Cover Page for Paper (ID 092)
Submission for the 15th ICCRTS –"The Evolution of C2"

Title: **IST-090 SOA Challenges for Disadvantaged Grids**

Topics:
2 Networks and Networking;
9 C2 Architectures and Technologies;
6 Modeling and Simulation.

Paper ID: 092

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Abstract:

Service Oriented Architecture (SOA) provides agile C2 functionality as services on a network, delivering flexibility, scalability and redundancy. SOA is currently available at the higher levels of command such as (deployed) headquarters, but not at tactical levels.

SOA is a proposed paradigm for delivering C2 at the tactical level. The objective of Task Group IST-090 of the NATO Research and Technology Organization's Information Systems Technology panel is to identify improvements for making SOA applicable at the tactical level, which typically include communication grids that are disadvantaged by line-of-sight connections, low bandwidth, intermittent availability, etceteras. IST-090 will provide requirements for using SOA over disadvantaged grids and build demonstrations that show how the challenges can be mitigated.

This paper describes the approach used by IST-090, including the following topic studies:
- Web-Services implementation: identify key elements for performance improvement, identify Web-Services limits. Focus: Force Level Functions, Geospatial WS, Network of proxies.
- Data Distribution Service: performance tests, connecting to Web Services
- Service Discovery: performance, candidate technologies, experiments
- Simulated and synthetic environment: resources, connecting real systems, Measures of Performance and Effectiveness

We believe that a SOA approach at the tactical C2 level facilitates a next step in the evolution of C2.

1 Introduction

Service Oriented Architecture (SOA) is a design paradigm that can be used to make C2 functionality available as software services over a network. Examples of such C2 functionalities are chat, speech (Voice over IP), observation report, real-time status, common operational picture, weapon availability, fire support request, Blue-Force Tracking, etceteras. Such SOA enabled C2 Services can be made available in a flexible, scalable and redundant way. For the end user there will not be much difference with current implementations of C2 functionality, except for the fact that there will be access to more and more specific information that will be more readily available.

SOA bases itself of the concept of wrapping software capabilities as *services.* In this context, a service is a piece of software that offers some sort of capability/functionality to others using standardized interfaces. This allows for the loose coupling of user and service that is essential if one is to deploy this technology in tactical networks.

By OASIS[1] definition [NC3TA], SOA 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" [NC3TA]. It is natural in such a context to think of one person's needs being met by capabilities offered by someone else or, in the world of distributed computing, one computer agent's requirements being met by a computer agent belonging to a different owner. There is not necessarily a one-to-one correlation between needs and capabilities; the granularity of needs and capabilities vary from fundamental to complex and any given need may require the combining of numerous capabilities while any single capability may address more than one need. The perceived value of SOA is that it provides a powerful framework for matching needs and capabilities and for combining capabilities to address those needs [NISP].

The use of SOAs has emerged as a major trend within the commercial sector and among nations developing NNEC type capabilities, because of the flexibility they provide in sharing information and information processing capabilities. SOAs provide mechanisms for using existing information services as well as providing a basis for developing new more advanced information services. Such mechanisms will allow many C2 needs to be satisfied by linking together existing information services in a modular, flexible fashion that can be readily adapted to changing operational context. The flexibility provided through the use of SOAs is particularly well suited to supporting the needs of coalition based Network-Centric Operations using systems of various nations, on different levels of transformation without the need of replacing them but only integrating into the SOA environment.

The value of SOA is that it provides a simple scalable paradigm for organizing large systems that require interoperability to realize the value inherent in the individual components. Indeed, SOA is scalable because it makes the fewest possible assumptions and also minimizes any trust assumptions that are often implicitly made in smaller scale systems. Moreover, apart from its inherent ability to scale and evolve, the infrastructure SOA encourages is also more agile and responsive than the one built on an exponential number of pair-wise interfaces. Therefore, SOA can also provide a solid foundation for developing operational context, based on business agility and adaptability

As mentioned above, the flexibility and loose coupling offered by the SOA paradigm means that both NATO and many of the NATO nations are basing their future information infrastructures on this paradigm. Web services, the most common and mature technology for implementing SOAs, will inevitably be a part of this development, at least for use in fixed infrastructure networks.

1 OASIS – Organization for the Advancement of Structured Information Standards

As Web services are developed for use in civilian networks, they will not necessarily perform satisfactorily in radio-based military networks. It is however vital that solutions used in tactical networks are able to fully interoperate with SOA solutions on other levels and there exists two possible approaches to achieve this:

First, one can use Web services on the tactical level and make improvements to both the Web services themselves and to underlying infrastructure to ensure that the Web services become less bandwidth intensive. The benefits to this approach include:

- All services and clients, no matter where or how they are connected to the infrastructure, interact with each other using the same interfaces (so the same services can be used everywhere without modification).
- Cross network interoperability is easy, since the same technology is being used at the application level everywhere.
- Using the same solutions everywhere means fewer solutions that need to be maintained and monitored.

Secondly, we can use non-Web service technology on the tactical level and provide interoperability through the use of gateways. The benefits to this approach include:

- As nothing is given up front, a non-Web service solution can be designed more specifically for the limitations of each individual network and can potentially be optimized further than Web services?
- Other solutions can provide functionality beyond what is supported by Web services, such as more fine-grained QoS-support and support for real time data (this functionality will be limited to work within the network the given solution is deployed in though).
- Gateways will handle interoperability (developing these can generate significant overhead - one is needed pr solution that is in use).

IST-090 investigates both these approaches, by both looking at how Web services can be optimized for tactical networks, while at the same time looking at other technologies that can be used to build a SOA at the tactical level. More specifically we are investigating the use of DDS as a SOA enabler on the tactical level.

The work is too much to tackle all at once by all involved nations together. Therefore we defined four Themes of Study that will be tackled by one working group each: Adaptation of Web services for use in tactical networks; DDS as an alternative for implementing SOA in tactical communications networks; Service Discovery; and finally Simulated and synthetic environments as a framework for demonstration and testing.

1.1 Current SOA-based C2 functionalities

Many SOA-based C2 functionalities are already available or being prototyped. The whole NATO concept is being developed based on the SOA concept (Core G, FFT, NMMR, IEG, NIRIS, MCCIS, BRITE – BWS). Many other countries have also shown their SOA – based implementations (Germany – SPC SOA, France – FoCCs-SOA, Finland – Mevat) [CWID] 2009 handbook. Utilization of SOA-based implementation of Web Services in a NEC environment has been shown in many international experiments. These prove that SOA technology improves collaboration, interoperation and information sharing in a Federation of Systems (FoS) [JSliwaMILCOM08].

Together, the nations that participate in IST-090 have much relevant experience in the area of implementing SOA in the area of C2. Some examples are provided below:

Example: *Coalition Warrior Interoperability Demonstration (CWID)*
The CWID demonstration [CWID] evaluates technologies and capabilities for exchanging information among coalition partners, military services, government agencies, first responders and U.S. combatant commanders. Information sharing technologies leverage decision-making and operational flexibility on the battlefield and during crisis response on the home front. Two specific CWID examples are described:

CWID 2006
SOA solutions need to work with different types of information and communication systems. During CWID exercises in 2006 tests of SOAP web services were performed that resulted in the conclusion that "service-oriented architecture implemented via the technology of Web services is the strategic means to achieving interoperability". However particular problems related to the utilization of protocols of the SOA stack like TCP/HTTP/SOAP have been recognized [TN1229].

CWID 2007
Another example of SOA-enabling of C2 software is an experiment [Haakseth et al., 2007] that took place at NATO CWID 2007, in which a hand held soldier system was connected to an already existing national C2 system using a Web service interface.

Example: *BRITE*
The Baseline for Rapid Iterative Transformational Experimentation (BRITE) is an experimentation framework which allows for the rapid implementation of new ideas and capabilities to support experimentation. It fits into the TIDE (Transforming Technology for Information, Decision and Execution superiority) concept. Its goal is to rapidly improve the IT capabilities of the NATO Alliance by reusing existing systems/components and by steering current and future projects towards greater openness and cooperation in a common framework. WISE 2.0 is part of this BRITE framework. These components are implemented as a Service Oriented Architecture (SOA).

Example: *Multi National Experimentation 6 (MNE 6) in phase 4.2*
This experiment is used to test technical possibilities in sharing maritime situational awareness between systems of the Baltic Sea. It encompasses Multinational Inter-agency Situational Awareness – Extended Maritime (MISA–EM). It includes e.g. the following systems: FIN: Mevat; SWE: Sucbas; POL: SWIBZ, NATO: BRITE, all based on web services and SOA based solutions [TIDE].

Example: *Norwegian national experiment*
Figure 1 (from [Natis, 2005]) shows the many ways SOA services can be constructed, either as a new SOA service, as a wrapped legacy service or as a composite service. During a Norwegian national experiment [Hafsøe et al., 2009] several of these mechanisms were tested using an experimental Cooperative ESM Operations (CESMO) software. This software was wrapped using Web service standards and was thus made available to new users. In addition, new functionality, in the form of an NFFI blue track service, was created from scratch using the same data sources.

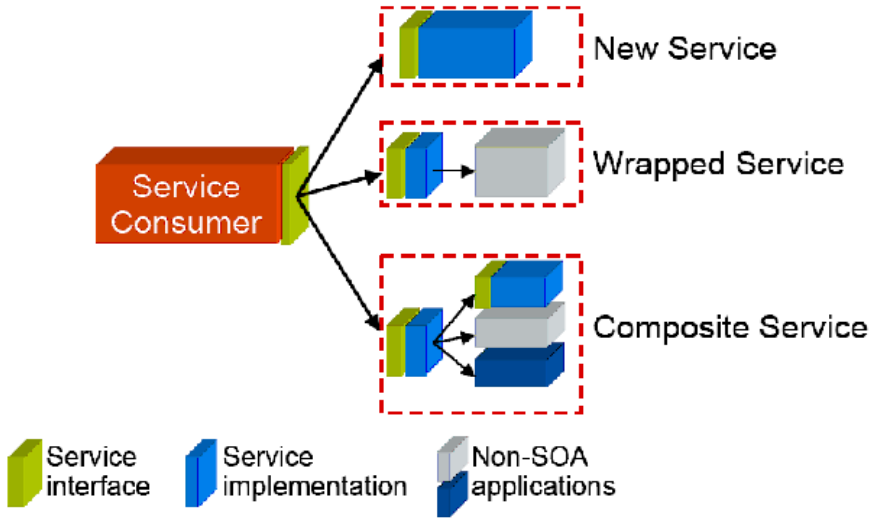

Figure 1: Different ways to construct SOA services

Example: *Joint NC3A/NOR experiment at Combined Endeavor 2009*
At Combined Endeavor (CE) in the Netherlands, 2009, experiments were performed using Web services in mobile networks and over reach-back links back to deployed infrastructure (i.e., the HQ) [Johnsen and Hafsøe, 2010]. Here, we were able to show the feasibility of employing Web services in an operational experiment for a specific set of communications hardware: NC3A used Rajant Breadcrumbs, whereas NOR used the KDA WM600 tactical radio. We were able to successfully discover and invoke Web services across the heterogeneous networks, through the use of proxies for delay tolerance and gateways for network- and discovery protocol interoperability.

The networks that are available at the tactical level, i.e. operations "in the field", are called "disadvantaged" because of their limitations: limited and intermittent availability (line-of-sight connections), low bandwidth, hostile disruptions, etceteras. These kinds of networks do indeed impose limitations on the required information exchanges. We think that these limitations can (at least partly) be resolved by making adaptations on both sides: adaption and streamlining of the SOA implementations and the communication mechanisms, as well as adapting the implementation of the applications. Of course we would like an answer to the following question: How we can get as much result as possible, with as little changes as possible?

1.2 Goal of Task group 090

It is the goal of Task group 090 of the Information Systems Technology (IST) panel of the NATO Research and Technology Organization (RTO) to address the above mentioned question. IST-090 runs from January 2009 to December 2011 and has the following objectives:

- Identify improvements to make SOA applicable on battlefield disadvantaged grids.
- Investigate Communication Paradigms, Mechanisms to reduce needed bandwidth, Mechanisms to improve reliability (deal with intermittent connectivity, link instability and latency) and Security (limited to investigating how security solutions discussed in other groups perform with respect to bandwidth requirements etceteras).
- Results should not impose interoperability restrictions. We should limit changes to client applications as much as possible to take the full advantage of the most visible benefit of web services: providing interoperability in a heterogeneous environment.

IST-090 will provide requirements for the use of SOA over Disadvantaged Grids and demonstrations that show how the challenges, provided by disadvantaged grids, for the implementation of SOA can be mitigated.

As IST-090 is still in the start-up phase, an important goal of this paper is to make known what work we intend to do and to get feedback from the community on our goals, focus and approach.

2 SOA advantages, disadvantages and relevance

2.1 SOA advantages

The SOA approach has demonstrated many advantages for the development and implementation of C4ISR systems in general. SOA's greatest advantage is the ability to seamlessly exchange information based on different policies and on a loose coupling of the components.

A more specific list of advantages can be found in [TN1229, page 6]:

- True interoperability: By allowing different categories of applications to interact with the same services, a highly cohesive interoperability environment is created. This allows normally disparate categories of applications, such as thin-client applications and legacy client-server applications, to share data they would not otherwise be able to share.
- Incremental functional improvement: Services can be added or refined without impact to existing operations. The risk inherent in new development can be constrained to smaller "chunks" of functionality.
- Broad reach: Service discovery allows potential business and integration partners to find deployed services they would not normally know about. This has the effect of reaching a broader market with little impact on existing infrastructure.
- Reuse potential: Existing services can be used again and again, thereby reducing the need for new development and the support requirements implied by that development.
- Technology transition: Highly decentralized and very loosely coupled, the SOA model allows for capabilities to be brought to and integrated within an operational environment with minimal impact to the existing system.

SOA can be realized in many ways and the most common approach is by using Web services, a grouping of open standards [Erl, 2004]. Web Services currently primarily utilizes the request/response pattern and therefore uses the synchronous mode. The asynchronous mode of exchange through the SOAP protocol offers a simple way to build interoperability with a good level of decoupling between presentation and transportation of information, supporting the Event Driven Architecture (EDA) approach to system design. Note that SOAP doesn't really say anything about the exchange of messages, it is just the message format used by the other Web service standards. The important feature of SOAP is that it is transport agnostic and can be used in both synchronous (request/response) and asynchronous (publish/subscribe) message exchanges.

Common use of XML as a basis for the different description languages of the different levels of abstraction (SOAP as the messaging format, WSDL for services description, UDDI for directories) resulted in the development of a wide offer of (COTS or open source) products;

Most of the commercial programming environments offer tools to easily realize "wrappers" to use legacy applications in Web services.

Note that this IST-090 acknowledges the importance of these technologies but that it is not limited to these technologies.

2.2 Web services disadvantages

There are some drawbacks which become apparent in a disadvantaged (constrained) military network:

- The use of SOAP as a message exchange format is a problem, because it is based on XML, which is verbose and therefore needs a high bandwidth. Compression technologies can be used to mitigate this.
- The most common way of transporting SOAP messages across a network is by using the SOAP HTTP binding, which in turn means through the use of TCP/IP. Using a connection oriented

protocol such as HTTP/TCP may be unfeasible in tactical networks with highly limited communication links. It is however possible to use other transport mechanisms, such as UDP and other standards that are more efficient in terms of bandwidth use, such as Data Distribution Service (DDS) or Military Message Handling System (MMHS)).

- The existing products are not designed for use in disadvantaged grids with a significant probability of unanticipated disconnections, because their development is mainly driven by the commercial market of WAN enterprise information systems.

2.3 Relevance of SOA for NATO

The large number of legacy systems within NATO and within allied countries justifies any improvement to increase interoperability of existing applications in the overall frame of NNEC. Thus, SOA is unquestionably an area of interest for NATO C4ISR [NNEC FS Vol I], [NAF v3], [TN1229]. What is more, it is emphasized that web services implementation of SOA should be used where it is possible [NNEC FS], [TN1229].

To cover the whole spectrum of NATO systems from the strategic to the tactical level, some improvements have to be identified to make SOA applicable on battlefield disadvantaged grids.

In the tactical military environment the bandwidth may be quite low and the connectivity may be intermittent with widely ranging communication gaps (seconds to days). Very useful research on this field has already been done, see [Middleware], but this does not focus explicitly on SOA.

Service orientation is a conceptual architecture which asymmetrically provides services to arbitrary service consumers facilitating information sharing in heterogeneous environment and thus supports to some degree the open-ended aspects of net-centricity. That is why the Networking and Information Infrastructure (NII) strategy (technological background of NATO NEC – NNEC – implementation) assumes that the NII will be implemented as a Federation of Systems (FoS), involving the use of Service Oriented Architectures (SOAs) [NISP (ADatP-34)], [NNEC FS Vol I], [NNEC FS Vol II], [NAF v. 3]. NII is characterized by the use of SOAs to expose business functions as consumable services that can be discovered and invoked across the network. The use of SOAs ease application and data sharing and provide a flexible mechanism for reusing existing services to enable the development of new, value-added information services [NISP].
The concept of every system viewing others as "services" in a loosely coupled manner is coherent with the concept of NNEC within the Federation of Systems. From a SOA perspective, it means that Information and Integration Services (IIS) Layer of NII architecture is to be thought of as a federation of services, where any NATO or national information system will be autonomous and provide specific services by means of implementing a standardized service interface [NISP]. Within this approach inclusion of a service-based system in the NII enables contributed systems to be independently managed and controlled by their owners within the framework of the FoS.

We will look at the work that is being done in other groups related to the NII. For example Core Enterprise Services WG (CESWG) has already published a framework document that is highly relevant to what we are doing. Even if our focus is on the tactical domain, it is vital that we also consider how the technologies we discuss will be able to interoperate with other systems on higher levels. CESWG points to SOA (implemented through Web services) as the key enabling technology. That does not mean that we are limited to using Web services in tactical systems, but we must take into account that we must co-exist with Web service based systems.

3 Objectives

3.1 Area of Research and Scope

The overall research focuses on the use of SOA on disadvantaged grids (e.g. Mobile Ad-hoc Networks) in "near real time". Sub-areas of research include:

- Communication paradigms
- Mechanisms to reduce needed bandwidth
- Mechanisms to improve reliability
- Security: Requirements posed by security will only be taken into account as far as relevant. Security is already the focus of other groups (IST-053, IST-061).

To evaluate our propositions for solutions we will use a concrete scenario as a global context of the study. The scenario will incorporate use cases and services (i.e. Blue Force Tracking, Observation report, Alert notification, UAV video feed, weather forecast…). An example of scenario is provided below.

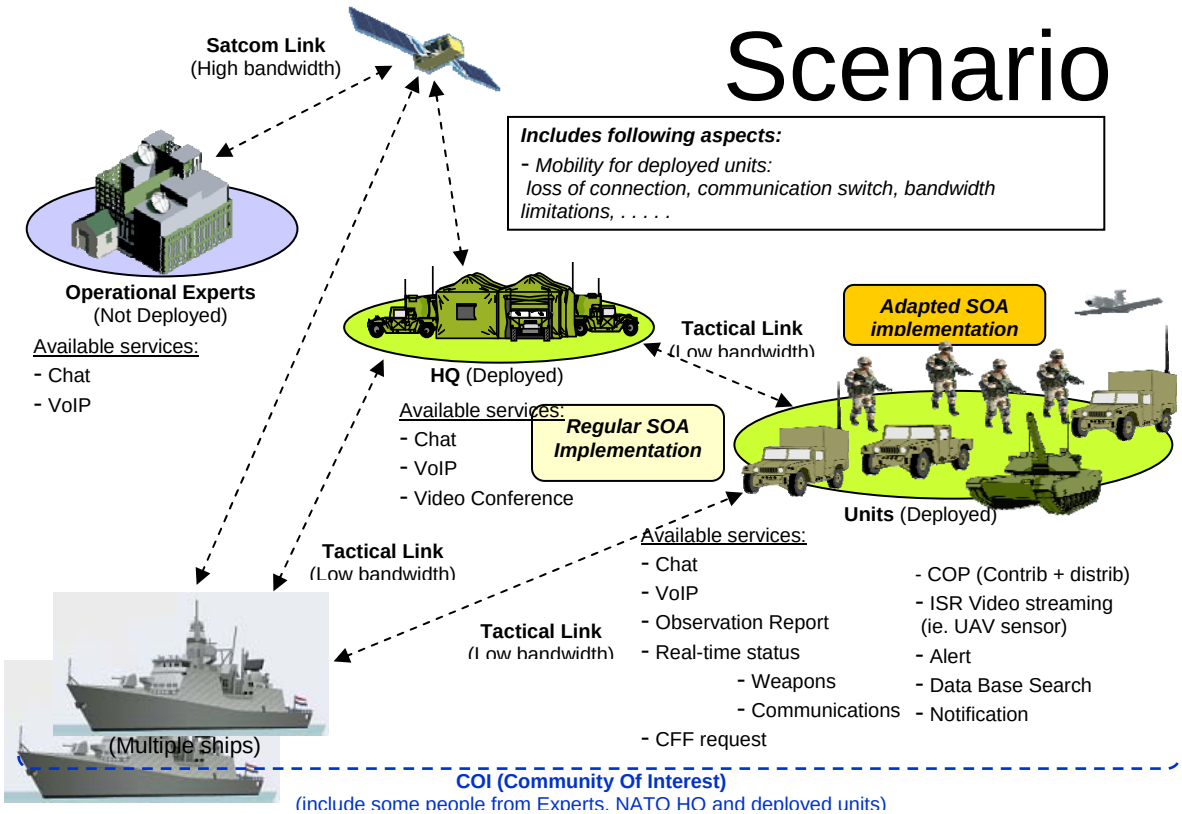

Figure 2: Example of Scenario

In figure 2 we have two kinds of SOA design and implementations: Regular (without Disadvantaged Grid limitations) and Adapted to tactical needs (with Disadvantaged Grid limitations). IST-090 will take in consideration the overall context of the scenario but will focus on SOA adapted to tactical needs.

To become a bit more concrete, we identify some examples of services that are applicable in this scenario. Common Operational Picture (COP), the Compilation, distribution and contribution of relevant information; Blue Force Tracking (BFT), providing information about own forces location; Intelligence Surveillance Recognition (ISR) Feed, the ability to access ISR Sensor information; Call For Fire (CFF), Fire support requests containing all information needed to determine the method of target attack. For the scenario the CFF comes from an observer; Alert Service, this is a high priority instant advertising of incoming emergencies and contingences; Observation Report, this involves the distribution of information collected on the battlefield through observation by deployed soldiers and a variety of electronic sensors; Database Search, this can consist of remote requests of information relevant to the operation by deployed units; Online Status, this involves monitoring the availability status of deployed units; Notification, this is the ability to be notified when a subscribed data changed. It is linked to a data subscription approach; Others: Chat, VoIP, Video, etcetera.

3.2 The specific goals and topics to be covered by IST-090

In the scenario described in the figure 2 it is possible to discern the following issues that should be analyzed to find the solution for making SOA applicable to Disadvantaged Grids.

Areas of research that are proposed to investigate include (but are not limited to):

- Communication paradigms: Request/Response, Publish/Subscribe (Message-centric approach, Data-centric approach). Technologies that support Publish/Subscribe pattern are: CORBA Notification Service; Web Service Notification; Message Oriented Middleware (JMS) and Data Distribution;
- Reduced dynamic service discovery;
- Mechanisms to reduce needed bandwidth (e.g. compression);
- Mechanisms to improve reliability (deal with intermittent connectivity / link instability and high latency);
- Adaptation of web services based on the context of the service call.

3.3 Expected end products and/or Deliverables

IST-090 expects to produce the following requirements for the use of SOA over Disadvantaged Grids: A description of the lessons learned from the experiments, demonstrations and a final report. The final report contains a description of test results and proposed solutions.

3.4 Planning

The duration of the Task Group will be three years starting in early 2009 with the final report submitted in 2011. The current planning is visualized in figure 3. It will be adapted according to actual progress being made.

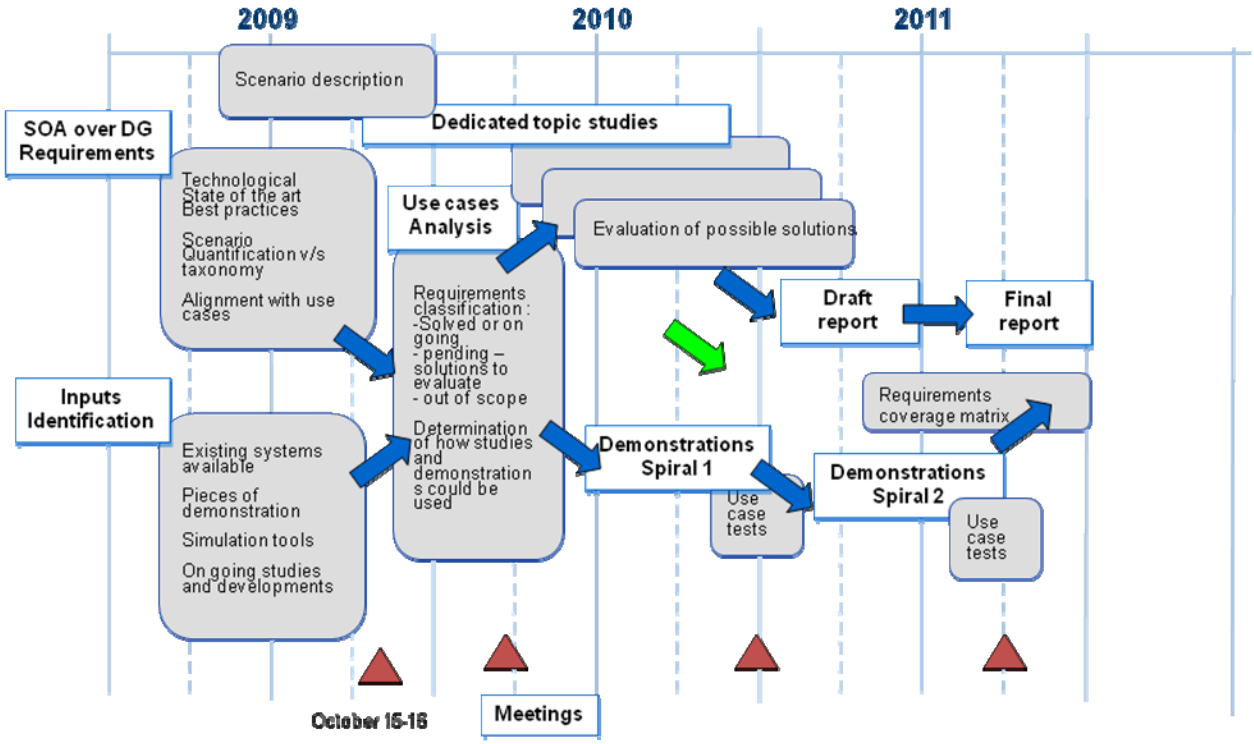

Figure 3: Planning

4 Approach

The work is too much to tackle all at once by all involved nations together. Therefore we defined four Themes of Study that will be tackled by one working group each.

- *Web services* is the most common technology used for implementation of SOAs. Web services is designed for use in fixed infrastructure networks, such as the Internet, and the technology needs to be adapted if it is to be used in tactical networks.
- *DDS* is a standards-based middleware that shows promise for use in low capacity networks and could be considered as an alternative for implementing SOA in tactical communications networks. If one chooses to base a tactical SOA implementation on a non Web service solution such as DDS, it is important to consider how such a solution will co-exist with Web service solutions used on higher levels. We would like to present DDS as a real alternative in tactical communications. In order to reach this goal, we have defined some tactical services which can be used as a first step of a future Tactical Data Interface.
- *Service Discovery* is an important part of any SOA, as service consumers must be able to find the available services before they can be used.
- The *simulated and synthetic environment* is something we need to look at to help us establish relevant use cases and also give us a framework for demonstrating/testing the technological solutions we come up with.

Each Working Group (WG) will find a use case and use this to coordinate and evaluate their research. We will have workshops and demonstration(s). The working groups will provide a presentation that describes what has been done and describes the problems that occurred and their implications. They will provide a comparison of results, including an identification of gaps (and their importance) and advise on what to do about the gaps. As far as possible, the WGs will provide (preliminary) statements about the use of SOAs for disadvantaged grids. The goals and approach of each of the four Themes of Study is elaborated below.

4.1 Web-Services implementation

Goal: Identify mechanisms to improve performance
Approach:

- The Web service standards are based on using SOAP as the message format. SOAP is in itself transport agnostic, meaning that you can use more or less any transport protocol to carry these messages. The most common way of doing this transport however, is by using HTTP/TCP. Finding alternatives to using a connection oriented transport protocol such as TCP is one aspect that needs to be addressed when one considers using Web services in tactical networks. We will examine this and other aspects of using Web services in disadvantaged grids and identify elements to be replaced by mechanisms that can improve performance.
- Earlier work has shown that is it possible to reduce the bandwidth requirements of Web services to such a degree that it is possible to use them in limited capacity networks [Lund et al., 2007]. However, one task that remains is to identify the minimum capacity required by Web services. Therefore, we plan to implement a WS that allows identification of WS limits. (e.g. Force Level Functions).
- Use network of proxies. Research has shown that using proxies is a convenient method for adding compression and delay-tolerance to COTS Web services [Skjervold et al., 2009]. This concept should be studied further, especially the part on networking the proxies in a dynamic manner.
- Explicitly consider Geospatial WS.

Web services is a technology, or more specifically a collection of standards. This technology is the most common way (but not the only way) to implement SOAs. Figure 4 shows a high-level view of the Web services communication stack:

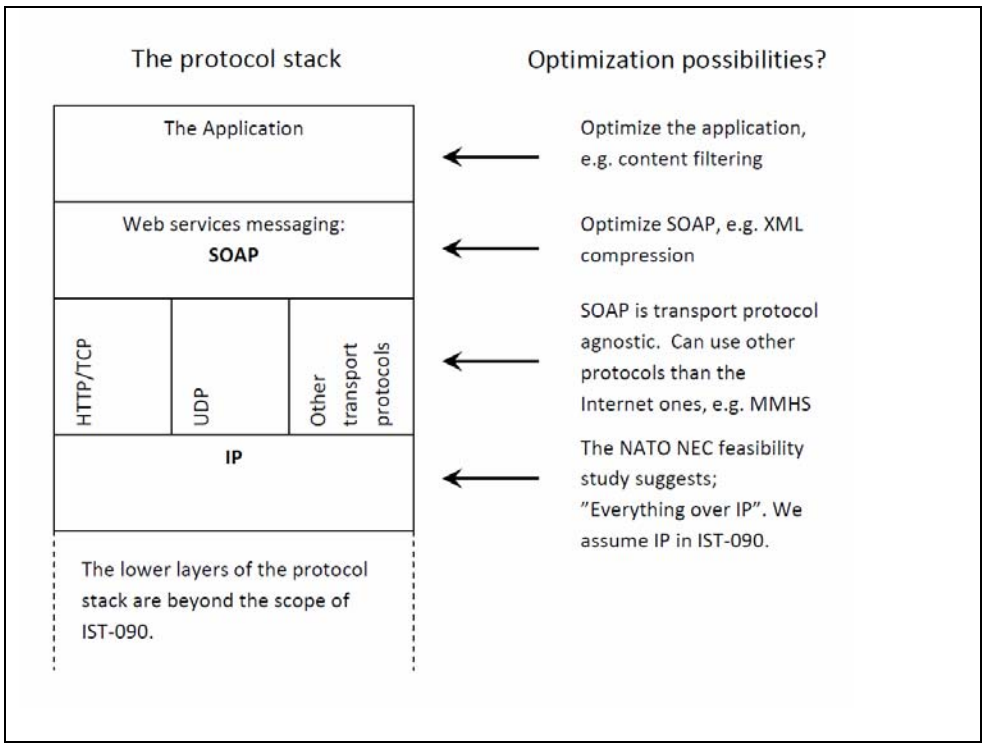

Figure 4: Optimizing the Web services stack

As we can see, there is room for optimizations several places in the protocol stack. At the application level, it is possible to limit the applications' need to exchange data by changing the data representation and performing content filtering [Hafsøe et al., 2007]. Below the application level we need some sort of standardized middleware to ensure interoperability across different systems. The NATO NEC (NNEC) feasibility study has identified SOA implemented by Web services technology as the *key enabler* for NNEC [Bartolomasi et al., 2005]. Web services are based on open standards and define an XML based messaging protocol called SOAP. Being based on XML, SOAP messages can be quite large. However, the benefit of SOAP is that it can be handled by COTS development tools and thus COTS clients and services. It is possible to reduce the footprint of XML by using compression. A previous study has shown that standards, such as GZIP and the emerging standard for efficient XML (EFX), compress XML quite well [Johnsen and Hafsøe, 2008]. SOAP is transport protocol agnostic, meaning that it can be carried by any transport protocol. In civil systems, the standardized SOAP binding to HTTP over TCP is used most of the time. There also exist bindings to other transport protocols such as UDP and SMTP. In a military network other protocols could be used, for example MMHS which is based on tactical transport protocols and adds store-and-forward capabilities [Johnsen et al., 2008]. Thus, there are several techniques that can be investigated in order to make Web services better suited to the tactical environment. In IST-090 we do not concern ourselves with radio technology or link layer issues, as this is being covered by other NATO groups. We assume that IP is used on the network layer, since the NNEC feasibility study has identified this as the common protocol for network interoperability – the so-called "Everything over IP" idea.

Current implementations of SOA based solutions for (deployed) headquarters rely on high bandwidth connections (e.g. high speed landlines and/or satellite links) that do not impose

limitations on the information exchanges that are required by these implementations. They are implemented up to the brigade HQ level. The capability to use SOA at the tactical level will facilitate a next step in the evolution of C2.

4.2 DDS (Data Distribution Service) at the tactical level

Goal: showing, testing and improving DDS as a standard middleware between systems and nations at the tactical level.

Approach:

- Performance tests (QoS): Developing a demonstrator which tests DDS performance as interoperability middleware.
- Connectors to Web Services (Proxy DDS-Web Services): Connecting the information which comes from tactical level (DDS) to strategic level (WS).
- Generate a DDS Implementations report: Knowing advantages and disadvantages of all DDS implementations (vendors). Advising on what implementations are the best choices in which circumstances.

4.3 Service Discovery

Goal: Find out what Service Discovery (SD) method provides the smallest delta in performance compared to existing network solutions

Approach:

- Review existing work – technologies, experiments etceteras. There exist several service discovery protocols, but few are suitable for use in disadvantaged grids. A survey of contemporary protocols seen in the context of Web services discovery in military networks has shown that current standards are insufficient for disadvantaged grids [Johnsen et al., 2009]. We need to experiment with new solutions that are better suited to the nature of disadvantaged grids.
- Identify Candidate technologies and experiments (relevant GAP analysis)
- Work with the Simulated and synthetic environment group to build an environment. This includes identifying key measures of effectiveness and measures of performance and establishing a baseline. Use traditional network methods (registry) to compare results.

4.4 Simulated and synthetic environment

Goals:

- Define what “disadvantages grids” exactly implies in order to provide a simulation environment to the others WGs.
- Determine what kind of input is needed to support our simulations and how connecting systems are coupled (ports, networks).
- Find out what environmental parameters should be simulated (bandwidth, loss of connectivity, latency, etceteras).
- Determine the performance parameters of a simulator: response times, throughput, etceteras.

Approach:

- Combine available simulation resources (e.g. CFBLNet).
- Optimally combine detailed simulation with minimal emulation.
- Capability to connect to real systems.
- Evaluation against measures of performance and measures of effectiveness.

5 Feedback wanted

As we stated in the introduction, an important goal of this paper is to make known what work we intend to do and to get feedback from the community on our goals, focus and approach. This feedback may consist of remarks on our approach, pointers to other ongoing research and/or actual collaboration. Therefore, in this section we would like to state more explicitly on which areas we would like feedback on.

We would like feedback for the areas of research that we proposed to investigate, such as: Communication paradigms: Request/Response; Publish/Subscribe (Message-centric approach, Data-centric approach); Reduced dynamic service discovery; Mechanisms to reduce needed bandwidth (e.g. compression); Mechanisms to improve reliability (deal with intermittent connectivity / link instability and high latency) and Adaptation of web services based on the context of the service call. Preferably of course this feedback should take the implementation area (real-time and disadvantaged grids) and the application area (military C2) into account.

Because we will organize our work in four dedicated Themes of Study, feedback is also welcome for these themes, again taking into account the implementation and application areas as defined above. The themes are: Adaptation of Web services for use in tactical networks; DDS as an alternative for implementing SOA in tactical communications networks; Service Discovery; and at last Simulated and synthetic environments as a framework for demonstration and testing.

6 Conclusions

The IST-090 Task Group is to provide recommendation to the IST panel in terms of SOA challenges over real time and disadvantaged grids. Therefore, its work is organized to investigate the most commonly used SOA implementations, test their performance in disadvantaged grids and propose modifications and mechanisms that are able to use these technologies on the tactical level, not limiting interoperability.

In the initial phase IST-090 has selected two technologies (DDS and Web Services) and some mechanisms (such as services discovery). The next step will be to gather experience in implementing these functionalities as they are and, further on, to provide and test improvements that would help deliver the situational awareness to the lowest command levels.

To define our approach in more detail we have investigated and inventoried the possible applications of SOA for Disadvantaged Grids in a (simple) scenario, based on the current experience of the participating nations. By indicating these possible applications we have also identified the possible relevance of SOA for NATO.

The identification of challenges to SOA implementations for real time and disadvantaged grids is a very important result of our work because this will drive new research programs/areas and it will prevent unsuccessful SOA applications in the future.

We identified and described a research path to do experimentation and analysis to find out where SOA can be used in disadvantaged grids and how this could be implemented. This path consists of the time-table for the task group and of the division of work in the four Themes of Study. This path will be adapted during the course of IST-090, based on actual progress.

Based on the steps mentioned above, we are currently defining a path that we think will lead to optimal use of the experience and knowledge in the participating nations to provide recommendation to the IST panel in terms of SOA challenges over real time and disadvantaged grids.

We acknowledge that the propositions for solutions that we will advise are important. However, they will not be a directly useable product. They should lead to further development in specific areas and suggest specific technologies for specific purposes.

Test results are very important to determine the limits of particular SOA implementations and their application in tactical networks. Once we are able to get such results, they can then be cited and treated as a reference point for further investigations.

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