XMSF as an Enabler for NATO M&S

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OVERVIEW

The Extensible Modeling and Simulation Framework (XMSF) is defined as a modeling-&-simulation-tailored set of self-consistent standards, processes and practices employing a set of web-based technologies and services to enable a new generation of Internet-distributed applications to emerge, develop and interoperate. Many software systems that composably scale to worldwide scope utilize the World Wide Web. Therefore, it is evident that an extensible web-enabled framework offers great promise to scale up the capabilities of M&S systems to meet the needs of training, analysis, acquisition, and the operational warfighter. By embracing commercial web technologies as a shared-communications platform and a ubiquitous-delivery framework, NATO M&S can fully leverage the burgeoning commercial web services industry.

XMSF has several high-level requirements derived from years of experience with M&S frameworks, and the challenges of their effective deployment across diverse networks and systems. XMSF must enable simulations to interact directly and scalably over a highly distributed network, achieved through compatibility between a web framework and networking technologies. XMSF must be equally usable by human and software agents. Clearly XMSF must support composable, reusable model components. XMSF use cannot be constrained by proprietary technology or legally encumbering patents which might discourage the free, open, ad hoc development of interconnected tactical models and simulations.

1 INTRODUCTION

XMSF [1] has two primary thrusts: development of exemplars to demonstrate the feasibility of XMSF technologies, and community outreach and engagement to encourage broad involvement and acceptance,

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especially with respect to development of broadly acceptable, open standards. These two thrusts provide feedback to each other. The exemplars inform the development of community standards. The community outreach encourages and engages other practitioners and users to enrich the pool of exemplars. It is only through broad experimentation and open discussion that we'll achieve standards that serve the entire NATO community. Over the last two years, XMSF has achieved significant success with both of these thrusts including:

- Web Enabled RTI (WE RTI)
- Extensible Battle Management Language (XBML)
- XMSF Distributed Continuous Experimentation Environment Viewer (XDV) and its successor, Experimentation Command and Control Viewer (XC2I)
- XML Schema Based Compression (XSBC)
- XMSF Profile Study Group in the Simulation Interoperability Standards Organization
- WebSim consortium between SISO, Web3D, OMG and OGC, and the WebSim conference

This paper describes these efforts in more detail and demonstrates how they support the future of NATO M&S.

2 NATO M&S REQUIREMENTS

Currently, NATO is in the process of a radical change through the NATO Transformation process and the development of new military requirements. However, these changes are supposed to be evolutionary instead of revolutionary, which means old solutions will be transformed gradually to meet the new requirement. Furthermore, many of the existing requirements are still valid as the responsible scientists and researchers proved to have foreseen some of the changes in their evaluations within the Long Time Scientific Studies conducted on behalf of NATO. The general NATO M&S Requirements are summarized in the NATO Modelling and Simulation Master Plan [10]. The IT constraints and solutions only recently have been updated and are summarized in the NATO Consultation, Command and Control Technical Architecture [11]. To embed these technical requirements into the operational context, the NATO Handbook [12] is very helpful. In addition, documentation of the NATO summits and other overview documents available in the On-Line Library of NATO [13] have to be considered.

The recent NATO summit that took place in Istanbul, Turkey, on 28 and 29 June 2004 is perceived as a milestone for NATO. Heads of State and Government of NATO's 26 member countries gathered for the first time after the Alliance's fifth and largest round of enlargement. During this summit, NATO reinforced the vital transatlantic link and built bridges of cooperation to other regions. The NATO leaders decided to expand the scope and nature of Allied operations, took measures to continue improving Alliance capabilities, and endorsed initiatives to enhance relations with existing partners and forge relations with new ones. Many of these operational points result in technical and system requirements to be supported by IT in general and by M&S in particular.

The NATO Transformation requirements can generally be summarized by stating that IT and M&S must increasingly support collaborative efforts to improve joint and combined capabilities. The partners are no longer limited to the military services of NATO nations, but must support the international war on terrorism as well as the increasing engagement of NATO in humanitarian relief operations and operations supporting the establishment of national governments after crisis or war, such as currently the case in Iraq and Afghanistan. This requires systems that are able to support Civil-Military Co-operations and all levels and echelons. Furthermore, these kinds of operations require a flat organisation hierarchy. The command and control structures with their rigid support that were sufficient during the Cold War are not sufficient and must be replaced with flexible IT structures supporting an agile and dynamic operation management. M&S must be an integral part of these systems, as new nations and partners not only must be trained to be able to operationally integrate into this new NATO structure, but training on the job using the operational equipments must become reality as well. Embedded M&S reaching the warfighter for training and education and embedded into distance learning efforts are required. Further, the use of operational M&S services within the real-world systems, in particular Command and Control infrastructures, will support orchestrating the agile management needed in modern warfare by taking account of the entities and their relations, dynamic aspects, behaviour, capabilities, constraints, and limitations. In order to support the user with applicable tools, organize and optimize his choice, obtain the necessary data, display uncertainties and assumptions, compose and execute the services, and display the result, intelligent software agents are also necessary.

An analysis of these documents and derived technical enablers lead to the following set of requirements that have to be met by future NATO IT infrastructures, which includes in particular supporting M&S services. The list in the following table is neither complete nor exclusive and must be enhanced and extended to fulfil NATO needs. The numbering system does not reflect priorities. However, these requirements are perceived to be a valuable hub from which the requirements for concrete NATO projects can be constructed.

Table 1. NATO IT Infrastructure/M&S Requirements

Req. #	NATO M&S Requirement
1	The NATO infrastructure must support collaborative efforts in which some collaboration partners are no longer limited to the military services of NATO nations.
2	The NATO infrastructure must be able to integrate national systems without affecting national sovereignty over those systems.
3	The NATO infrastructure must be open enough to support all potential national contributions.
4	The NATO infrastructure must improve joint and combined capabilities.
5	The NATO infrastructure must support the transatlantic link and support building bridges of cooperation to other regions.
6	Processes for migration of legacy systems and means to orchestrate the resulting international federations must be supported.
7	Because NATO does not have a single focal point to co-ordinate M&S activities, solutions must be open enough to support heterogeneous infrastructures as provided by supporting nations.
8	The use, development, and employment of M&S in Military Exercises, Training, and Decision Support, to include impact assessments and lessons-learned, is required.
9	M&S must be an integral part of the NATO IT Infrastructure.
10	M&S must support the NATO Response Force.

Req. #	NATO M&S Requirement
11	M&S must support defense against terrorism.
12	M&S must support humanitarian relief operations.
13	M&S must support operations providing for the establishment of national governments after crisis or war.
14	M&S must be integrated into Network Centric Warfare.
15	Operational M&S services within real-world systems, in particular Command and Control infrastructures, are needed.
16	Embedded M&S reaching the warfighter for training and education is needed.
17	Embedded M&S supporting distance learning is required.
18	Applied standards are not limited to military standards, but also commercially viable solutions – supported by national industry – are required. To minimize constraints, open standards are to be preferred.

Without going into detail, it is obvious that the majority of these requirements will not be fulfilled by systems following exclusively military standards. The use of open standards and well-defined interfaces is mandatory to enable collaborative efforts improving joint and combined capabilities. Within the following sections, we will show which requirements are met by the XMSF initiative, which is increasingly gaining international interest, and how those requirements are met.

3 WEB ENABLED RTI (WE RTI)

The goal for the Web Enabled RTI (WE RTI) is to be able to have multiple federates reside as web services on a Wide Area Network (WAN), permitting an end-user to compose a federation from a browser. To be able to meet this goal, the supporting federates need to be configurable, instantiated, and monitored by the end-user. This requires capabilities that go outside the normal operation of an RTI, and also requires an additional web service layer that controls these administrative activities.

For this exemplar [2, 3] we built a prototype HLA federation using XMSF compliant web services for communication between federates in an existing federation, in this case SOAP [4] and BEEP [5]. We created SOAP-formatted RTI interfaces employing the BEEP communication layer. These RTI interfaces are consistent with the Java bindings for the DMSO/SAIC RTI. BEEP allows bi-directional calls through the interface, enabling Federate Ambassador call backs. By relinking the client federate with these interfaces, we have taken the initial steps to making it callable as a web service. This approach also enables encapsulation of non-reentrant RTI libraries and will eventually permit multiple instances of federates as web services.

3.1 SOAP and BEEP

SOAP is a lightweight, XML-based protocol for exchanging structured data and remote procedure calls. SOAP provides a framework describing the content and processing directives for a message, a set of conventions for making remote procedure calls and encoding their responses, and an extensible encoding scheme that allows for the encoding of user-defined data types. A typical SOAP message consists of an Envelope, which encapsulates a single SOAP packet, an optional Head, which contains processing and routing instructions, and a Body, which contains the actual message content. The advantages of using SOAP as our protocol for remote procedure invocation are many. First, it is a truly cross-platform and cross-language solution. By using SOAP we have not tied any component to a particular operating system or programming language. Second, it is a human readable data format, making development and debugging simpler. Finally, it allows us to set and release a standard XML schema for the HLA mapping so that third parties can develop fully compatible libraries.

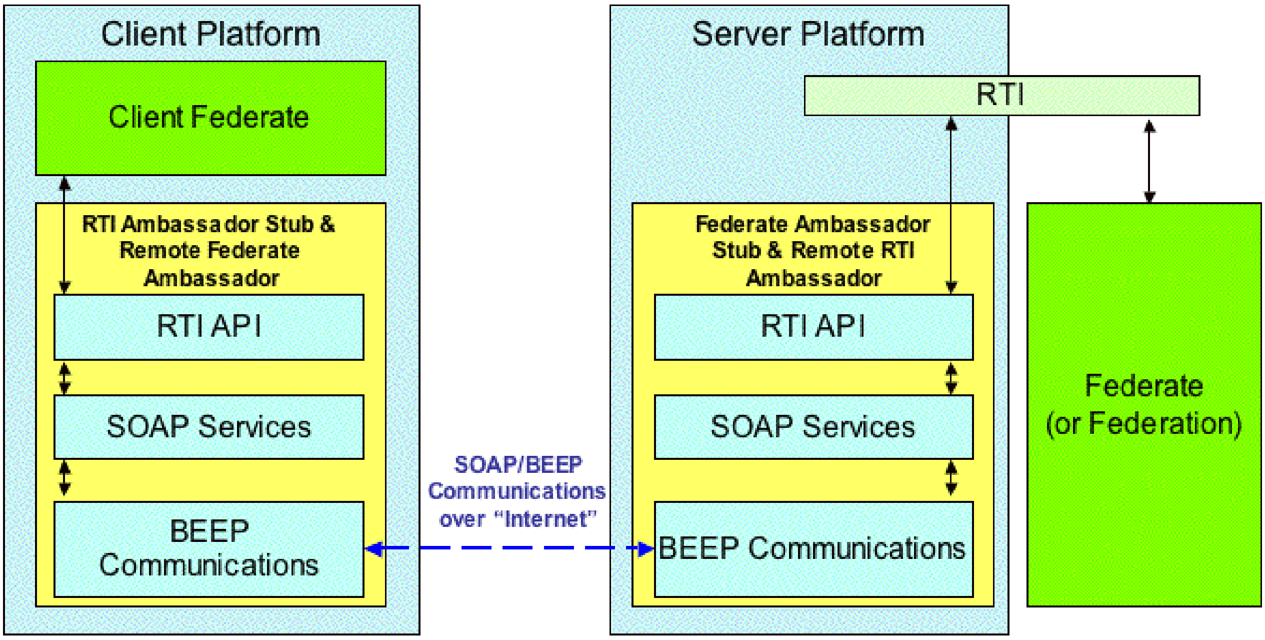

Figure 1. Web-Enabled RTI Architecture

BEEP is an application layer protocol for designing other application layer protocols. The BEEP core libraries provide a mapping of the basic packet structure onto TCP, a set of security protocols such as Simple Authentication and Security Layer (SASL) and Transport Layer Security (TLS), and an extensible architecture for defining the service's own protocol on top of BEEP. The communication pattern is simple and lightweight. A client connects to a server process and requests one or more Profiles, where a Profile is a user-defined application protocol. If the server recognizes at least one of the Profiles, a Session, roughly equivalent to a connection, is instantiated. Each Session can then support multiple Channels, where a Channel encapsulates all communications for a given Profile. Using this model we were able to separate RTIAmbassador calls from FederateAmbassador callbacks by assigning each a separate Profile for which we opened a separate Channel. Figure 1 illustrates this architecture.

3.2 The Federation Process Model

The process model for the web-enabled federation is as follows:

1. The user initiates the federate (or federates) in server side federation

   a. Server side federate starts the federation

2. The user initiates the client

   a. The client spawns an RTI Ambassador Stub

   b. The RTI Ambassador Stub spawns a Federate Ambassador

   c. The Federate Ambassador spawns a Federate Ambassador Stub

   d. The stubs make remote SOAP calls to initialize the remote RTI and Federate Ambassadors

3. Client RTI calls go through the RTI Ambassador Stub, out to remote RTI Ambassador via SOAP, which passes the calls to the RTI

4. Communications from the RTI pass to the Remote Federate Ambassador, to the Federate Ambassador Stub via SOAP, and pass to the client.

3.3 Translating the APIs to SOAP

Below is a code sample from the WE RTI itself. The RTI Ambassador Stub call for getAttributeHandle is:

```
public int getAttributeHandle(String theName, int whichClass) {
  synchronized(this) {
    org.w3c.dom.Element theCall = null;
    try {
// theSOAPDoc is an instance of a
// org.w3c.dom document
      theCall=theSOAPDoc.createElement( "getAttributeHandle");
      org.w3c.dom.Element firstArg = theSOAPDoc.createElement("theName");
      firstArg.setAttribute("className", "java.lang.String");
      org.w3c.dom.Text value1 = theSOAPDoc.createTextNode(theName);
      firstArg.appendChild(value1);
      theCall.appendChild(firstArg);
// repeat above for each argument
    }catch(Exception e) {
        //error handling code
    }
// sendSOAPCall handles the sending of the
// XML over the BEEP connection and
// deserialization of the response
    Message theReply = sendSOAPCall(theCall);
// depending on the return type of the
// message, either get the handle or
// throw an error
    switch(theReply.getMessageType()) {
    case Message.MESSAGE_TYPE_RPY:
      org.w3c.dom.Element replyTag = getSOAPMethodResponse(theReply);
      try{
        String replyValue = replyTag.getAttributeNode("value").getValue();
        int result = Integer.decode(replyValue). intValue();
      }catch(Exception g) {
         throw new RTIinternalError("Method RTIAmbassadorStub. getAttributeHandle()
         threw the following exception: " + g.getMessage());
      }
      return result;
    case Message.MESSAGE_TYPE_ERR:
//read and throw appropriate error here
    default:
      throw new RTIinternalError("");
    }
  }
}
```

This request results in the following SOAP:

```
<?xml version="1.0" encoding="UTF-8"?>
<soap-env:Envelope xmlns:soap-env="http://schemas.xmlsoap.org/soap/envelope/">
  <soap-env:Header/>
  <soap-env:Body>
    <Method methodName="getAttributeHandle">
        <Argument>
                                <Integer>>15</Integer>
        </Argument>
        <Argument>
                                <String>testClass</String>
        </Argument>
    </Method>
  </soap-env:Body>
</soap-env:Envelope>
```

In this case, 15 is the class handle for the class of which testClass is an attribute. The SOAP response, that returns a value of 42, looks like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<soap-env:Envelope xmlns:soap-env="http://schemas.xmlsoap.org/soap/envelope/">
  <soap-env:Header/>
  <soap-env:Body>
    <ReturnValue methodName="getAttributeHandle">
        <Value>
                <Integer>42</Integer>
        </Value>
    </ReturnValue>
  </soap-env:Body>
</soap-env:Envelope>
```

3.4 What's Important About This Exemplar

As has been demonstrated so many times in the past, federations can be run on a LAN. However, the implications of running this and other federations via web services are enormous. A legacy simulation may be made available without moving its dedicated hardware or trying to create a new installation on potentially rare hardware1, both very expensive propositions. The simulation can stay home based with its technical support and configuration management. There's no switching to supporting different federations at different times. The positive impact on lifecycle costs and availability can be significant.

This exemplar demonstrates that we are capable of implementing bi-directional communication initiation over the Web using SOAP and BEEP. This approach is superior to http's uni-directional initiation that makes it unsuitable for supporting simulation communication patterns. This technology enables existing HLA compliant federates to be integrated easily over the Internet, including through most firewalls with minimal reconfiguration! The concept of placing the simulation in the DMZ2 also aids in making it a web service. Furthermore, it demonstrates web service wrapping of existing architectures, which means that this same approach can also be applied to the Distributed Interactive Simulation (DIS) protocol, Aggregate Level Simulation Protocol (ALSP), etc.

[1] Consider just the cost of moving hardware and people to support Millennium Challenge 02.

[2] The demilitarized zone (DMZ) of a network is one of the connections to a corporate firewall. Computers with controlled external access that will be connected to the Internet, e.g. web servers, are typically placed in the DMZ.

3.5 Meeting NATO M&S Requirements

Table 2 demonstrates how the capabilities of the WE RTI enable NATO M&S.

Table 2. WE RTI Enabling NATO M&S

NATO M&S Requirement	Enabling WE RTI Capability
3– support all national contributions 4 – improve joint and combined capabilities 6 – migration of legacy systems 7 – support heterogeneous infrastructures 16 – embedded M&S reaching the warfighter for training and education 17 – M&S supporting distance learning	• Use of open standards such as SOAP, XML, and BEEP • Extension of HLA via web services
14 – Network Centric Warfare	• Extension of HLA via web services
18 – commercially viable solutions	• Use of open standards such as SOAP, XML, and BEEP

4 XBML

Taking the widest possible interpretation, BML is defined as follows: *"BML is the unambiguous language used to Command and Control forces and equipment conducting military operations and to provide for situational awareness and a shared, common operational picture."* In other words, BML was developed as a common standard to represent military tasks, actions and missions, both in simulations and Command and Control systems and therefore is applicable in the context of this section as well. A proof of principle BML prototype was developed in the domain of ground forces (for a US Army Mechanized Brigade). BML will allow a commander to develop a plan and exchange data with other organizations – the commander's subordinates, his superiors and his equals. To this end, three views are necessary to cope with all BML challenges:

- BML *doctrine*: Every term used within BML must be unambiguously defined and must be rooted in military doctrine. Doctrine is also the basis for the strategic views and business processes supported by the Platform Independent Model (PIM).

- BML *representation*: The representation structures and relates the terms defined in the doctrine in a way that they result in the description of executable missions and tasks. A mission is hereby defined by a sequence of tasks that must be executed in an orchestrated manner. This is done using extensions and enhancements of the Command and Control Information Exchange Data Model (C2IEDM).

- BML *protocols*: In order to communicate the necessary initialization data into BML and the resulting executable missions and tasks from the BML to the executing system, communication protocols are needed. XBML uses XML to structure the data and web services and SOAP to communicate.

More detailed information on XBML may be found in other recent publications [6, 7], including one being presented at this same conference. A Study Group within the Simulation Interoperability Standard Organization currently evaluates the use of BML in coalition operations. The technical constraints, prototypical implementations and the applicability to NATO are topics of a paper that will be presented during this conference [7]; therefore a detailed description and evaluation is not necessary.

4.1 Meeting NATO M&S Requirements

Table 3 demonstrates how the capabilities of XBML enable NATO M&S.

Table 3. XBML Enabling NATO M&S

NATO M&S Requirement	Enabling XBML Capability
2 – integrating national systems without affecting the national sovereignty	• BML allows various national presentations of the same operational concept • BML mediates and migrates based on the loose coupling of systems
4 – improving joint and combined capabilities	• BML supports every services (joint) and nationality (combined) with its own representation of the common operation. This helps to understand the other partners and their processes and creates shared awareness.
15 – operational M&S in Command and Control systems	• BML generates executable tasks that can be used within real Command and Control Systems, simulation systems and robotics. This facilitates the integration of components via a common language (BML).
16 – Embedded M&S reaching the warfighter for training and education	• The warfighter can learn the view of international partners via their BML using his own systems. Learning and exercising of necessary alignment skills is immediately supported by the various BML.

5 XDV AND XC2I

In addition to the typical staff structure of a military organization, the U.S. Joint Forces Command (JFCOM) comprises the Joint Training Directorate (J7) and the Joint Experimentation Directorate (J9). Both directorates are strongly engaged in the transformation process of the U.S. Armed Forces and the enablement of collaboration in joint and combined operations. JFCOM experts leveraged their experiences with NATO to support the transformation of the NATO Headquarters in Norfolk, Virginia, from the Supreme Allied Commander Atlantic (SACLANT) into the Allied Command Transformation (ACT). Operational requirements and derived technical requirements of JFCOM and ACT can therefore often be directly mapped to each other. The M&S requirements for effective and efficient support of JFCOM are therefore applicable to NATO, in particular NATO ACT, as well.

The XMSF partners are supporting JFCOM with two projects. The M&S IT infrastructure of J9 is the Distributed Continuous Experimentation Environment (DCEE), which is primarily High Level Architecture (HLA) based, although alternative protocols from the Command and Control domains as well as DIS are supported as well. After a briefing of XMSF concepts, J9 supported the XMSF team with funding for a prototype exploring proof of feasibility and applicability of open web-based standards in this context. This resulted in the XMSF DCEE Viewer (XDV) project.

Based on the success of this project, J9 decided to continue this work with the Experimentation Command and Control Interface (XC2I). J7 has subsequently become interested in XC2I. In the following subsections, both projects are described in light of how they support NATO M&S requirements.

5.1 XDV

The XMSF DCEE Viewer (XDV) is a web-based, low-cost viewer for Distributed Continuous Experimentation Environment (DCEE) based events. Our concept for XDV is simple: every eligible stakeholder interested in observing execution of the ongoing experiment can log into the federation and use the viewer software to follow the actual experiment. The necessary software was installed on COTS PCs connected via Internet protocols, allowing eligible stakeholders to follow the experiment from wherever they were located. XDV was demonstrated both within the DCEE, and between the DCEE and the Virginia Modeling, Analysis & Simulation Center (VMASC) Battle Lab. As the DCEE is part of the U.S. Defense Research Network (DREN), the demonstration constituted a nationwide experiment.

The task is similar to creating the Common Relevant Operational Picture (CROP) during a joint operation, in which the various information pieces of the C4I systems of the services have to be unified. However, there are two key differences between the challenges in creating a CROP and in displaying the experiment during execution:

- There is no need for data fusion in experiment monitors. Other than in the C4I domain, the data from the participating simulations are “ground truth” data, and variances are caused by aggregation/disaggregation procedures or variances within the resolution of the models, i.e., variations are reproducible and of interest to those monitoring the experiment.

- Dynamic aspects are more important in experiment monitoring than in the CROP.

The XMSF team successfully demonstrated that, via rapid prototype development, it was possible under XMSF to develop the viewer in a two-month period. The viewer supports both 2D unit level and 3D unit level views. The XDV has the following properties:

- The XDV is unclassified Internet/web protocol-based software, although it may be used in a secure environment to view classified data.

- An eligible stakeholder can download the software to his/her COTS PC or Common Operating Picture (COP) compliant system and execute it after installation.

- The XDV can display all information exchanged within the DCEE, i.e., all information elements comprised in the enhanced Millennium Challenge 02 Federation Object Model (FOM) are mapped to at least one element of the XDV Graphical User Interface (GUI).

- The XDV is individually configurable, i.e., the user can decide what predefined entities to view.

- Because the XDV is a passive subscriber, its execution does not slow down the overall execution of the experiment.

The time delay between the occurrence of an event in the experimentation and its display on the XDV used by the stakeholder was demonstrated to be sufficiently small as to be negligible for human users.

Figure 2 illustrates the logical architecture of XDV.

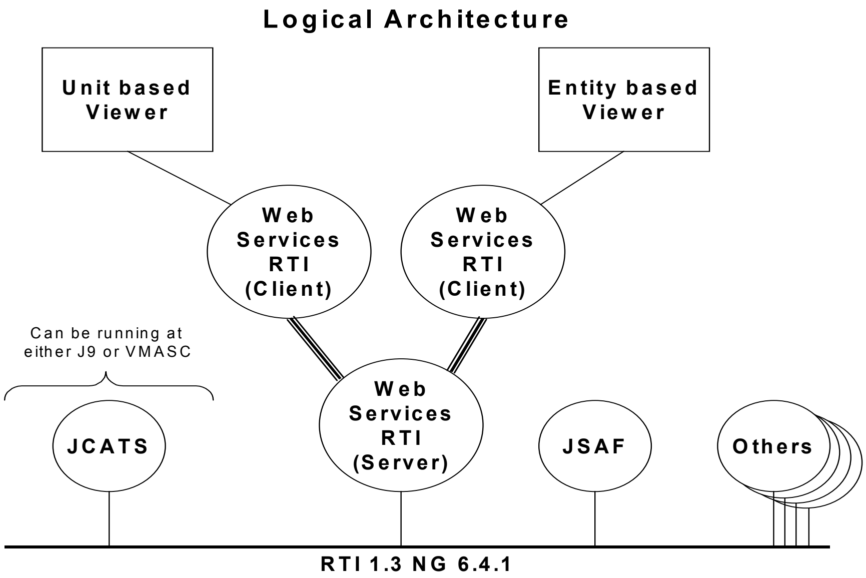

Figure 2. XDV Logical Architecture

Although the viewer was designed to support only 500 entities, it was able to participate in a federation run at VMASC with 800 entities, and another federation run at DCEE with over 19,000 entities.

5.2 XC2I

The Experimentation Command and Control Interface (XC2I) [8, 9] is an extension of XDV. XC2I has been a collaborative effort between SAIC, GMU, and VMASC with funding from JFCOM J9. The eventual goal of which is to develop a flexible 2D/3D viewer/controller for C2I distributed simulations. The rationale for such a system is one of straightforward economics: it is often neither practical nor effective to relocate ranking officers to simulation centers in order to allow them to view and interact with systems engaged in cooperative simulation events. A single, flexible C2I viewer/controller platform which can remotely connect to these events and be transparently tailored to different systems would allow these officers to view and interact with the simulations without the cost in time and money associated with relocation.

The prototype implementation was designed to interact with an HLA-compliant simulation of distributed Joint Semi-Automated Forces (JSAF) instances customized for Joint Urban Operations (JUO) scenarios and was interconnected using Run Time Infrastructure-STOW (RTI-s). This meant that actual implementations were needed for the access control subsystem, Area of Interest Management (AOIM), Aggregation Interest Management (AGIM), and an HLA data feed connector built for RTI-s. An additional data feed connector was also required to connect directly to the JSAF Persistent Object Store (POS) as not all required data could be retrieved directly via RTI-s. Finally, a Command and Control Interest Management Language (C2IML)-aware [8] control system needed to be added, with another connection directly to the POS, to allow orders to be passed from the XC2I client to entities controlled directly by JSAF. The visualization component chosen for the front-end was a modified SOFVIZ 3D viewer, itself a customization of OpenSceneGraph for the Windows platform, a product of the TERREX company. Alternatively, the open source software OpenMap was modified to be used for 2D display. Both viewer components used the same Data Storage Layer. Figure 3 shows an overview of the architecture.

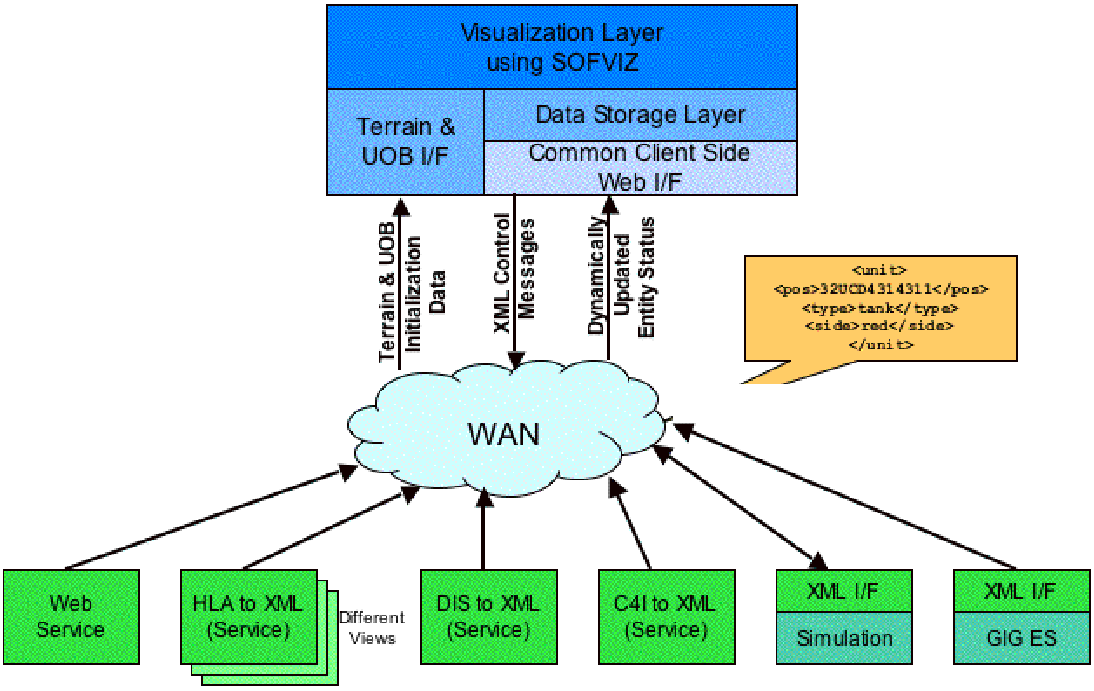

Figure 3. Experimentation Command and Control Interface Concept[3]

Web Services Interest Management (WSIM) [8] is a key component of the XC2I architecture. Figure 4 shows the software modules in the WSIM architecture.

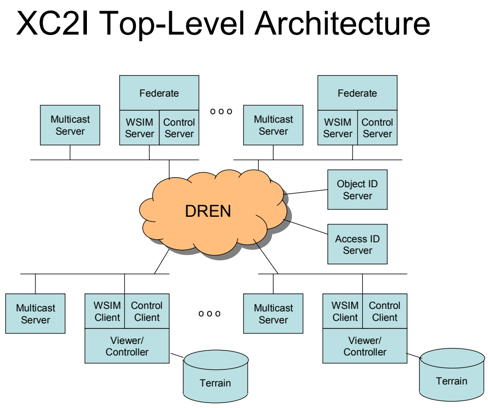

Figure 4. XC2I Web Service Interest Management Top-Level Architecture

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[3] The terrain and unit order of battle (UOB) interfaces weren't significantly exercised in our preliminary experiments.

The functions of the WSIM client are to interface to the supporting network services, and to provide role-based access control (RBAC) [9], an area of interest management user interface, and an aggregation interest management user interface to the GUI client. The WSIM server is responsible for adding tags to federate data and feeding data to clients. The input data is tagged by an interface to the simulation, federation, or other data source, to enable filtering at subsequent layers. A particular focus of our work has been to resolve the differences in communication performance implied by various possible XC2I applications. If client-server communication is implemented as a standard XML/SOAP/HTTP Web service, the client must poll the server continually for updates. Furthermore, the protocol overhead in this type of service can present an unacceptable network load where large simulations with many objects are to be viewed. Consequently, we specified and prototyped two types of communication: a classical web service and a streaming multicast service. Whereas a given experimentation environment is expected to have multiple instances of the WSIM client and server, there are three other servers that provide coordinating support, so that only one instance of each is needed. (Shadow backups could be used if extremely high reliability is needed.) The three servers are an access ID server, the schema server, and an object ID server.

5.3 Meeting NATO M&S Requirements

Table 4 demonstrates how the capabilities of XDV and XC2I enable NATO M&S.

Table 4. XDV and XC2I Enabling NATO M&S

NATO M&S Requirement	Enabling XDV/XC2I Capability
1 – collaborative efforts no longer limited to military services 2 – no affect on national sovereignty	• Role-based access control
8 – M&S in military exercises, training, and decision support 14 – Network Centric Warfare	• Low cost support of all these capabilities • Support for remote viewing via web services
3 – support all national contributions 7 – support heterogeneous infrastructures 18 – commercially viable solutions	• Use of open standards such as XML and SOAP
15 – M&S services within C2 infrastructures	• This is the fundamental purpose of XDV and XC2I

6 XSBC

XML Schema Based Compression (XSBC) is a system for automatically converting XML into a binary format that is more compact, faster to parse, and performs databinding operations more quickly. While XML's great advantages are its ubiquity and human readability, this comes at some cost, namely document size and the requirement to parse text data and put the resulting information into applications. These limitations in high performance applications are becoming more widely recognized, and several organizations have come up with their own systems for avoiding this problem by adopting a binary format for XML. To avoid the spectre of multiple, incompatible binary standards the W3C has instituted a Binary XML Characterization Group, the first of a series of steps towards establishing a W3C standard. The Naval Postgraduate School is participating in this standards process and XSBC has been used as one of the example binary applications.

It is anticipated that binary format XML will simply be an additional format to the existing XML documents. As such, XML will remain the bedrock of web services. A different, binary format would simply be a faster version of an existing XML document.

Studies by Sun Microsystems of their own system show that the speed of binary XML can approach that of Common Object Request Broker Architecture (CORBA) method calls.

6.1 Meeting NATO M&S Requirements

Table 5 demonstrates how the capabilities of XPSP enable NATO M&S.

Table 5. XPSP Enabling NATO M&S

NATO M&S Requirement	Enabling XPSP Capability
18 - applied standards are not limited to military standards	• The W3C is in the process of characterizing a binary format for XML. This is likely to evolve into a widespread standard that includes web services such as SOAP and RPC as used in web-based application servers. The Naval Postgraduate School is participating in the standards process and XSBC has been used as one of the many examples of binary XML formats.

7 XMSF PROFILE STUDY GROUP

While the concept and benefits of XMSF are easy to understand, translating that to a concrete understanding of the structure of XMSF is more challenging. XMSF will be a set of profiles rather than a single architecture where a profile is a formal technical specification for interoperability of web based technologies in support of modeling and simulation. A profile may define a new capability or define interoperability between two or more existing capabilities. These profiles will enable inter- and intra-domain interoperability. At a macro level, a profile will consist of:

- Applicable web technologies and protocol standards
- Applicable data and metadata standards, both existing and purpose specific
- A tailoring of the set of selected standards, e.g. tailoring of authentication standards
- Recommendations and guidelines for implementation

For profiles to successfully enable interoperability their initial content and structure must be agreed on. As the underlying technologies and standards evolve the profiles and their implementations will need to be upgraded in an iterative fashion to maintain interoperability. The purpose of the XMSF profile study group (SG) within the Simulation Interoperability Standards Organization (SISO) (http://www.sisostds.org) is to determine the required scope for XMSF profiles and to define their structure. The SG has set the following tasking for itself:

1. Develop profile definition including objectives.

2. Develop a profile conops.

3. Identify potential candidate implementations for profiling.

4. Survey profile definitions in other technology domains.

5. Determine applicability of other profile definitions to XMSF.

6. Review early XMSF exemplars to identify the breadth of information required to document interoperability with the exemplars.

7. Identify XMSF specific requirements for profiles.

8. Identify/specify/recommend a mechanism for documenting the interrelationships of the applicable web-based technologies, protocol standards, and metadata markups selected for a profile.

9. Draft XMSF profile standard.

The relationships among the steps in this process are illustrated in Figure 5.

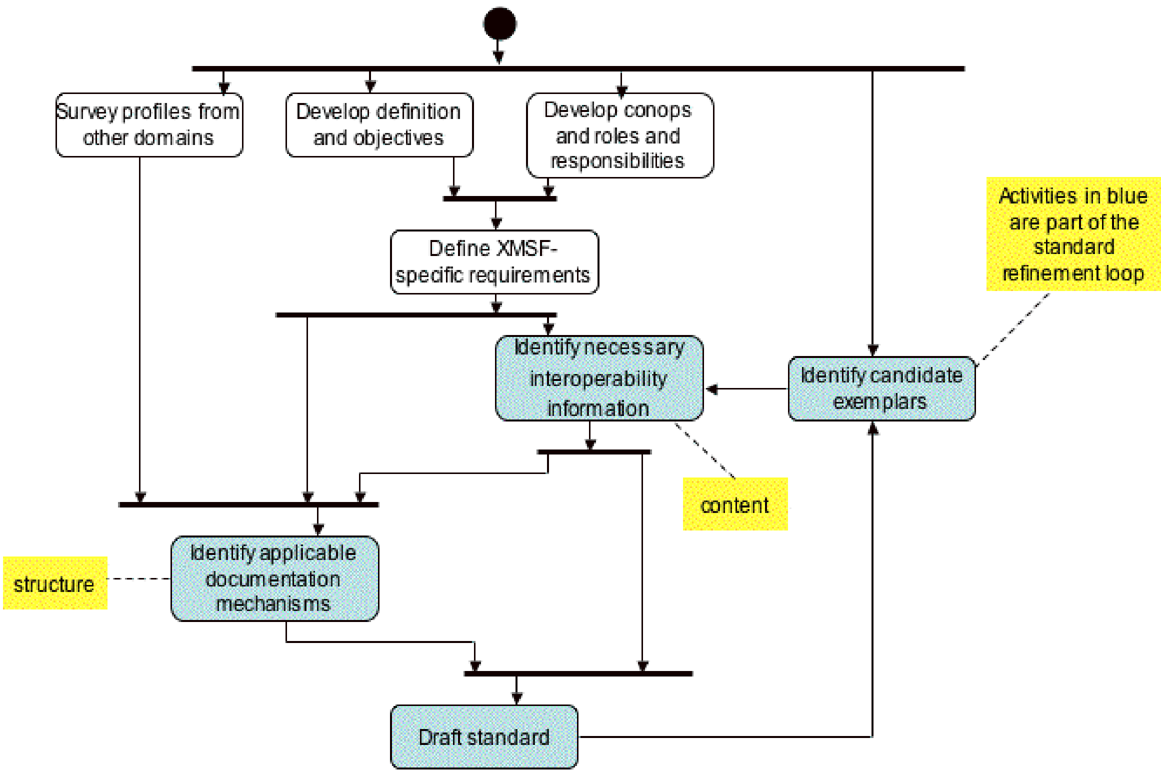

Figure 5. XMSF Profile SG Process

The SG has successfully completed the first task of developing a profile definition with objectives.

> *XMSF profiles are formal technical specifications for application of interoperable web based technologies to enabling composable and reusable modeling and simulation, and facilitating enterprise integration. The objectives of XMSF profiles are to:*

- *Provide unambiguous specification of the functionality of components, and interfaces among components of the framework - what can I expect it to do?*
- *Ensure interoperability between existing and new web enabled technologies, both within M&S and in related domains - how do I physically integrate with it?*
- *Provide the necessary metadata to facilitate composability and reuse of components across multiple M&S application domains - how do I semantically integrate with it?*
- *Facilitate development of new applications and services that are functionally interchangeable with existing applications and services - how can I build another one?*
- *Enable development of new applications and services that readily extend functionality for continuous evolution of capabilities - how can I build a better one?*

In addition, the SG has made significant progress on the second task of developing a profile conops including defining stakeholders roles and responsibilities, and the relationships between stakeholders. The current (incomplete) progress is illustrated in Figure 6.

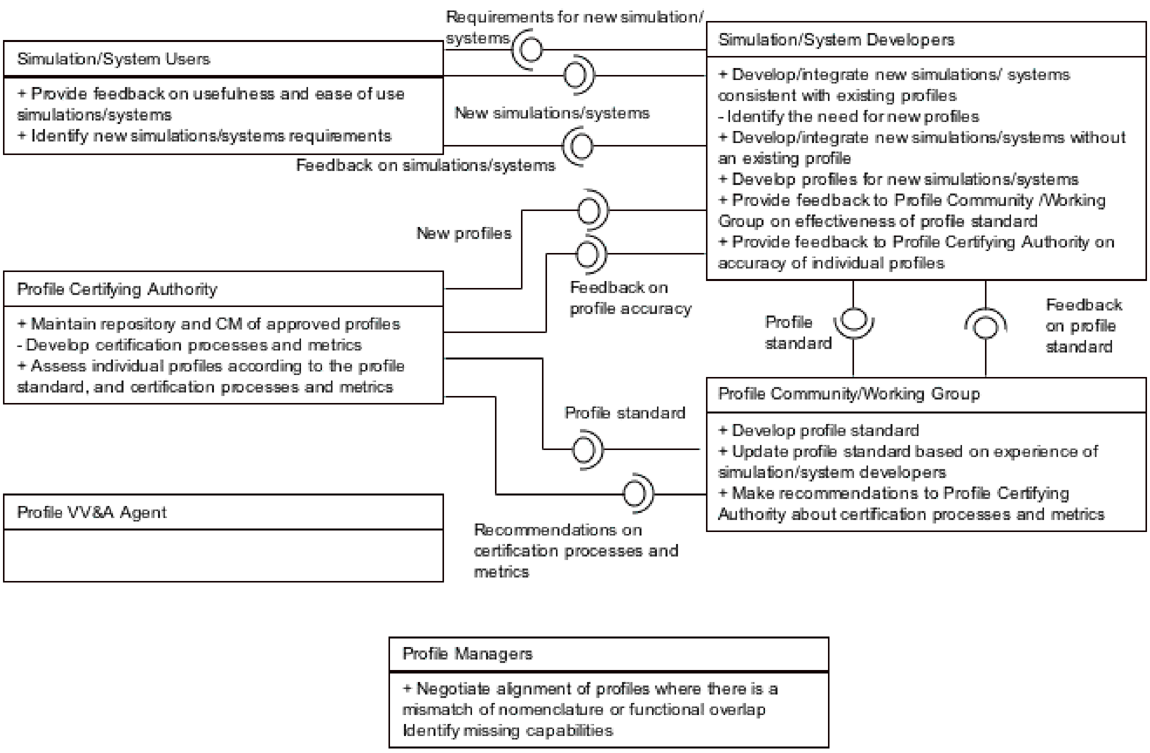

Figure 6. XMSF Profile Conops

7.1 Meeting NATO M&S Requirements

Table 6 demonstrates how the XMSF profile standard will enable NATO M&S.

Table 6. XMSF Profile Standard Enabling NATO M&S

NATO M&S Requirement	Enabling XMSF Profile Standard Capability
1 – collaborative efforts no longer limited to military services 2 – no affect on national sovereignty 3 – open enough to support all potential national contributions 18 – commercially viable solutions	• International, open standards effort
6 – migration of legacy system and orchestration of resulting international federations 9 – M&S in military exercises, training, and decision support 16 – embedded M&S reaching the warfighter for training and education 17 – M&S supporting distance learning	• Support for integration of many existing technologies via web services

8 WEBSIM

The WebSim Partnership (http://www.websim.net) is a loosely coupled union of standards organizations in the M&S domain who have common interest in the advancement of standards addressing business processes and technical issues that support the migration of M&S capabilities to a World Wide Web (WWW or W3) based environment. Hence, the WebSim Partnership represents the desire of these organizations to collaborate in the development and conduct of coordination, outreach and education program activities to encourage advancement of standards-based, interoperable, web-enabled M&S, thereby advancing the objectives of each organization's membership, while retaining the independent identity, processes, and functions of each.

The current members of the WebSim Partnership are the Object Management Group (OMG), the Open GIS Consortium, Inc. (OGC), the Simulation Interoperability Standards Organization (SISO), and the Web3D consortium (Web3D).

The WebSim Partnership vision is of M&S components participating as part of a horizontally integrated system of systems architecture using web technologies and aligned business practices. Under this style of architecture, M&S components should be autonomous systems capable of interfacing with other operational systems, data feeds, and data consumers in real-time. Decision makers should be able to task M&S systems as part of their set of normal operational tools. M&S systems, in turn, should be able to integrate components of the operational system with simulated components and data to perform rapid and relevant what-if analysis for decision makers. Migration of legacy components must be supported as well.

The specific working objectives for the WebSim Partnership are:

- Develop and implement an Annual Workshop on Web Enabled Modeling and Simulation.
- Develop and implement collocated workshops with other events conducted by WebSim Parnership member organizations to increase synergy between the organizations and their activities in the future.
- Develop and coordinate the production and dissemination by WebSim Partnership member organizations of appropriate joint outreach and marketing materials to raise awareness and interest in web-enabled modeling and simulation objectives, and to encourage membership and participation in the activities of the participating organizations. Outreach and marketing may include (but not be limited to) management and hosting of a WebSim website, development of print brochures and fact sheets, development of articles for submission to popular journals and other publications, etc.
- Encourage the emergence of an integrated Web Enabled Modeling and Simulation community by facilitating collaboration between the membership of the WebSim Partnership member organizations.
- Coordinate work programs among WebSim Partnership member organizations to ensure that the talents and capabilities of each are employed to the best advantage of the WebSim community.

8.1 Meeting NATO M&S Requirements

Table 7 demonstrates how WebSim enables NATO M&S.

Table 7. WebSim Enabling NATO M&S

NATO M&S Requirement	Enabling WebSim Capability
1 – collaborative efforts no longer limited to military services 2 – no affect on national sovereignty 3 – open enough to support all potential national contributions 18 – commercially viable solutions	• Collaboration between international standards organizations, including commercial organizations

9 SUMMARY

XMSF's commitment to open web standards, its use of a conceptual framework rather than language specific constructs, and its application of XML schema definitions support NATO's requirements for collaboration and interoperability. The XMSF partners are "leading the parade" for international standardization of these capabilities with the XMSF Profile Study Group and the WebSim Consortium.

10 REFERENCES

The website of the Simulation Interoperability Standards Organization is a valuable source of information regarding the topic of this paper. Most of the information is available to the public, however, some areas require a password, which automatically comes with the membership, and some very limited areas are reserved for administration business of special committees. For more information, please refer to http://www.sisostds.org.

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