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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 theese 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 properary solutions, better to use commercial off-the-shelf software. Therefore, by putting the optimization in proxies, the client and services can remain unchange while the proxy handles the optimalization.

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 attribute to make data communicating difficult. In order to address this issue, NATO has choosen Service-Oritented 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 businiss logic is divided into smaller chunks of logic, refered 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 registery*, where service providers publish service descriptions. Service consumers finds the services it needs by contacting the service registery. The communcation between services occour through the exchange of standarized messages.

Following the SOA principles dictates a loose coupling between services and service consumers which allows software system to bemore 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 communcation. Loose coupling with regards to location allows the location of an service to be changed without needing to repogram, reconfigure, or restart the service consumers. This is possible through the usage of the service registery, which is updated with the new location.

Furthermore SOA enables service implementation neutrality. The implentation of service is completly separated from the service description. This allows re-implementation and alteration of a service without affecting the service consumers. Another benefit with SOA is reusablity 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 common used approach is the Web service standard, using the SOAP messaging protocol. To achieve interoperability between systems from different nations and vendors, NATO has choosen the Web service technology in order to realize SOA principles. This allows member nations to implement their own technology as long as they adher to the standards. Web services are are discussed in detail in section 9

1.2 Tactical networks

Mobile tactical networks are characterized by 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 has 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 commu-

nications grid that link the nodes[4].

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[5].

1.2.1 End-to-end connections

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

1.2.2 Network heterogeneity

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

1.2.3 Web Service overhead

Web services generates overhead.

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 umerkelig 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 reccomandation 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[6]:

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.

11 Optimization techniques

Web services enabels interoperability betweens system, but also increase the information overhead, requriering higher data rate demands. By using proxies, we can freely choose the communcations 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 communcation between a Web Service and a Web Service client. The optimalization can be implemented at different levels of the protocol stack in use. Table 1 lists an overview of possible optimalization techniques studied in this thesis.

11.1 Compressing the payload

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

- GZIP
- EFX(Efficient XML).

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

Protocol Stack	Optimalization 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: Optimalization possibillities.

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 1.2, 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 capasity 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.

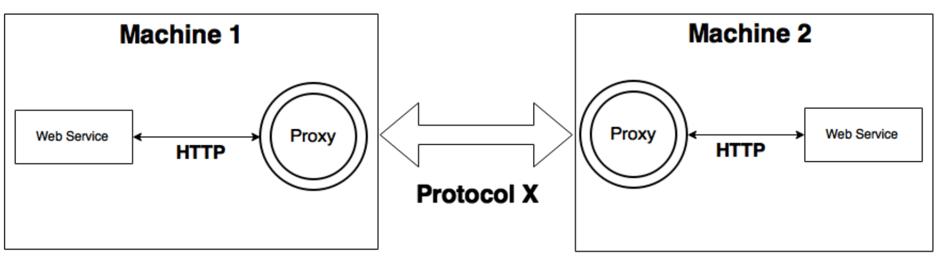

Figure 1: Architectural overview of proposed design

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