An Architecture for Web-Services Based Interest Management in Real Time Distributed Simulation

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Presentation Overview

• Background: XMSF and Web Services
• Web Service Issues
• Interest Management Project
• WSIM Architecture
  – Area of Interest Management
  – Aggregation Interest Management
  – Role-Based Access Control
• Streaming Delivery Issues
• Conclusions
XMSF Motivation

• Transformational technologies are needed to scale up defense modeling/simulation to meet real-world needs
• Web technologies provide a common framework:
  – Dynamic capabilities, open standards, Web business model provide lift to support government and commercial success
  – Easy use and open extensibility for developers and users, fueling rapid growth of interoperable simulations
  – Bring defense modeling/simulation/tactical support into mainstream of enterprise-wide best-business practices
XMSF Precepts

- **Web-based technologies** can provide an extensible modeling and simulation architecture, to support a new generation of interoperable applications
- Simulation support is needed for operational warfighting capabilities
- XML-based architecture can provide a bridge between emerging rehearsal/reality/replay requirements and open/commercial Web standards
- Particularly promising for C4I-Simulation interoperation
- **Web = best tech strategy + best business case**
What Does XMSF “Look Like?”

• A set of profiles rather than a single architecture
  – Formal technical specifications 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

• XMSF profiles will include
  – Applicable Web technologies, protocol standards, data and metadata standards
  – A tailoring of the set of selected standards
  – Recommendations and guidelines for implementation

Architecture for WSIM - Morse, Brunton, Pullen, McAndrews, Tolk, Muguira
## Web Services

<table>
<thead>
<tr>
<th>Repositories</th>
<th>Administrative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where approved services reside</td>
<td>Exemplar: DoD XML Registry</td>
</tr>
<tr>
<td><strong>Services Discovery</strong></td>
<td><strong>UDDI, LDAP</strong></td>
</tr>
<tr>
<td>Publish, search capabilities</td>
<td>Universal Description, Discovery Integration Lightweight Directory Access Protocol</td>
</tr>
<tr>
<td><strong>Services Description</strong></td>
<td><strong>WSDL, BPEL4WS</strong></td>
</tr>
<tr>
<td>Detailed methods, parameters</td>
<td>Web Services Description Language Business Process Execution Language for Web Services</td>
</tr>
<tr>
<td><strong>XML Messaging</strong></td>
<td><strong>XML-RPC, SOAP, XMLP</strong></td>
</tr>
<tr>
<td>Simple XML encoding/decoding</td>
<td>Remote Procedure Calls, XML Protocol</td>
</tr>
<tr>
<td><strong>Service Transport</strong></td>
<td><strong>HTTP, SMTP, FTP, BEEP</strong></td>
</tr>
<tr>
<td>Move messages between apps</td>
<td>Transfer is independent of messages</td>
</tr>
</tbody>
</table>
Web Services Protocol Stack

Service Provider
- SOAP
- HTTP
- BEEP
- SMTP
- TCP / IP

Service Registry
- UDDI
- WSDL
- HTTP
- TCP / IP

Service Consumer
- SOAP
- HTTP
- BEEP
- SMTP
- TCP / IP

WAN / Internet
XC2I Viewer

- US JFCOM experimentation environment
  - Complex and rich
  - Basically a very large LAN-based NVE
  - 100k objects in hybrid HLA/DIS system
- Desirable to extend access over WAN
  - View a subspace
  - Control object behavior
WSIM Motivation

XC2I Potential Information Flow Estimate

- **Viewers**
  - Each potentially has 10000 objects viewable
  - 100 different simultaneous views maximum
  - Viewers may or may not overlap
  - A viewer that zooms out uses aggregation service such that there are no more updates per second from the service than when zoomed in

- **Federates**
  - 250 processors
  - 5000 objects per processor
  - Average update period 2.5 seconds

- **Worst-case aggregate flow:**
  
  400 K updates/s (~100 bytes each)
  40 MBytes/s = 320 Mb/s => not feasible on WAN

  (sensitive to the viewable objects and max views)
Ways to Reduce Network Impact of Viewer

- Limit scope in geographic and other dimensions
- Aggregate objects at server
- Don’t transmit movements too fine to be seen
- Decrease the viewer refresh rate to preclude network overload
  - statically as startup parameter
  - or dynamically as necessary during execution
- Use streaming multicast for high-volume flows
WSIM Overview

The user subscribes to types of entities in a geographic region using a GUI

- Make the process as easy and visual as possible
  - Point & click
  - Drag & drop
- Insulate the user from the details of the Interest Management (IM) protocol and underlying, native IM mechanisms
  - Mapping is handled at layers beneath the viewer
- A user can only subscribe to entities in the current viewbox
  - If an entity of interest moves out of the viewbox (“out of scope”), its updates won’t be delivered again until it’s back in scope, but the subscription will remain in effect
  - This is enforced by the viewer, not by the IM protocol
Top-Level Architecture With WSIM

Architecture for WSIM - Morse, Brunton, Pullen, McAndrews, Tolk, Muguira
WSIM Functions

Area of Interest Management

The IM protocol is focused on C2 viewers
- Not as general as HLA DDM because it explicitly includes geographic location and entity type
- But broader than JFCOM JUO
  - Tailoring is handled in one of the mapping layers
- The same protocol can be used with other federations by changing only the bottom mapping layer
### WS Interest Management Layers

#### Generic

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>User’s IM language/interface</td>
<td></td>
</tr>
<tr>
<td>Mapping between user’s IM &amp; IM protocol</td>
<td></td>
</tr>
<tr>
<td>IM protocol</td>
<td></td>
</tr>
<tr>
<td>Mapping between IM protocol and native IM</td>
<td></td>
</tr>
<tr>
<td>Native IM</td>
<td></td>
</tr>
</tbody>
</table>

#### JFCOM J9 JUO

<table>
<thead>
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<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUI: user selects lat/lon/alt, entity (or aggregation) type</td>
<td></td>
</tr>
<tr>
<td>Mapping between GUI inputs &amp; IM protocol</td>
<td></td>
</tr>
<tr>
<td>XML Interest Expressions (some tags derived from C2IEDM)</td>
<td></td>
</tr>
<tr>
<td>Mapping between IM protocol, and JSAF POB &amp; RTI regions</td>
<td></td>
</tr>
<tr>
<td>JSAF POB &amp; RTI regions</td>
<td></td>
</tr>
</tbody>
</table>

*Not necessarily a one-to-one mapping to physical architecture components*

Architecture for WSIM - Morse, Brunton, Pullen, McAndrews, Tolk, Muguira
WSIM Functions
Aggregation Interest Management

Aggregation:

- “the ability to group entities while preserving the effects of entity behavior and interaction”
- type driven: based on the organization types of the simulated platform and entities established in the military order of battle
- instance driven: based on specific user requirements, e.g. “show these three objects as one icon”
- Instance driven overrides type driven
- Applicable to generic military command & control
WSIM Functions
Role-Based Access Control

• Participants have defined access rights
• Don’t send viewer data that will not be displayed
• Combined with latest Web security
  – Globally unique signed certificate
  – Distributed identity management, e.g. LDAP
  – GUI for role selection (within user’s prescribed rights)
Detailed WSIM Architecture

Client

WSIM Client GUI
- AC
- AOIM
- AGIM

DIS Viewer
- C2 to DIS (debug)
- Client Data API
  - Multicast transport
  - HTTP transport

Server

Access ID Server*
- Role request/Token

Broker/Access Control*
- Access request/ACK
- AOIM request/ACK
- AGIM request/ACK

AOIM Filter
- XML tagged state change data
- XML tagged client data requests

AGIM Filter
- XML tagged state change data
- XML tagged client data requests AGIM filtered

Broker/Access Control*
- XML tagged state change data
- XML tagged client data requests AOIM transformed

Thin Service with AC and compression
- Thin Service with AC
- Thin Service with Compression

Integrated WSIM Server

State Change data

Multicast transport

XML parser

Schema
- C2 schema
- IM schema
- AG schema

Object ID server

LEGEND:
- XML
- XML/HTTP
- XML/SOAP
- Compressed XML
- other

Instance enumeration request/value

POB-tagged
- POB-tagged state change data
- POB-tagged client data requests

FOM-tagged
- FOM-tagged state change data
- FOM-tagged client data requests

DIS PDU
- DIS PDU state change data input

Final state change data input
Web Service Overhead (~3000%)

<table>
<thead>
<tr>
<th>Pure Web service</th>
<th>Web service plus multicast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect</td>
<td>- 136 Bytes</td>
</tr>
<tr>
<td>HTTP Request Seg 1</td>
<td>- 1500 Bytes</td>
</tr>
<tr>
<td>Client Ack 1</td>
<td>- 40 Bytes</td>
</tr>
<tr>
<td>HTTP Request Seg 2</td>
<td>- 120 Bytes</td>
</tr>
<tr>
<td>Client Ack 2</td>
<td>- 40 Bytes</td>
</tr>
<tr>
<td>HTTP Response Seg 1</td>
<td>- 833 Bytes</td>
</tr>
<tr>
<td>HTTP Response Seg 2</td>
<td>- 40 Bytes</td>
</tr>
<tr>
<td>Client Ack for seg 1</td>
<td>- 40 Bytes</td>
</tr>
<tr>
<td>Client Ack for seg 2</td>
<td>- 40 Bytes</td>
</tr>
<tr>
<td>Response 1</td>
<td>- 40 Bytes</td>
</tr>
<tr>
<td>Ack 1</td>
<td>- 48 Bytes</td>
</tr>
<tr>
<td>Response 2</td>
<td>- 48 Bytes</td>
</tr>
<tr>
<td>Ack 2</td>
<td>- 40 Bytes</td>
</tr>
</tbody>
</table>

Total Per Computation : 2829 Bytes

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</tr>
<tr>
<td>HTTP Response Seg 1</td>
</tr>
<tr>
<td>HTTP Response Seg 2</td>
</tr>
<tr>
<td>Client Ack for seg 1</td>
</tr>
<tr>
<td>Client Ack for seg 2</td>
</tr>
<tr>
<td>Response</td>
</tr>
</tbody>
</table>

Total for setup: 2886 Bytes

Multicast Packet Size average - 88 Bytes

Grand Total = 2886 + 350 * 88
= 33686 Bytes

Grand Total = 136 +350 * 2829
= 990286 Bytes
Web Services for XC2I

• Pro:
  – Easy to create
  – Easy to interface
  – Easy to compose
  – Use everywhere data volume is low

• Con:
  – Significant overhead
  – Don’t use for massive data flows
Multicast Server (XOM)

- Provides multicasting service over WAN
  - Couples to IP multicast on LAN
  - Minimizes traffic using optimal transfer tree
- See companion paper
Overlay Multicast Tree

IP Multicast tree:

Architecture for WSIM - Morse, Brunton, Pullen, McAndrews, Tolk, Muguira
WSIM with Streaming Multicast

TCP/IP plus UDP/IPmc

Architecture for WSIM - Morse, Brunton, Pullen, McAndrews, Tolk, Muguira
Conclusions

• The XMSF approach is showing great promise as a basis for distributed software interoperation
  – In particular, distributed simulation
• We have developed an architecture for generic Web-service interest management
  – Prototype now running
• However, we have found some limitations in the approach
  – Web services need to be extended for high performance systems
  – We used streaming multicast for the extension