

# Improving the performance of Web Services in Disconnected, Intermittent and Limited Environments

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### **Abstract**

In this thesis I investigate different techniques to improve the performance of Web services in typical tactical network environments.

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# Part I

## Introduction

Military units may operate under conditions where the reliability of the network connection is low. They can operate far from existing communication infrastructure and rely only on wireless communication. Such networks are often characterized by unreliable connections with low bandwidth and high error rates making communication difficult. In a military scenario it is necessary for units at all operational levels to seamlessly exchange information across different types of communication systems. To NATO, this concept is referred to as Network Enabled Capability(NEC). In a feasibility study, NATO identified the Service-Oriented Architecture and Web Services as key enablers[1].

Web services is well tested in civil environments where the network is stable and the bandwidth is abundant. However, military tactical networks may suffer from high error rates and low bandwidth which can leave the Web services unusable. To overcome these challenges we can apply optimization techniques at different layers of the protocol stack which is investigated in this thesis.

Expensive to alter and build own proprietary solutions, better to use commercial off-the-shelf software. Therefore, by putting the optimization in proxies, the client and services can remain unchanged while the proxy handles the optimization.

## 1 Background and Motivation

NATO is an military alliance consisting of 28 member countries[2] and which primary goal is to protect the freedom and security of its members through political and military means. In joint military operations the relatively large number of member countries can be a challenge when setting up machine-to machine information exchange. Differences in communication systems and equipment can contribute to make data communicating difficult. In order to address this issue, NATO has chosen Service-Oriented Architecture concept.

### 1.1 Service-Oriented Architecture

Service-Oriented Architecture(SOA) is an architectural pattern where application components provide services to other components over a network. SOA is built on principles such as object-orientation and distributed computing and aims to get a loose coupling between clients and services. In their reference model for Service Oriented Architecture[3], the Organization for the Advancement of Structured Information Standards (OASIS) defines SOA as:

*Service Oriented Architecture is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use*

*capabilities to produce desired effects consistent with measurable preconditions and expectations.*

In SOA business logic is divided into smaller chunks of logic, referred to as *services*. A service can be business related, e.g. a patient register service, or a infrastructure service used by other services and not by a user application. Services are provided by *service providers* and are consumed by *service consumers*. The service provider is responsible for creating a service description, making the service available to others and implementing the service according to the service description. Services are made available through a *service registry*, where service providers publish service descriptions. Service consumers finds the services it needs by contacting the service registry. The communication between services occur through the exchange of standardized messages.

Following the SOA principles dictates a loose coupling between services and service consumers which allows software system to be more flexible. Loose coupling with regards to time enables services and its consumers to not be available at the same instance of time. This enables asynchronous communication. Loose coupling with regards to location allows the location of a service to be changed without needing to reprogram, reconfigure, or restart the service consumers. This is possible through the usage of the service registry, which is updated with the new location.

Furthermore SOA enables service implementation neutrality. The implementation of service is completely separated from the service description. This allows re-implementation and alteration of a service without affecting the service consumers. Thus this can contribute to keep development costs low and avoiding proprietary solutions and vendor lock-in. Another benefit with SOA is reusability by dividing common business processes into services, which may help cost reduction and avoids duplication.

SOA is only a pattern and the concepts can be realized by a range of implementations. The most commonly used approach is the Web service standard, using the SOAP messaging protocol. To achieve interoperability between systems from different nations and vendors, NATO has chosen the Web service technology in order to realize the SOA principles. This allows member nations to implement their own technology as long as they adhere to the standards. Web services are discussed in detail in section 9.

## 1.2 Tactical networks

Military mobile tactical networks are characterized by the fact that the units use tactical communication equipment which includes technologies like VHF, UHF, HF, tactical broadband and satellites. Examples of such units are mobile units like vehicles, foot soldiers and field headquarters. These types of networks have low bandwidth, possibly high delay, high error rates and frequent disconnections. They are often called disadvantaged grids or DIL. NATO studies have identified such networks to have the following characteristics:

*Disadvantaged grids are characterized by low bandwidth, variable throughput, unreliable connectivity, and energy constraints imposed by the wireless communications grid that link the nodes[4].*

## 2 Problem Statement

Most of the Web Service solutions used today are aimed for civilian use and does not necessarily perform well in military environments. In contrast to civilian networks where bandwidth are abundant, mobile tactical networks may suffer from high error rates and low bandwidth.

In my master thesis I will investigate different optimization techniques that can be applied to improve communication. In order for the clients and services to remain interoperable the optimization techniques will be placed in proxies.

The Web Services will communicate with his counter part over HTTP as regular, with all traffic going through the proxy. The Web Service itself does not need to pay attention to the bad connectivity, the proxy will choose the appropriate protocol and configuration.

## 3 Premises

Ikke endre web-servicene.

## 4 Scope and Limitations

Snevre inn oppgaven.

## 5 Research Methodology

Denning.

## 6 Contribution

The outcome of this thesis is an recommendation regarding which optimizations techniques which can be used in DIL to enhance the performance of Web services.

## 7 Outline

Hvordan er resten av oppgaven strukturert.

## Part II

# Background

In this part, I will present relevant technologies.

## 8 Related Work

Diskuterer eksisterende arbeid.

## 9 Web services

The World Wide Web Consortium has defined Web Services as[5]:

*A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards.*

However, there also exist other types of Web services which does not follow this definition. RESTful web services let users manipulate data using a set of stateless operations. REST services have gained a lot of traction in the civil industry in the latest years.

## 10 DIL

Disconnected, Intermittent and Limited environments (DIL) definer hva DIL er og hvilke begrensninger det legger.

These constrains of mobile tactical networks are central in order to understand the problem at hand, and I will therefore explain the concepts here:

**Bandwidth and throughput** The terms bandwidth and throughput are used interchangeably in the networking community and refers to the data transfer rate; how fast data can be transported from one point to another in given time period. This is often expressed in bits per second.

**Unreliable connectivity** Units that are participating in a tactical network are highly mobile and may disconnect from a network either voluntarily or not. Unplanned loss of connectivity can be due to various reasons, such as loss of signal or equipment malfunction.

**Energy constraints imposed by the wireless communication grid** The battery capacity and the transmission range of the communication equipment for mobile units may be limited. Another issue is that in some cases military units are required to enter radio silence in order to avoid being detected by the enemy. During radio silence units may only receive data and not send any.

Theese constrains imposes some challenges when employing Web services in tactical networks. In paper X, tree areas that need to be addresses are identified[6].

#### 10.0.1 End-to-end connections

Attempting to establish and maintaining connections in DIL environments can lead to increased communication overhead and possible complete breakdown of communication.

#### 10.0.2 Network heterogeneity

Different technologies used. Different performance in networks may lead to buildup of data in buffers, risking loss of information.

#### 10.0.3 Web Service overhead

Web services generates overhead.

## 11 Optimization techniques

Web services enables interoperability between system, but also increase the information overhead, requiring higher data rate demands. By using proxies, we can freely choose the communications protocols and configurations between the proxy pair without altering the Web Services themself. In this thesis I will investigate different techniques in order to optimize the communication between a Web Service and a Web Service client. The optimization can be implemented at different levels of the protocol stack in use. Table 1 lists an overview of possible optimization techniques studied in this thesis.

### 11.1 Compressing the payload

The first optimization techniques deals with the optimization of the encoding. By compressing the Web service payload, we can reduce the amount of data that need to be sent.

- GZIP

Protocol Stack	Optimization possibilities
The application	Optimize the application
Web service messaging: SOAP	Optimize SOAP, e.g XML compression
HTTP/TCP, UDP or other transport protocols	SOAP is transport agnostic. Other protocols can be used.
IP	NATO NEC feasibility study suggests that all protocols should be over IP.
Lower layers	Not in the scope of this thesis.

Table 1: Optimization possibillities.

- EFX(Efficient XML).

Previous experiments shows EFX has the compression results with GZIP as the second best alternative[7].

## 11.2 Reducing overhead of SOAP

HTTP/TCP is the most used transport protocol for SOAP messages, but since SOAP is transport protocol agnostic different protocols can be used. Experiments show that this is possible.

Transport Protocol	Summary
HTTP over TCP	Widely used. Breaks down in DIL environments.
Military Message Handling System(MMHS)	Optimize the application
Stream Control Transmission Protocol(SCTP)	Features multihoming.
Advanced Message Queuing Protocol(AMPQ)	Application level protocol. Employs a broker architecture with store-and-forward capabilities.
SOAP directly on TCP	Its possible

Table 2: Transport protocols

## 12 Proxies

A proxy is a server that acts as intermediary for requests between a client and server over a network. Proxies can be used to accomplish different tasks, from caching web conten to bypassing filtering and censorship. We can group proxies into three types, forwarding proxies, reverse proxies and gateway proxies.

## 13 Requirement Analysis

A discussed in section 10, the dependency on end-to-end connections needs to be removed. This can be done by adding proxies to the network. Mobile units have to carry batteries with them and the capacity is therefore limited. Advanced compression techniques may reduce the overhead, but also requires more battery. This tradeoff needs to be considered.

Requirement	Priority
Receive and forward HTTP 1.X requests	1
Allow modifications on the payload	1
Allow configuration of HTTP timeouts	1
Keep HTTP-connection alive	1
Support protocol X and y	2

Table 3: Proxy requirements

## 14 Summary

# Part III Design and Implementation

## 15 Overall Design

## 16 Proxy

### 16.1 Squid

Squid is a fully-featured HTTP/1.0 proxy.

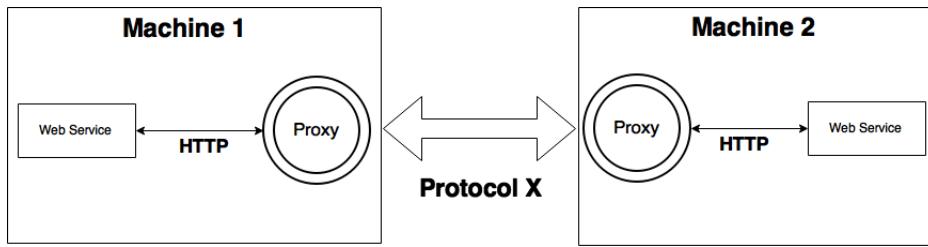


Figure 1: Architectural overview of proposed design

## 16.2 Tuning application server configuration

## 16.3 Alternative transport protocols

## 17 Summary

## Part IV

# Testing and Evaluation

## 18 Evaluation Tools

## Part V

# Conclusion and Future Work

## 19 Conclusion

## 20 Future Work

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