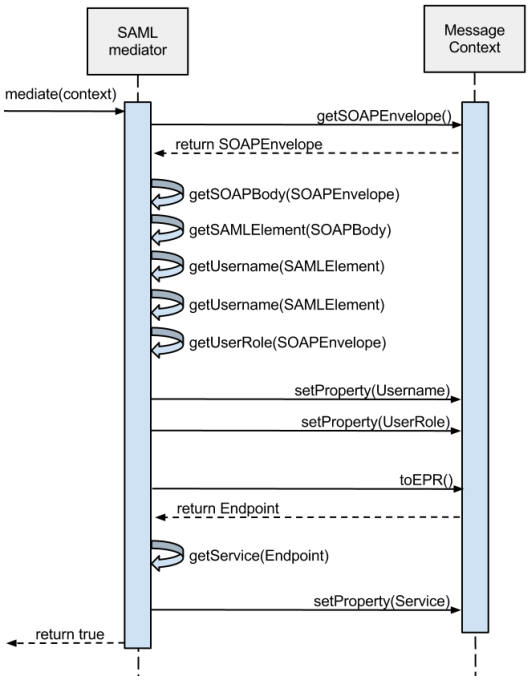


Figure 23: SAML mediator sequence diagram
This diagram describes how the SAML mediator will get data from the message, and set it in the message context so it can be used later in the response sequence

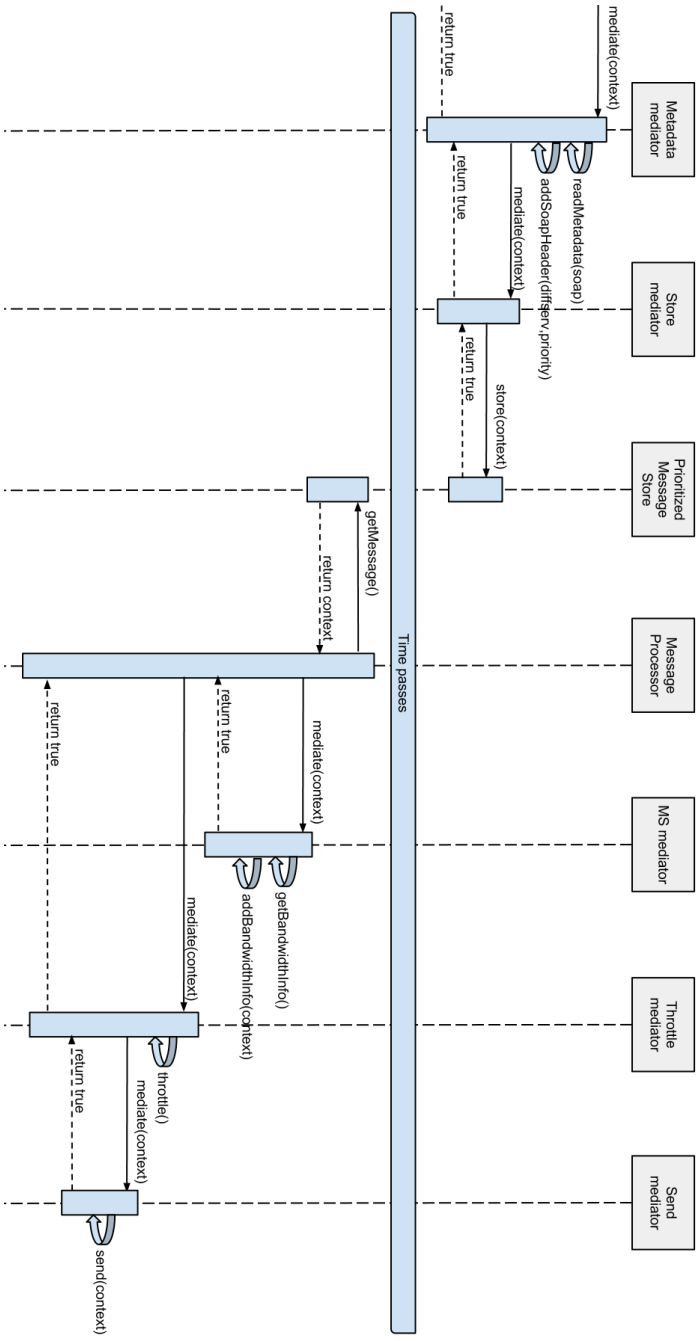


Figure 24: Response sequence sequence diagram
This diagram describes, in some detail, how a response message from the web service to the Client is passed through the ESB.

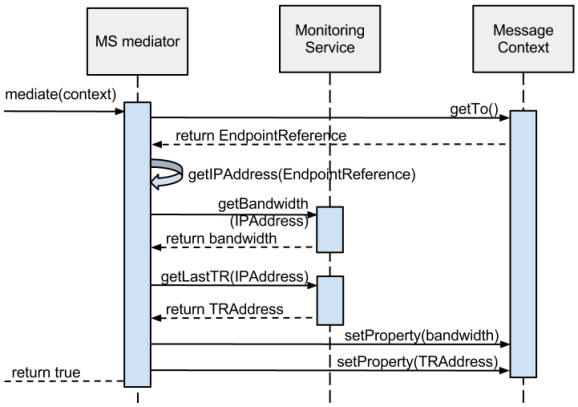


Figure 25: Metadata mediator sequence
This diagram describes how the Metadata mediator retrieves previously stored properties from the message context, determines a priority for the message, and sets priority and diffserv properties in the message context

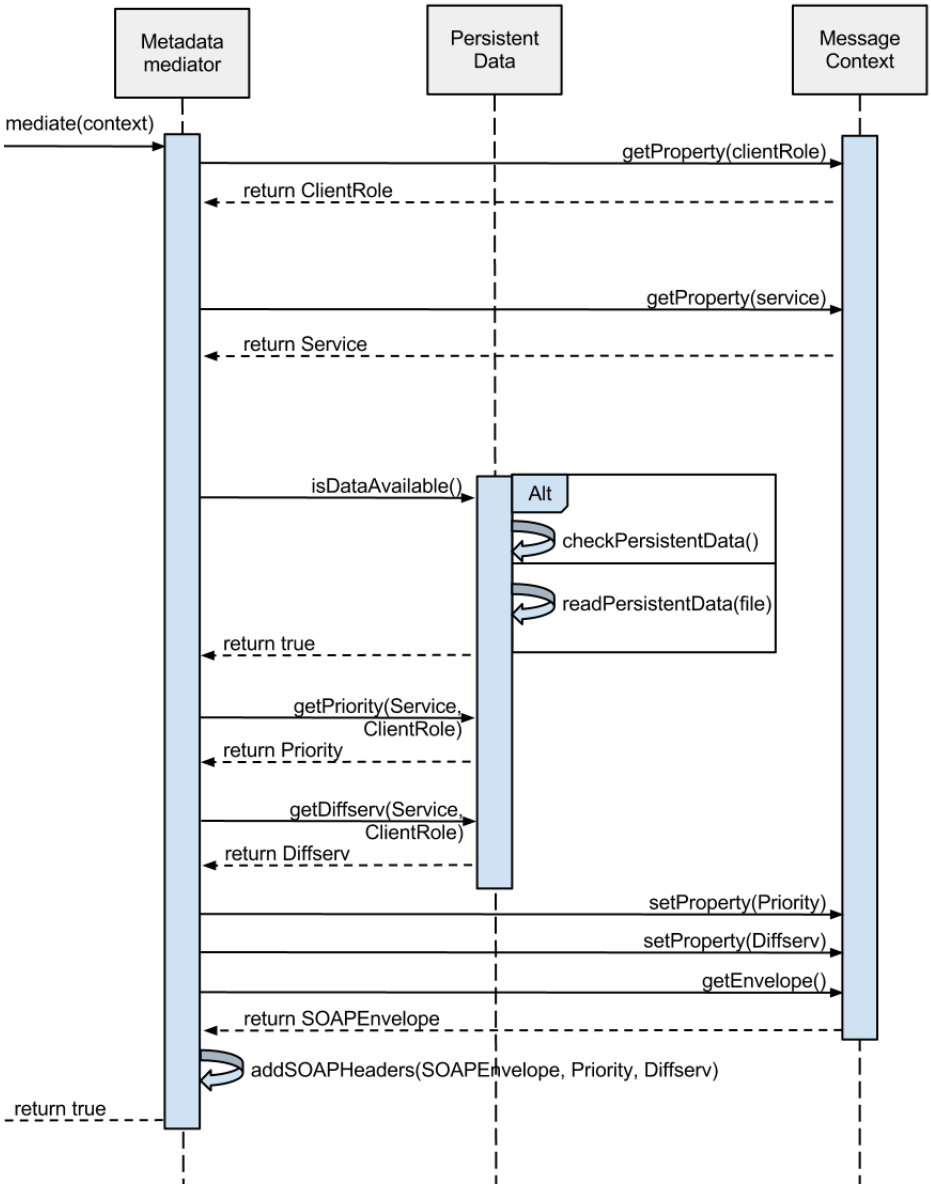


Figure 26: MS mediator sequence diagram
This diagram describes the MS mediator contacting the Monitoring Service for bandwidth information

6.2.7 Configuration of the ESB

This section will be about how the ESB is to be configured.

6.2.8 Modification of the ESB

The WSO2 ESB source code will have to be modified to allow for setting the diffserv field in the IP-header of packets sent. The idea is that we will set a property, DiffServ, in the message context, and let the HTTPsender get this property and set it on the socket used for sending.

The source code for all the dependencies of WSO2 ESB is included in its source code. As such we only altered files in this source. This made it easier for us to build and create a runnable instance of WSO2's ESB. To also try and support future versions of Apache Synapse and WSO2 we have also applied the changes to the latest version of the underlying libraries.

In Apache Synapse we have altered the way it sends responses to already established connections. This alteration is dependent on support in the underlying library of Apache HTTPComponents(HC for short) which we have also altered to include support for setting traffic class. Since Synapse is dependent on HC we are, as of the midterm report, trying to get our changes accepted into HC[43]. We have included in our references SVN diff files and included instructions on how to apply them to a newly downloaded version of HC. We are planning to also push our changes in Synapse upstream, but we are waiting for the acceptance of our HC changes first.

7 Implementation

[This section describes the changes and inconsitencies from the design part. We might also discuss implementation specifics and details that are important for the system to work.]

8 Testing

[The testing setup and suite. The testing method and how we did the testing.]

9 Conclusion

[The summarised findings of the project and presentation of the key findings.]

9.1 Project accomplishments

[Did we reach the goal?]

9.2 Future Work

[What we would have to do in the future to complete or continue this work.]

9.3 Prototype demonstration

Discuss the prototype presentation on monday and the results of it.

[43]Link to our ticket in HTTPComponents HTTPCore issue tracker [JIRA: HTTPCore Issue 295]

10 Project Evaluation

[This is the section where we evaluate the project and the past process.]

10.1 Task evaluation

10.2 Team organization

10.3 Planning

10.4 Methodology

10.5 Meetings

10.6 Communication

Group communication
The communication inside the team worked good, 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.

Supervisor communication
The overall communication with the supervisor has been as expected. Some times there would have been nice with an answer to some of the emails about meetings. Typically we ask the supervisor for a meeting, decide time and place, and the supervisor doesn't confirm the meeting time, but he shows up so there is not really a problem. The communication with the supervisor has been as expected.

Customer communication
The communication with the customer went well. We had a lot of communication over email, and we had weekly meetings over Skype.

10.7 Design phase

- went smoothly, but did the design work out as we planned it?

10.8 Implementation phase

10.9 Overall Summary

A Work Breakdown Structure

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

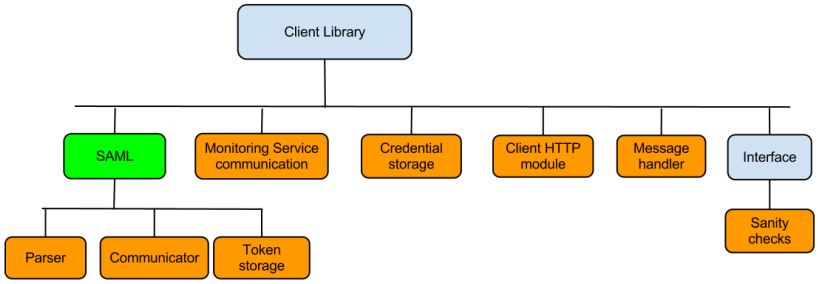


Figure 27: WBS-Client
The work break down structure for the client library.

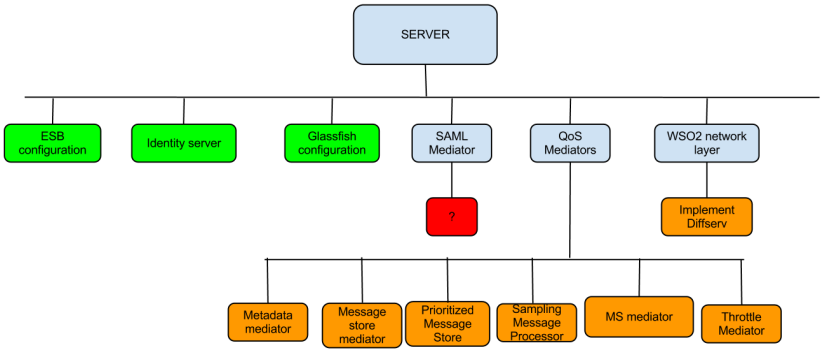


Figure 28: WBS-Server
The work break down structure for the server.

B Client User Guide

[The client user guide.]

C Server Setup Guide

[The server setup guide]

D File Attachments

The files can be unpacked using the pdftk program in Linux with the command: pdftk filetest.pdf unpack_files

Risk List

 Gantt Diagram

 Quality of Service (QoS) support for Web services in military networks

Glossary

LaTeX A document preparation system for the TeXtypesetting program http://www.latex-project.org/. 23

Agile methods A group of software development methodologies based on iterative and incremental development http://en.wikipedia.org/wiki/Agile_software_development. 20

Apache Synapse A lightweight and high-performance Enterprise Service Bus http://synapse.apache.org/. 39

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. 16

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. 22

Git A free and open source, distributed version control system http://www.git-scm.com. 23

GitHub A web-based hosting service for software development projects that use the Git version control system http://www.github.com. 23

GlassFish An dpplication server written in Java http://glassfish.java.net/. 5

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. 17

HTTPComponents A toolset of low level Java components focused on HTTP and associating protocols http://hc.apache.org/. 25

IDE Integrated Development Environment. A software application that provides facilities for software development such as source code editor, compiler etc.. 24

Identity Server http://wso2.com/products/identity-server/. 9

IP address A numerical label assigned to each device connected to the Internet. 41

Java Coding Conventions http://www.oracle.com/technetwork/java/codeconv-138413.html. 24

JUnit A testing framework for the Java programming language http://junit.org/. 23

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. 10

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

Monitoring Service Monitoring Service, a service that provides bandwidth monitoring, running on the same server as the Tactical Router.. 10

NS3 A network simulator http://www.nsnam.org/. 7

OpenSAML A set of open source C++ Java libraries to support developers working with SAML. https://wiki.shibboleth.net/confluence/display/OpenSAML/Home/. 11

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. 13

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. 10

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. 4

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). 20

SOAP A lightweight protocol intended for exchanging structured information in the implementaion of web services in computer networks http://www.w3.org/TR/soap12-part1/#intro. 4, 5

Subversion Subversion exists to be universally recognized and adopted as an open-source, centralized version control system characterized by its reliability as a safe haven for valuable data; the simplicity of its model and usage; and its ability to support the needs of a wide variety of users and projects, from individuals to large-scale enterprise operations. https://subversion.apache.org/. 23

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.. 10

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. 20

WBS Work Breakdown Structure. An oriented decomposition of a project into smaller components http://en.wikipedia.org/wiki/Work_breakdown_structure. 22

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. 5

WSO2 ESB An Enterprise Service Bus built on top of Apache Synapse. http://wso2.com/products/enterprise-service-bus/. 5

XACML eXtensible Access Control Markup Language https://secure.wikimedia.org/wikipedia/en/wiki/Xacml. 5

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/. 25

XP Extreme programming is a type of agile software development http://en.wikipedia.org/wiki/Extreme_programming_practices. 20

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. note: TODO.

E Attachments

[Here we will add all the attachments. The weekly reports, schedule, activity plans and so on.]

¡¡¡¡¡¡¡ HEAD =======
old

The files can be unpacked using the pdftk program in Linux with the command: pdftk filetest.pdf unpack_files

 Risk List

 Gantt Diagram

 Quality of Service (QoS) support for Web services in military networks

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