Maturing Supporting Software for C2-Simulation Interoperation

J. Mark Pullen and Lisa Nicklas

George Mason University C^{4}I Center

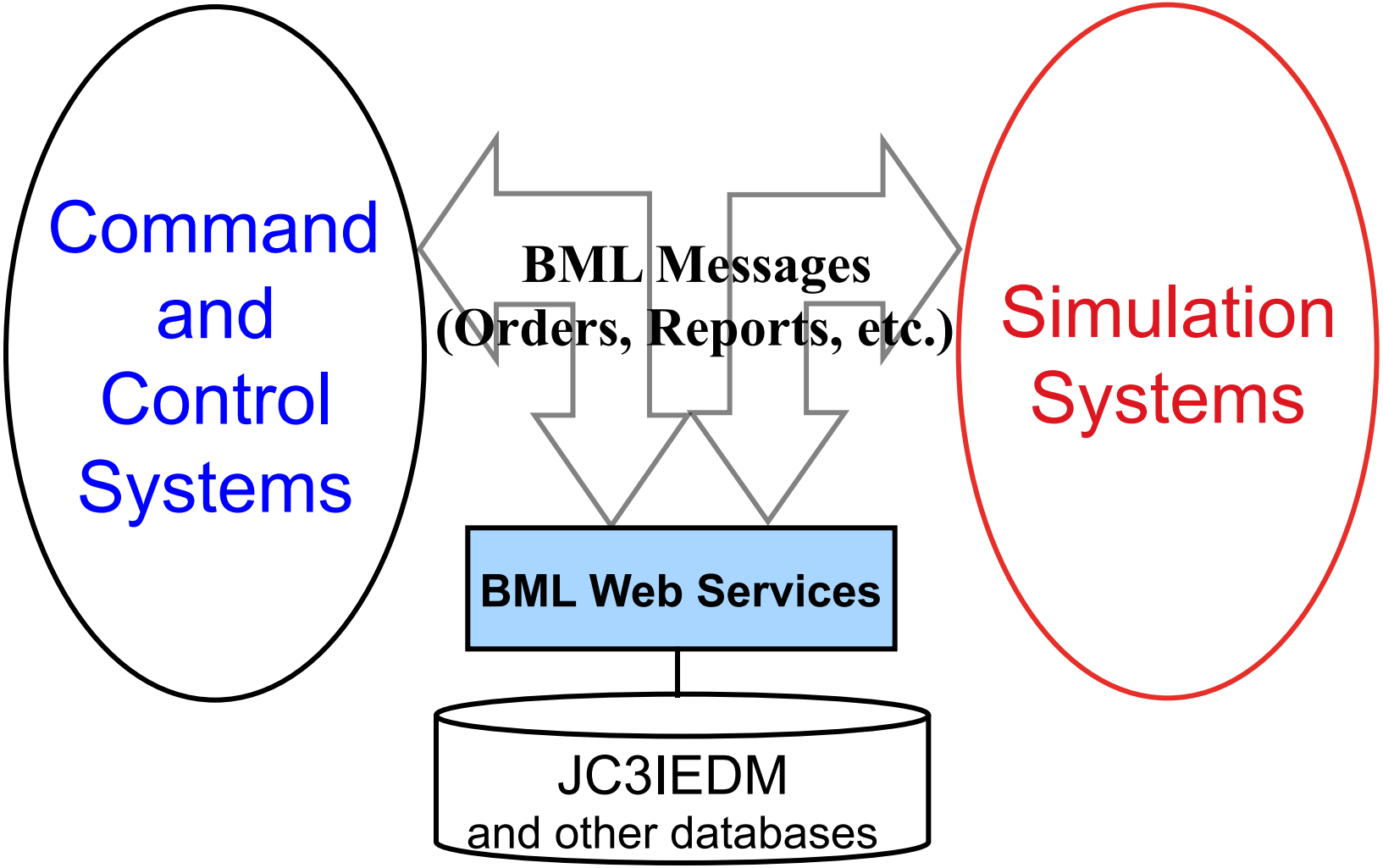
Presentation Overview

- BML Architecture
- Scripted BML Background
- SBML Enhancements
  - Programmability
  - Publish/subscribe of dynamic topics
  - Performance issues
  - Example of application
- Client support: BMLC2GUI
- Conclusions

BML Purpose and Operation

- Facilitates C2-Simulation interoperation
  - Exchange of Orders and reports in standard format
- Current architecture uses a repository service to hold state submitted by client C2 and Simulation systems
  - Web service with XML input – Network Centric
  - Data stored in JC3IEDM and can be replicated

BML Architecture



A Note on Open Source

- Our laboratory has open source policy
- Community shares supporting software
  - Often, server/middleware
- Supports re-use at system and component levels
- Avoids vendor lock-in and dead-end
- Open release avoids some restrictions (ITAR)
  - But can't be used if software contains any sensitive information

BML Community is Well-Suited to Open Source Server/Middleware

- International group with shared need for software to support interoperation
- Initial capability comes from a university
  - Sharing is natural in academic world
- Other forms of sharing require complex agreements
- Works best when participants provide specific feedback on problems
  - MSG-048 sometimes identified location of bug and fix
  - Next step: contribute improvements

Scripted BML Server Background

- Middleware functions don't change
  - Mapping BML to JC3IEDM and push/pull to database
  - Program these once and get them right
- Interpreted WS offers flexibility
  - Rapid implementation of new BML constructs
  - Easy to modify underlying data model
    - MIP standard also continues to change
  - Reduces time and cost for prototyping
  - Scripting language provides a concise definition of BML-to-data model mappings
  - Although bugs still happen, the number of possible mistakes is far smaller
- Scripted operation may, however, be slower
  - Multithreading helps this
  - But a hard-coded implementation is likely to perform better

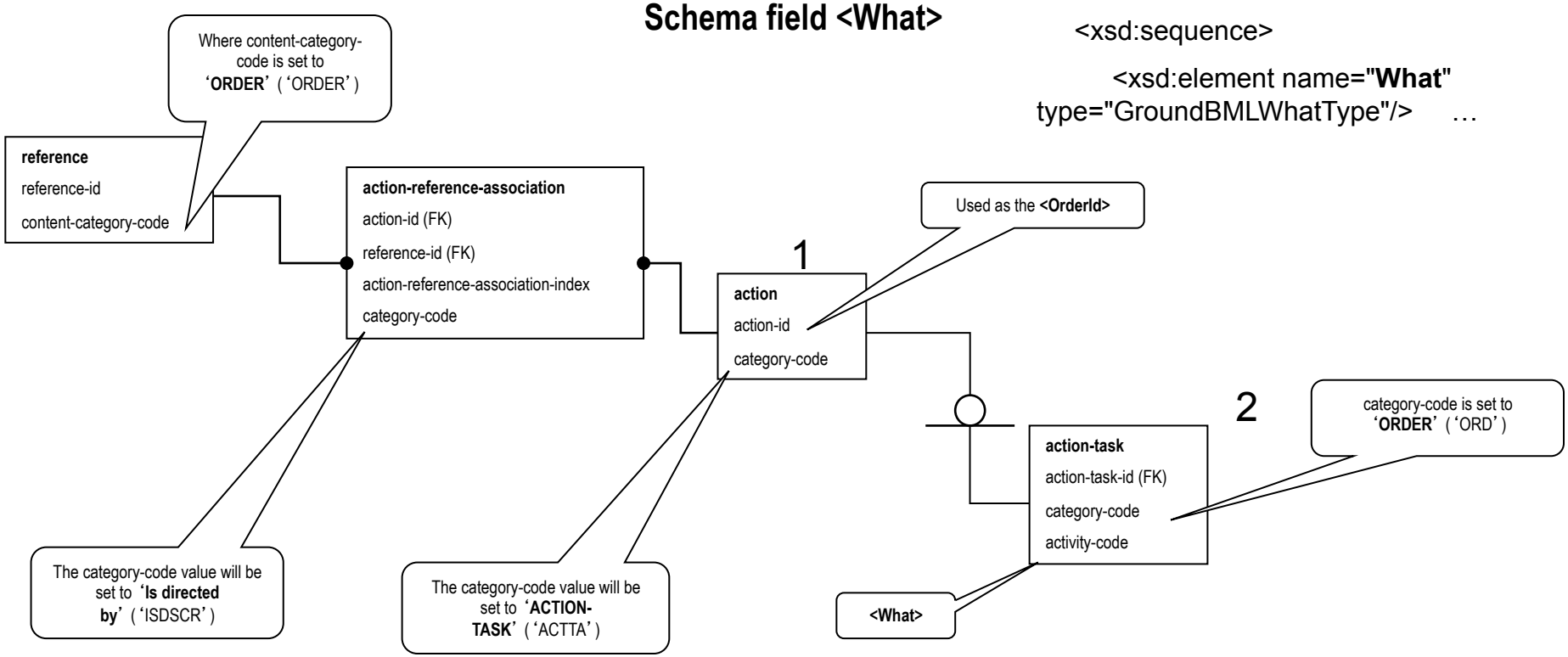
The Old Way: IDEF1x Mapping Definition

JBML mapping to JC3IEDM

Schema field <What>

Schema Reference:

```
<xsd:complexType name="CommandType">
  <xsd:sequence>
    <xsd:element name="What" type="GroundBMLWhatType"/>  …
```

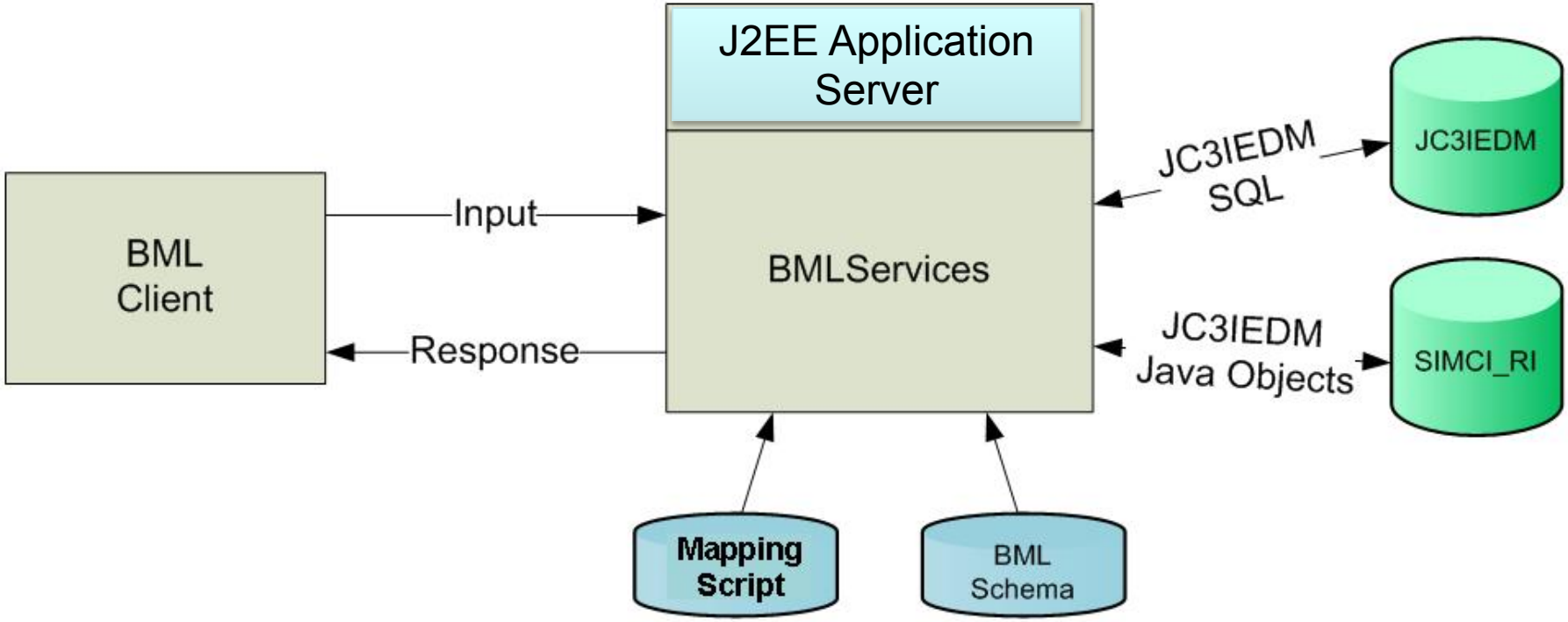


Not machine readable though highly structured
Script is a concise XML coding of this

Scripted BML WS Design

- Basic operations: *push* and *pull*
  - Currently, servers for SQL and RI databases
  - Scripts implement BML Orders and Reports
- Script defines implementation of Business Objects (constituents of the higher-level BML grammar) over the JC3IEDM data model
  - BO is an XML subtree rooted at a defined node in the XML file – can invoke other BO
- Interpreter uses two files plus WS input
  - Mapping file contains script
  - BML schema file provides necessary context
  - XML namespace capable

Scripted BML WS Configuration



Two implementations: MySQL and SIMCI RI

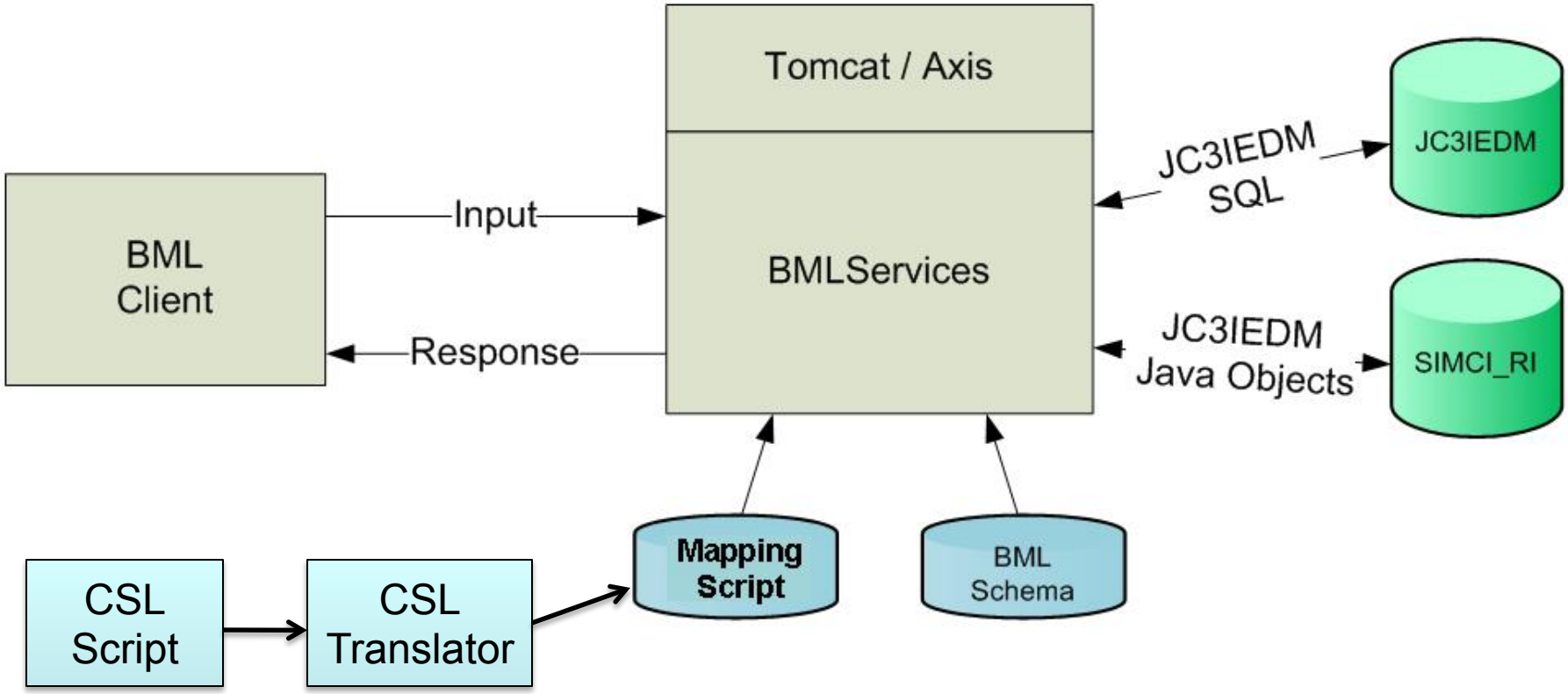
SBML Enhancements

- Condensed Scripting Language (CSL)
- Pushing a Complete Thought in JC3IEDM
- BML Namespaces
- Multithreaded Operation
- Logging/Replay
- SISO C-BML Implementation
- OPORD and NATO OPORD
- Publish/Subscribe Dynamic Topics
- RESTful service and multi-language interface

Condensed Scripting Language

- Coding the script in XML makes parsing simple
- But XML is verbose and thus hard to read
- We’ve defined a condensed format which is isomorphic to the XML script and thus simple to translate
  - Intended to invoke business objects that produce a “complete thought” in JC3IEDM
  - We expect the result will be more modular as well as much more readable
  - So we needed a mechanism to make this work

Where CSL Is Used



Pushing a Complete Thought in JC3IEDM

- MIP provides recommended usage for JC3IEDM
  - "A database update or query must constitute a complete logical military thought."
    - JC3IEDM 3.0.2 Annex O. 5/14/2009
- We understand this to mean all the data about a business object (composite) should be completed at the same time
  - Don't push incomplete data to database
- We've added terms in scripting language to define a complete thought and an SBML mechanism to consolidate the push
  - ri_start and ri_end

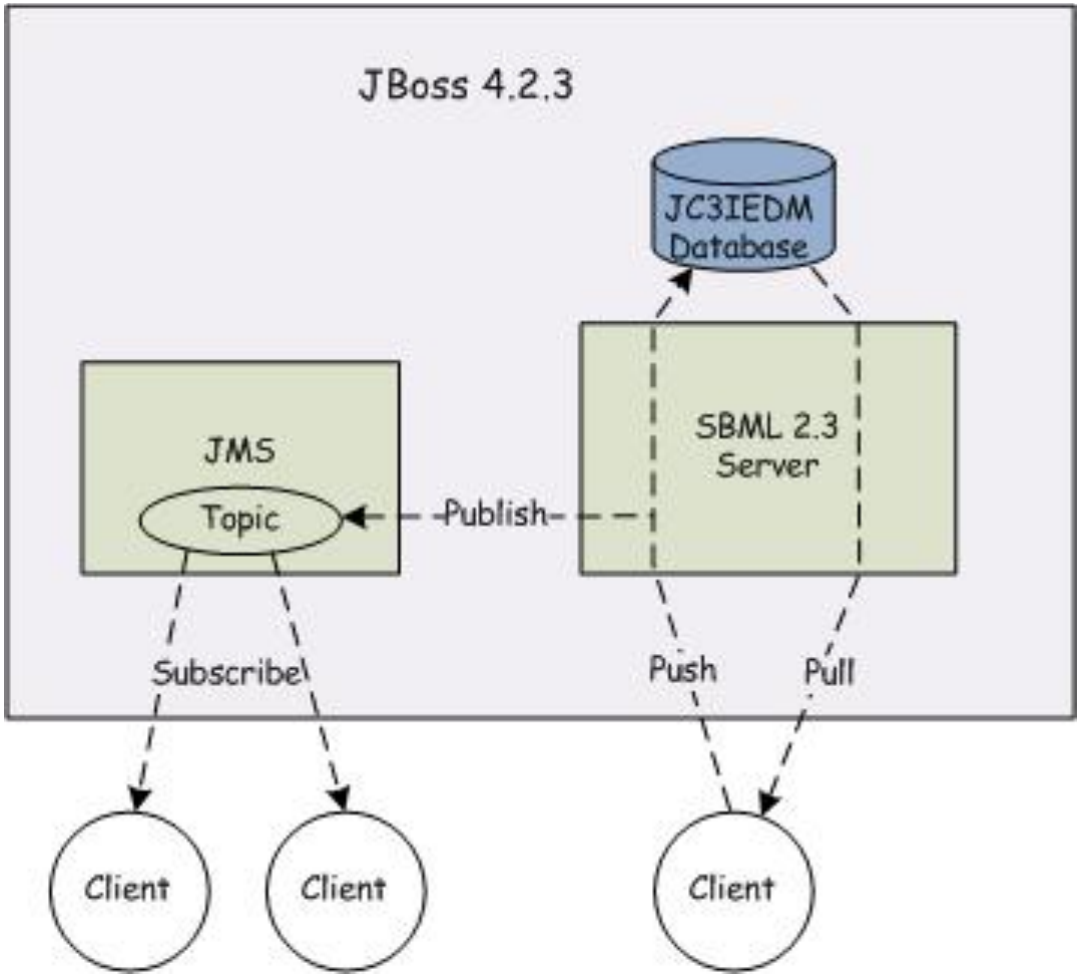
Condensed Scripting Language Example

```
BOTransaction TaskeeWhoPush (task_act_id) ()
{
  ri_start Unit unit_id;
  GET unit unit_id (formal_abbrd_name_txt = UnitID);
  PUT act_res (
          act_id = task_act_id,
          act_res_index = act_res_index, cat_code = "RI",
          authorising_org_id = unit_id) ;
  PUT act_res_item (
          act_id = task_act_id,
          act_res_index = act_res_index,
          obj_item_id = unit_id ) ;
  ri_end;
  BOReturn
  {
    BOReturnElement
    {
      Tag Result "OK";
    }
  }
}
```

Polling vs Publish/Subscribe

- "Pure" Web Service is always accessed by *push* or *pull* transaction from client
  - No provision for server to initiate action
- For clients to stay up to date they must pull latest status from server at rate determined by their need for up-to-date information (called *polling*)
  - Result: MSG-048 server in 2008 spent most of its time responding to status pulls
- Publish/subscribe gets around this by letting clients identify the categories of information they need – they *subscribe* to *Topics*
  - Server sends them a copy of every update associated with each subscribe Topic
  - More timely updates and a dramatic reduction in overhead

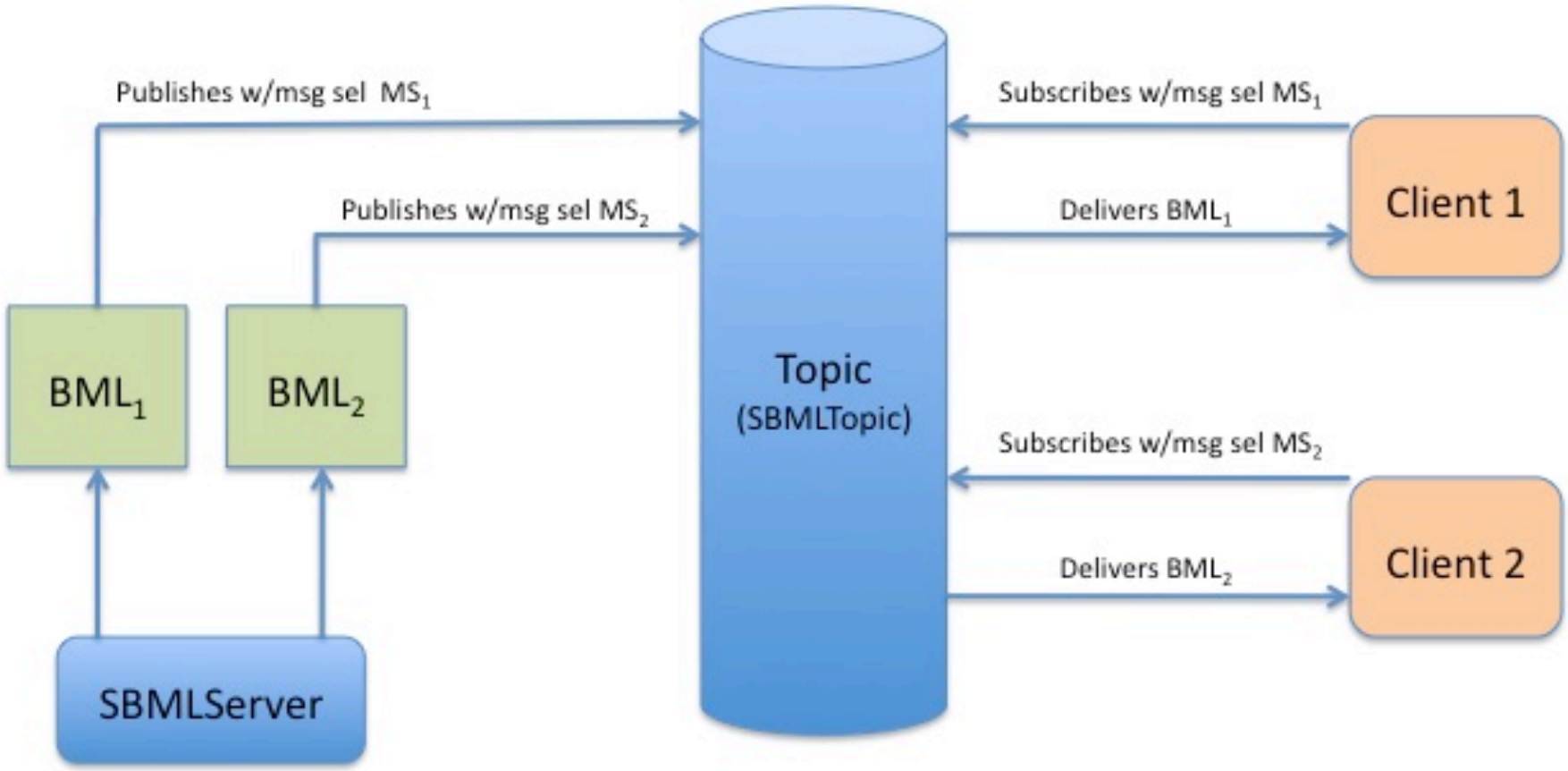
Publish/Subscribe Architecture



Publish/Subscribe Dynamic Topics

- Topic assignment
  - MSG-048 experimentation was the largest BML coalition to date, so we kept it simple
  - Topics were chosen in advance and coded in server
- Dynamic topics
  - More powerful approach allows Topics to be assigned at runtime
  - Implemented using JMS Message Selectors working through a single static Topic
  - Client defines interest using XPath

Message Selectors for Dynamic Topics



Sample msgSelectors XML

```
<?xml version="1.0" encoding="UTF-8"?>
<Message>
    <Selector>
        <name>allGSR</name>
        <search>//TypeOfReport[. = 'GeneralStatusReport']
  </search>
    </Selector>
    <Selector>
        <name>allOrder</name>
        <search>//OrderPush</search>
    </Selector>
    <Selector>
        <name>allSIMCI</name>
        <search>/*[contains(name(),'REP')]</search>
    </Selector>
</Message>
```

Java Code to add msgSelector

```
…
import edu.gmu.c4i.sbmlclientlib.SBMLClient;
…
// create a client to the SBMLserver webservice
SBMLClient sbmlClient = new SBMLClient(host);

// add a new Message Selector
String s = null;
try
{
    s = "//newwho:ListWho";
    String selectorName = sbmlClient.addMsgSelector(s);
    System.out.println("added msg selector " + selectorName);
}
catch (Exception e)
{
    System.out.println("Unable to add Message Selector " + s + " "
        + e.getMessage());
}
```

BML Namespaces

- SBML must parse XML input
  - Both BML itself and script are XML
  - Should comply with W3C specifications
- This was hard to do, so deferred initially
  - Now we have completed it
  - Done by mapping BML to various schemas from which it is assembled
  - Allows validation of BML/XML with namespace
- Existing scripts have been modified to use namespaces correctly

Namespace Example

```
<?xml version="1.0" encoding="UTF-8"?>
<BusinessObjectInput …
   <!-- Define URI to prefix mapping for namespaces -->
   <Namespace>
      <uri>http://netlab.gmu.edu/IBML</uri>
      <prefix>bml</prefix>
   </Namespace>
   <Namespace>
      <uri>http://netlab.gmu.edu/JBML/BML</uri>
      <prefix>newwho</prefix>
   </Namespace>
   <Namespace>
      <uri>http://netlab.gmu.edu/JBML/MSDL</uri>
      <prefix>msdl</prefix>
   </Namespace>
   <Namespace>
      <uri>urn:int:nato:standard:mip:jc3iedm:3.1a:oo:2.0</uri>
      <prefix>jc3iedm</prefix>
   </Namespace>
</BusinessObjectInput>
```

```
BOTransaction LowerOrderPush()()
  {
    Assign [bml:OrderID] OrderIDwv;
    IfThen (OrderIDwv EQ "")
    {
      Abort OrderID does not exist in the input file;
    }
    GET  ACT act_id (name_txt EQ [bml:OrderID]);
    Assign act_id order_act_id;
    IfThen (act_id NE "")
    {
      Abort OrderID already exists;
    }
    GET  UNIT unit_id assignTo=taskerWhoUnitID
      (formal_abbrd_name_txt EQ
          [bml:TaskerWho/bml:UnitID]);
    IfThen (taskerWhoUnitID EQ "")
    {
          Abort Invalid or Absent TaskerWho in
  Order;
    }
```

Multithreaded Operation in SBML

- A known disadvantage of XML is its verbosity
- Results in a lot of network traffic and contributes to performance problems
  - Parsing and SOAP processing also take time
- When message volume is high, this can be offset somewhat by multithreading
  - SBML designed to support experiments not production
  - But even in experimental environment performance may be needed
  - So we've revised SBML code to work multithreaded
- Latest achievement:
  - Over 10 Reports/second with 8 processors on lab server
  - Expect this to scale to at least 16 processors

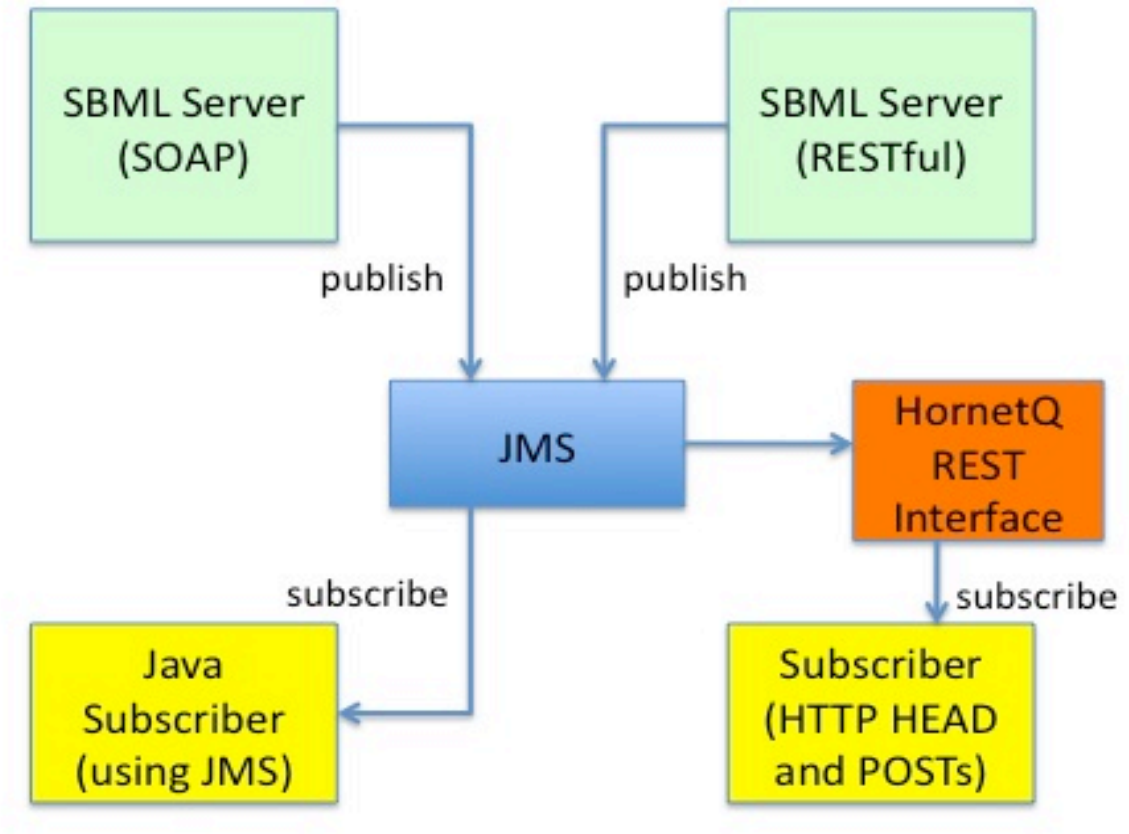
Logging/Replay in SBML

- Logging/replay is very useful in development and experimentation
  - Allows exact review and comparison of results
  - May be used to repeat input sequences for testing
- Initial SBML had only console log
  - Could capture transactions but they were difficult to extract
- We’ve added input/output logging to SBMLv2.4
  - And a replay client to regenerate traffic
- We expect this functionality will grow as users find ways it should be enhanced

RESTful Services

- Representational State Transfer (REST)
  - More efficient because it does not use SOAP
  - Our measurements indicate 15% improvement
- Client Language flexibility
  - JBoss supports SOAP and RESTful messaging
  - RESTful supports any subscriber that has access to a HTTP client library
  - This will avoid need to use Java Native Interface intermediary on C++ clients

HornetQ REST Interface

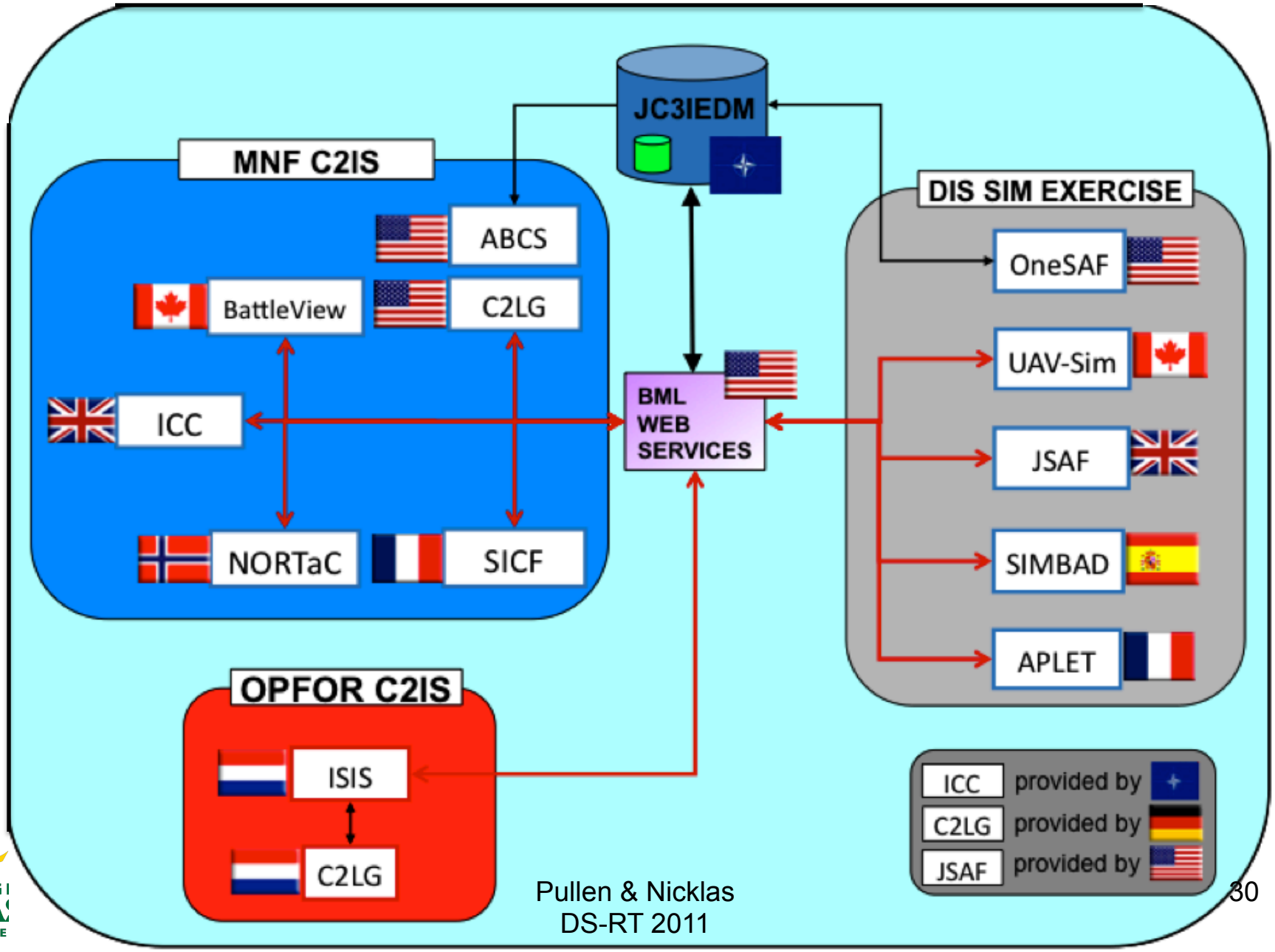


SBML Summary

- Scripted BML WS served well as development tool for MSG-048 and SIMCI
  - Enables developing reliable services more rapidly
  - Open source http://netlab.gmu.edu/OpenBML
  - Offered Reference Implementation for SISO C-BML
- Enhancements make SBML more useful
  - Complete Thought enhances modularity
  - Namespace implementation complies with W3C
  - Multithreaded operation 10X (or more) performance
  - Logging/replay improves utility
  - Publish/Subscribe now has dynamic Topics
  - Includes more efficient RESTful services that also support a range of client programming languages

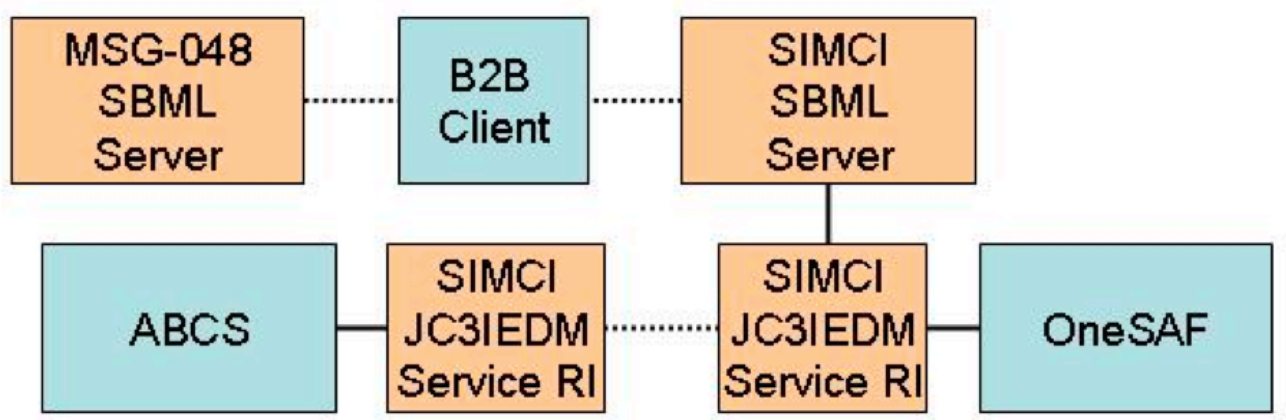
SBML Application

MSG-048 2009 Architecture



Multiple SBML Servers in MSG-048

- US C2 and Simulation systems in MSG-048 came from SIMCI project which used the Java JC3IEDM RI that was not available to other MSG-048 participants
  - All other systems used the database implementation
- We built a "back-to-back client" to pass BML reports between from RI-based SBML to MSG-048 SBML



SISO C-BML Implementation

- SISO has released Phase 1 Trial Use Draft Schema and mappings
  - Standard composite “FiveWs”
  - Abstracted and Light versions
- GMU has implemented CompositesLight portion of the schema in SBML push/pull
  - With IBML Order/Report from MSG-048
  - With JC3IEDM database
  - Also full schema as push/pull of XML documents (not mapped to JC3IEDM)

OPORD Schemas for SBML

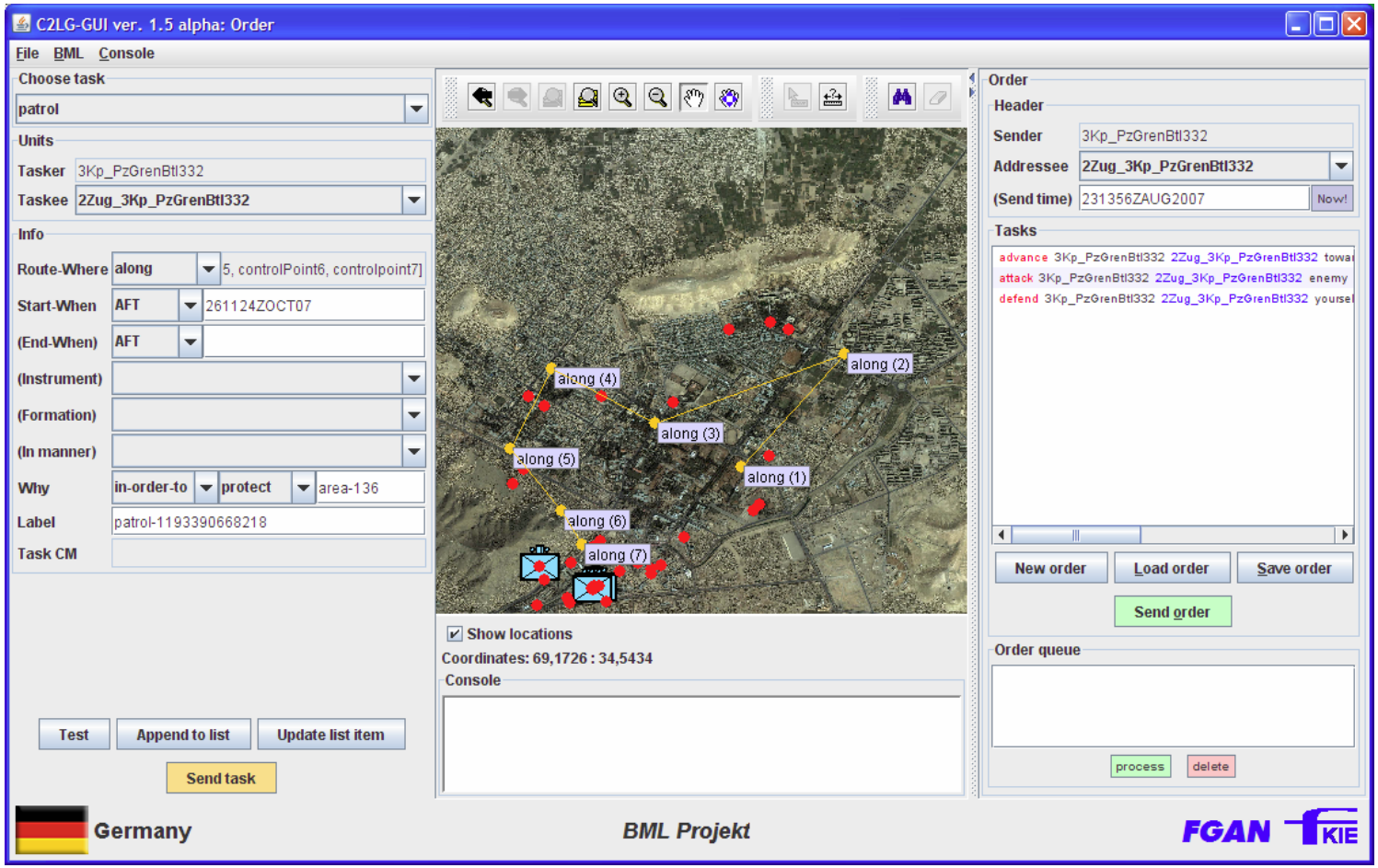
- Major application of BML is OPerations ORDer
- Recent Army CIO/G6 project supported detailed BML architecture
  - See http://c4i.gmu.edu/BML
- This included a five-paragraph OPORD based on earlier work done for AGC
  - Significantly more detailed than MSG-048 schema
  - Also posted SBML script – see webpage
- SIMCI project converted this to NATO OPORD
  - Will include SISO C-BML CompositesLight compliant script for NATO OPORD

Battle Management Language Command and Control Graphical User Interface (BMLC2GUI)

C2LG GUI

- Command & Control Lexical Grammar (C2LG) Graphical User Interface (GUI) was constructed by the German research center FGAN (now part of Fraunhofer FKIE)
- The C2LG GUI was created to generate "pure" BML statements that were valid grammar statements.
- In many BML activities, the C2LG GUI was used as an "integration hub" to take the input from C2 systems and construct a "valid" JBML Order that could be sent and ingested by different nation's simulations.
- FGAN operates under rules that would not allow them to release the C2LG GUI to the whole BML community.

C2LG GUI


C2LG-GUI ver. 1.5 alpha: Order
File BML Console
Choose task
patrol
Units
Tasker 3Kp_PzGrenBtl332
Taskee 2Zug_3Kp_PzGrenBtl332
Info
Route-Where along 5, controlPoint6, controlpoint7]
Start-When AFT 261124ZOCT07
(End-When) AFT
(Instrument)
(Formation)
(In manner)
Why in-order-to protect area-136
Label patrol-1193390668218
Task CM
Test
Append to list
Update list item
Send task
along (1)
along (2)
along (3)
along (4)
along (5)
along (6)
along (7)
Show locations
Coordinates: 69,1726 : 34,5434
Console
Order
Header
Sender 3Kp_PzGrenBtl332
Addressee 2Zug_3Kp_PzGrenBtl332
(Send time) 231356ZAUG2007
Now!
Tasks
advance 3Kp_PzGrenBtl332 2Zug_3Kp_PzGrenBtl332 towa
attack 3Kp_PzGrenBtl332 2Zug_3Kp_PzGrenBtl332 enemy
defend 3Kp_PzGrenBtl332 2Zug_3Kp_PzGrenBtl332 yourse
New order
Load order
Save order
Send order
Order queue
process
delete
Germany
BML Projekt
FGAN
FKIE

BML C2 GUI

- Patterned after Fraunhofer-FKIE C2LG GUI
  - Usable as editor or monitor
  - Reads/writes Orders and Reports
  - Auto-configures to any BML schema
  - View and modify a BML-XML file
  - Map/image display shows 2525B icons from XML
  - Future version will enter geolocation data in BML-XML file
  - Open source at http://c4i.gmu.edu/BML

BML C2 GUI : ORDER

Task | TaskerWho | TaskOrganization | ControlMeasures

Task

1 GroundTask, UnitID, 2TF A TEAM, SEIZE, HADES 3, AtWhere, JBMLAtWhere, HADES 3, AREAOFINTEREST, AREA, WhereLocat...
2 GroundTask, UnitID, 2TF B TEAM, SEIZE, HADES 3, AtWhere, JBMLAtWhere, HADES 3, AREAOFINTEREST, AREA, WhereLocat...

Add | Copy | Delete

Task

	TaskeeWho	What	
1	UnitID, 2TF A TEAM	SEIZE	HADES 3, AtWhere, JBMLAtWhere, HADES 3, AREAOFINTEREST, AREA, WhereLocation, GDC, 4

Add | Copy | Delete

GroundTask

TaskeeWho

UnitID

UnitID: 2TF A TEAM

What

WhatCode: SEIZE

Where

WhereID: HADES 3

UNNAMED1: AtWhere

AtWhere: JBMLAtWhere

WhereLabel: HADES 3

WhereCategory: AREAOFINTEREST

WhereClass: AREA

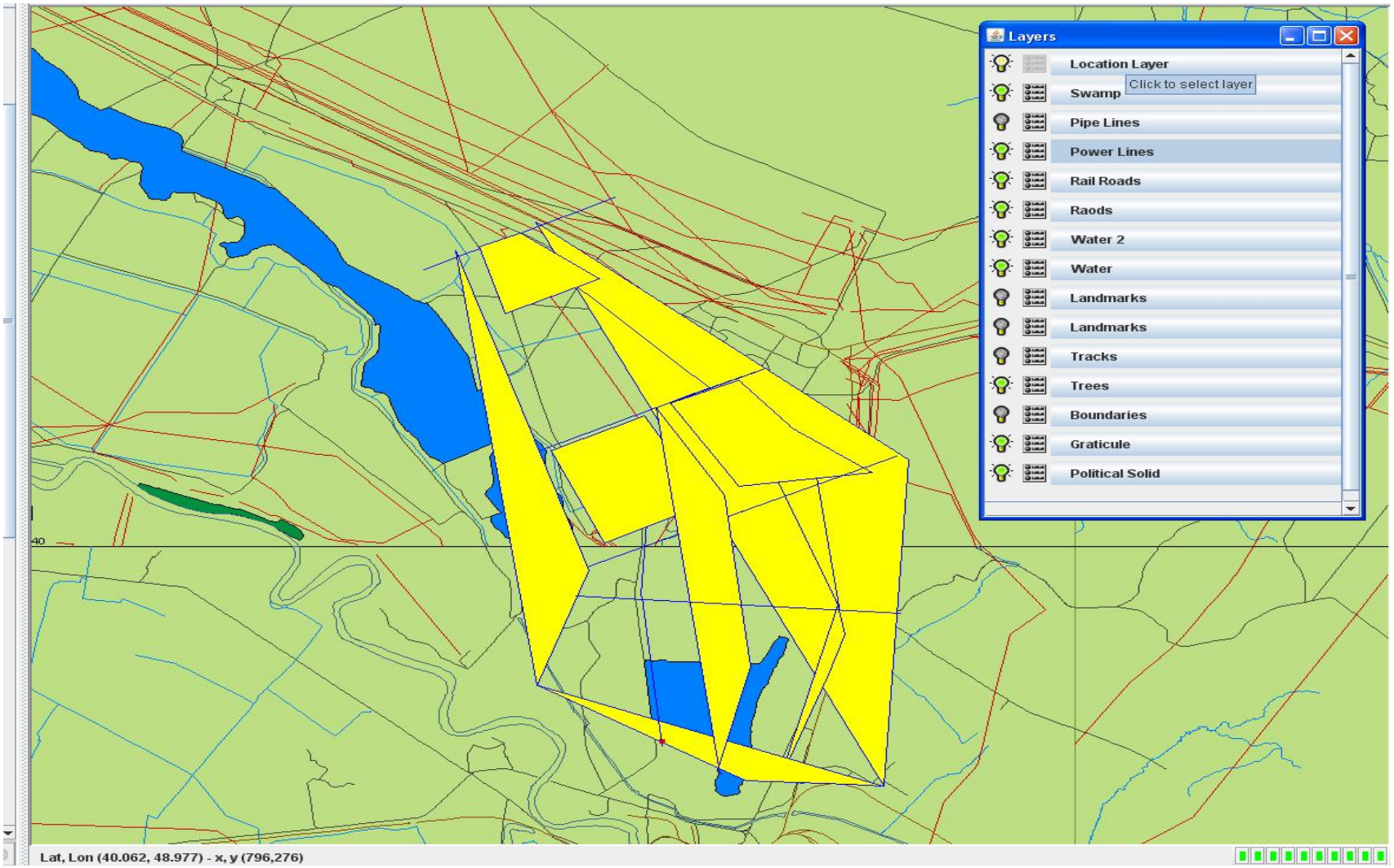
WhereValue

WhereLocation

	WhereLocation
1	GDC, 40.0646754, 48.8700762, 0.0

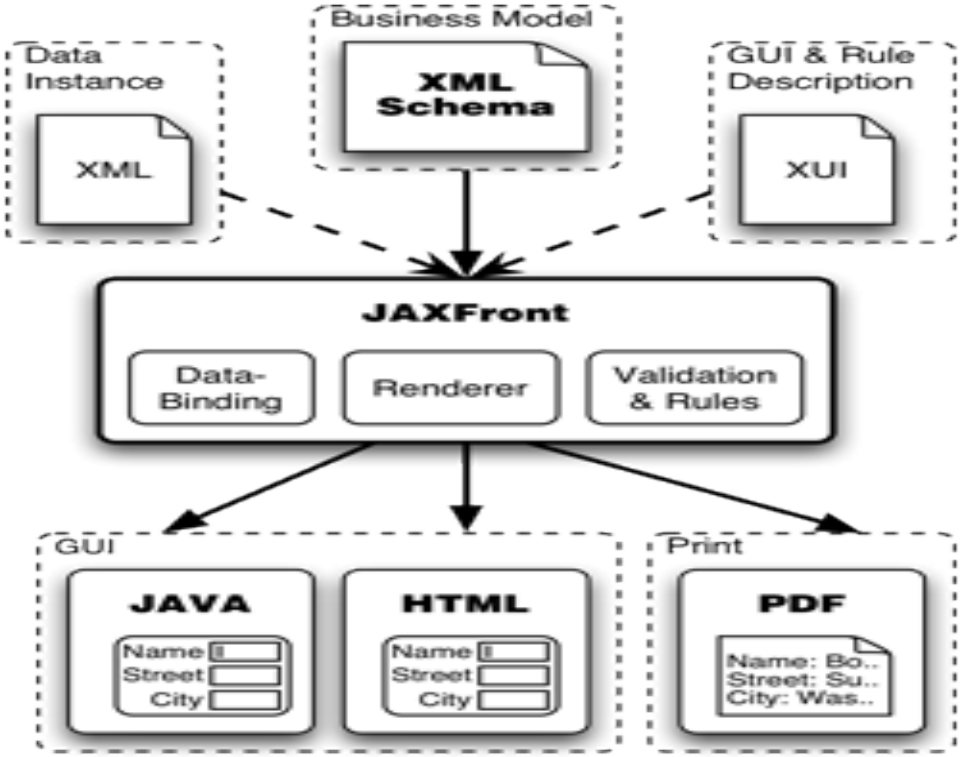
Add

BML C2 GUI : CONTROL FEATURES



JaxFront – Open Source XML Java Editing

- JAXFront architecture



Source: http://www.jaxfront.org.

BML C2 GUI : Report with 2525B Icon

Refresh Map | Erase Locations | Test DOM | Test Editor | Pull Test

BMLReport

Report

	CategoryOfReport	TypeOfReport	UNN
1	StatusReport	TaskStatusReport	StatusReport, GeneralStatusReport, UnitID, 2, 2, FR, Taskee, U

Add | Copy | Delete

Report

CategoryOfReport: StatusReport
TypeOfReport: TaskStatusReport
UNNAMED1: StatusReport
StatusReport: GeneralStatusReport

ReporterWho
UnitID
UnitID: 2
Context: 2
Hostility: FR

Executer
Taskee
Taskee: UnitID
UnitID: U1
OpStatus: MOPS

WhereLocation
Sequence:
WhereLocation: GDC
Latitude: 40.5
Longitude: 47.5
ElevationAGL: 2

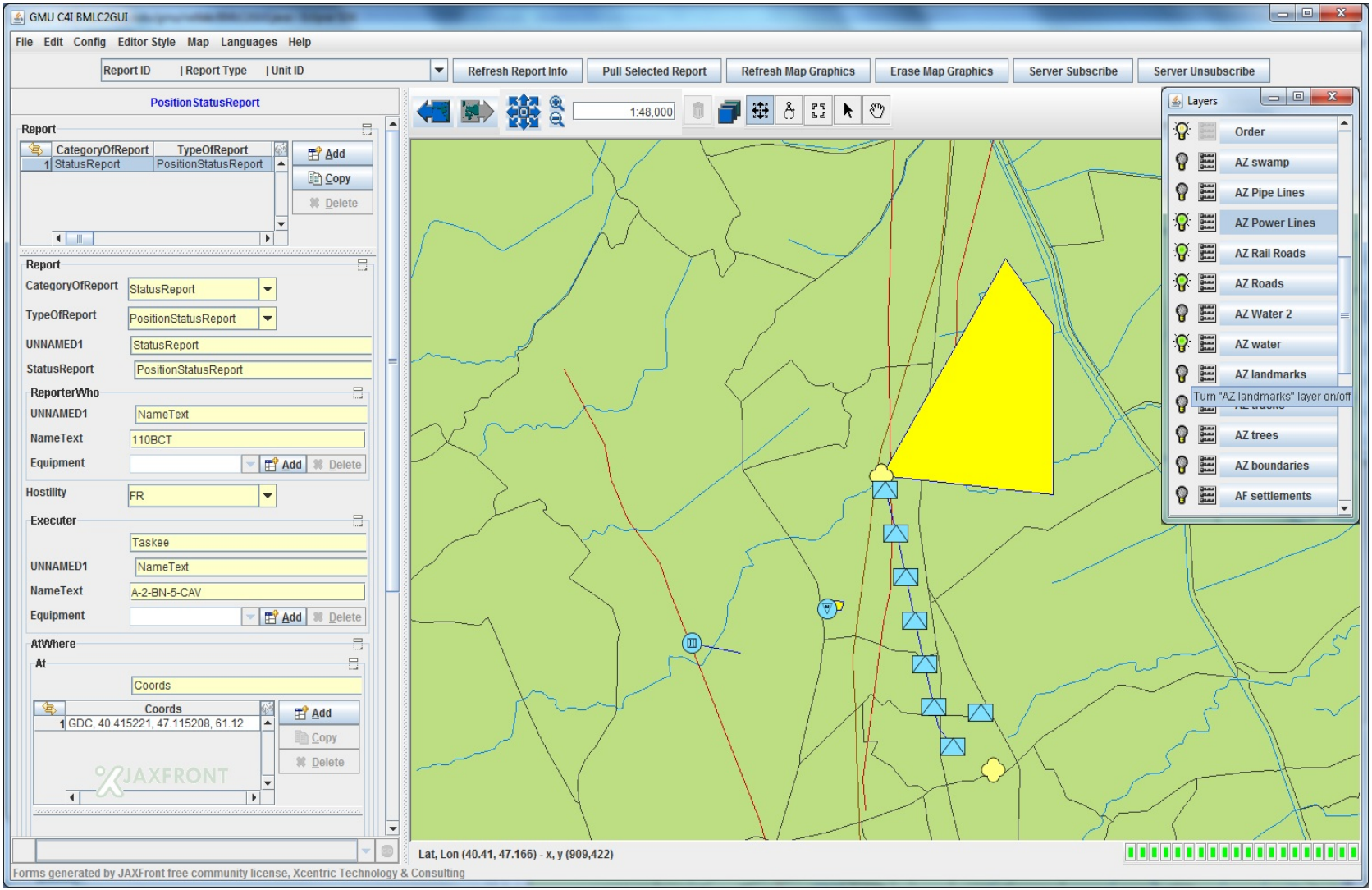
VelocityVector
Magnitude: 1
BearingDegrees: 1

When: 1
ReportID: 1
Credibility

1:1,500,000

Lat, Lon (39.943, 48.233) - x, y (739,635)

BML C2 GUI : Position Status Report



SBML Services in the BMLC2GUI

- The BMLC2GUI uses the Web Services maintained by SBMLServer through the SBMLClient application.
  - CallListWho: is used by the GUI to bring up all the necessary information about a unit given its UnitID in order to compose the MILSTD2525b key (String characters) that enables the tool to draw the correct unit symbol in its desired position.

```
<callListWho>
<UnitID>3</UnitID>
</callListWho>
```

- The BMLC2GUI is open source - could be modified to use other source of Unit information

SBML Services in the BMLC2GUI

– GetLatestReportIDs: is used by the GUI to build a list of report information:

```
<GetLatestReportIDs>
</GetLatestReportIDs>
```

– ReportPull: is used by the GUI to pull a report from the SBML Web Service so that it can be viewed or edited and its geospatial information be extracted and illustrated on the map.

```
<ReportPull>
<ReportID>410</ReportID>
</ReportPull>
```

JaxFront – Open Source XML Java Editing

- JaxFront is a technology developed by Switzerland's Xcentric Technology & Consulting GmbH.
- It is "a technology to generate graphical user interfaces on multiple channels (Java Swing, HTML, PDF) on the basis of an XML schema".
- Web site http://www.jaxfront.org
- The BML C2 GUI uses the Free Community version (Open-Source) of JaxFront as a major component for editing BML documents.
- The user can dynamically generate GUIs that allow the user to edit XML data without being exposed to the underlying XML technology.

BMLC2GUI Forms Creation

- The core of the BMLC2GUI is the use of JAXFront's libraries to build a new and a customized type of XML Document Object Module (DOM) that can be rendered as Java Swing objects.
- The JaxFront's DOM Builder takes the following parameters to generate a JAXFront document:
  - The XML document.
  - The Schema.
  - The XUI (optional): XML User Interface file used to customized the view of the XML document
  - The XML root node

BMLC2GUI Geospatial Aspect

- After the successful rendering of the XML document, we start extracting the geospatial information (Latitude, Longitude coordinates representing positions or dimensions of objects) on the map.
- We parse the document and pass the elements and values to OpenMap's MapHandler
- The MapHandler draws and controls the following types of layers:
  - Country or area of interest geospatial data layers. In our case (ESRI shape files).
  - BML objects and geospatial information: unit, minefield, bridge, spot, track.
  - MIL-STD-2525b symbols

Open Map

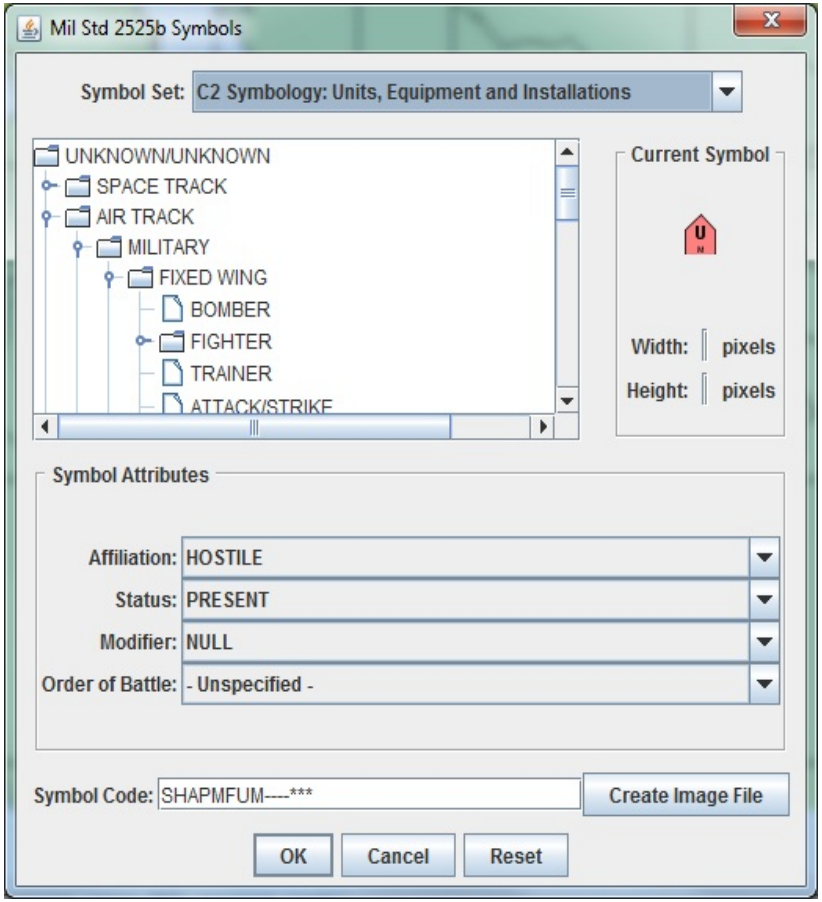
- Open Source JavaBeans based Geospatial development tool.
- From BBN Technologies, now part of Raytheon.
  http://openmap.bbn.com
- BMLC2GUI is using the latest version of OpenMap 4.6.5, released March 5, 2009.
- It provides various capabilities to allow users to see and manipulate geospatial information.
- OpenMap supports various map data file formats.

Open Map

- BMLC2GUI uses ESRI (commercial) file format.
  - .shp “shape” files
- The BMLC2GUI uses OpenMap to display the different data layers on the map in addition to drawing BML objects, units and control measures at their corresponding locations.
- Users already are finding ways to enhance our interface

Open Map - MIL-STD-2525B

- The BMLC2GUI makes use of the OpenMap's implementation of MIL-STD-2525B symbols
- The unit/object symbol is constructed from the UnitID / objectType during the geospatial information extraction.
- The corresponding unit/object symbol is drawn at the Lat-Lon coordinates
- Objects can be minefield, bridge, spot,…



BML C2 GUI Functionality Summary

- Editing a BML Document
- Serialization of a BML Document
- Validation of a BML Document
- Pulling a BML Document
- Pushing a BML Document
- Retrieving Latest Reports
- Surrogate C2 System

C2 Capability

- Primary use of BMC2GUI is to support development
- Also can be used to generate orders (but not rapidly)
- Implements the SBMLSubscriber Client application to connect to the subscription service of the SBMLServer
- This enables the GUI to listen to any published BML activity such as reports being generated
- The main usage of the Subscriber in the GUI is to pull new BML reports of any type and display them immediately on the screen in the editing/viewing panel
  - Displayed with appropriate geospatial information
  - Can provide a simple track
- There is a lot of room for enhancement by the community

BMLC2GUI Summary

- Provides an easy-to-use, comprehensive tool for the BML end user
- Platform-independent and command-line free BML editing and viewing
- Geospatial capabilities
- Validation and Serialization
- Being open-source makes it less expensive to own and operate
  - And supports BML community enhancements
- Customization and enhancements possible by the BML community
- Open source at http://c4i.gmu.edu/BML

Conclusions

- Infrastructure software development is unglamorous but absolutely essential
- Developing a new approach such as SBML is only the start
- Research on the BML paradigm is not practical without mature, robust supporting software
- This work is enabling research at system level to understand merits of coalition BML