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Incorporating C2-Simulation Interoperability Services Into an Operational C2 System

Topics
Experimentation, Metrics, and Analysis
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ABSTRACT

Since 2003, a community focused on achieving interoperability among command and control (C2) systems and simulation systems has developed a new area of technology known as Battle Management Language (BML). Their vision is that a common basis for interoperation will lead to a future where military organizations can link their C2 and simulation systems without special preparation, in support of coalition operations. This paper reports on a project to incorporate a Coalition BML capability into an operational military C2 system by integrating capabilities of an open source BML server (SBMLserver) from the George Mason University C4I Center into the Widely Integrated Systems Environment (WISE) for C2, developed by Saab Corporation. The first demonstration of this system combined Saab's 9LandBMS C2 system with WISE, SBMLserver, and the US Army OneSAF simulation system. The 9LandBMS system is capable of operating in degraded communication environments, introducing the challenge of successful interoperabilty with data-intensive simulation systems in such an environment. The paper summarizes the issues and current state of technology and standards for C2-simulation interoperability and explains the design and implementation principles employed for its incorporation into WISE. The resulting new capability offers coalitions the ability to achieve the long-sought goal of C2-simulation interoperation using off-the-shelf products.

1. Introduction

Since 2003, a community focused on achieving interoperability among command and control (C2) systems and simulation systems has developed a new area of technology known as Battle Management Language (BML) [1]. Their vision is that a common basis for interoperation will lead to a future where military organizations can link their C2 and simulation systems without special preparation, in support of coalition operations [2]. Projected operational uses include collective training, planning support, and mission rehearsal. The BML community has developed several successful prototypes for experimental use in the context of two NATO Technical Activities [3, 4] and a pair of standards under the Simulation Interoperability Standards Organization (SISO) [5, 6, 7].

Conceptually, BML in all of these contexts has the same purpose: to facilitate interoperation among C2 and simulation systems by providing a common, agreed-to format for the exchange of information such as orders and reports, including necessary support such as initialization for C2 and simulation systems. In recent implementation, this has been accomplished by providing a repository service that the participating systems can use to post and retrieve messages expressed in standard formats. As shown in Figure 1 below, the service is implemented as middleware that is essential to the operation of BML and can be either centralized or distributed. Recent implementations have focused on use of Extensible Markup Language (XML) along with Web service (WS) technology, a choice that is consistent with the Network Centric Operations strategy adopted by the US Department of Defense and its coalition allies [1, 2]. Figure 1 depicts a "system of systems" and shows data paths for the BML initialization, tasking, and reports. Each block in the figure is a complete system in its own right.

This paper reports on a project to incorporate a Coalition BML capability into an operational military C2 system by integrating capabilities of an open source BML server (SBMLserver) from the George Mason University C4I Center into the Widely Integrated Systems Environment (WISE) for C2, developed by Saab Corporation. The first demonstration of this system combined Saab's 9LandBMS C2 system with WISE, SBMLserver, and the US Army OneSAF simulation system. The 9LandBMS system is capable of operating in degraded communication environments, introducing the challenge of successful interoperability with data-intensive simulation systems in such an environment.

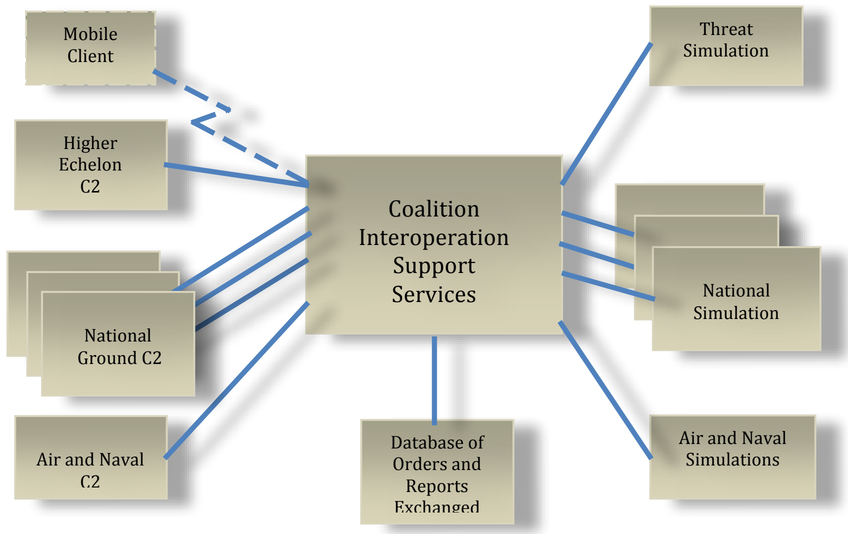

Figure 1. Overall Client-Server Architecture

2. Standards for C2-Simulation Interoperation

There are two important standards for C2-simulation interoperation, both developed by the Simulation Interoperability Standards Organization (SISO). The Military Scenario Definition Language (MSDL) deals with initialization issues while the Coalition Battle Management Language (C-BML) deals with tasking and situational awareness issues.

MSDL [5] is intended to reduce scenario development time and cost by enabling creation of a separable simulation independent military scenario format, focusing on real-world military scenario aspects, using the industry standard data model definition eXtensible Markup Language (XML) that can easily and dependably be accepted as input by current and evolving simulations. The initial MSDL capability was prototyped within OneSAF during its early architectural development phase between 2001 and 2004. A SISO Study Group (SG) concluded that there was a community-wide need for a standardized military scenario format to enable sharing of valuable scenario products and to reduce development time and cost. The standardized scenario format also provides a way to automate the largely manual reproduction of a scenario into multiple simulation scenario formats and reduce the number of errors introduced during this manual process.

The SISO MSDL standard expanded previous OneSAF work and aligned it with the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM). The MSDL standard approved in 2008 includes weather information and a scenario identification section. In addition to its use in OneSAF, MSDL version 1.0 has been employed by the US Army Modeling and Simulation Office (AMSO), US Air Force, and US Marine Corps as well as NATO MSG-085 activities including Spain, France, the United Kingdom, Norway, Germany, Canada, and others.

The MSDL scenario is the element that binds together the components to be used for a particular activity using BML. Once the scenario has been initialized and the signal given by the master controller, participating organizations may add additional components to the scenario. These include:

- Geographic Region of Interest
- Force/Sides
- Units
- Equipment
- Installations
- Overlays
- Graphics

In 2005, a different SISO study group created a plan to develop a C-BML standard [6]. The corresponding product development group (PDG) was chartered in 2007. The approach has generally followed the Lexical Grammar approach introduced by Schade and Hieb [7]. Progress has been slow, for reasons documented in [8]. However, the C-BML Phase 1 Draft Standard reached the point of Trial Use in 2011, was balloted successfully in 2012, and is expected to be approved soon. Informing the standardization process have been multiple projects under various US DoD sponsors [9-12] and an ongoing sequence of experimental BML configurations developed and demonstrated by the members of NATO MSG-048 and MSG-085 [13-15].

There are three areas in MSDL and C-BML that must be aligned for efficient combined use of the two standards: task organization, tasks, and tactical graphics. Work on convergence is reported in [16,17]; efforts to finalize a converged C-BML are currently underway in the aftermath of balloting for the Phase One standard, while version 2 of MSDL is now under development.

- Various ongoing projects, including SISO C-BML development, have independently derived formats for the friendly and adversary order of battle (ORBAT), also called Task Organization in military orders. The primary requirements are to identify (1) the name and type of each unit (including its US MIL STD 2525C icon or NATO APP-6C; (2) command relationships (parent and child). MSDL has standardized an XML document structure for this purpose, which has been used successfully by multiple national teams in MSG-085 and can serve the needs of both standards.

- The definition of actions to be carried out, their interrelations, and the control measures to be employed, is the basic reason for existence of C-BML. The MSDL standard includes a placeholder for an initial tasking which has not been developed in detail; it has no provision for a continuing flow of orders, or for reports. The C-BML representation of tasks can serve the needs of both standards.

- Tactical graphics define a common symbolic representation for maps, etc. that are central to military operations. US MIL STD 2525C and NATO APP-6C are existing, relevant standards. Convergence of MSDL and C-BML simply requires adoption of common data structures that implement the standards, which is the purpose of ongoing work that aims at cross-referencing of documents between the two standards, using the unique identifiers for the tactical graphics or unit/platform [17].

3. Scripted BML Server

Experience to date in development of BML indicates that the language will continue to grow and change. This is likely to be true of both the BML itself and of the underlying database representation used to implement the scripted server capability. However, it also has become clear that some aspects of BML middleware are likely to remain the same for a considerable time: the XML input structure and the need for a repository server to store a representation of BML in a well-structured relational database, accessed via the Structured Query Language (SQL). This implied an opportunity for a re-usable system component: a scripted server that can convert between a relational database and XML documents based on a set of mapping files and XML Schema files. The scripted server introduced in [18] and now named "SBMLServer," accepts *push* and *pull* transactions (BML/MSDL XML documents) and processes them according to a script (or mapping file, also written in a special scripting language). The initial implementation of the scripted approach may have lower performance when compared to hard-coded implementations, but the approach has several advantages:

- new BML constructs can be implemented and tested rapidly
- changes to the data model that underlies the database can be implemented and tested rapidly
- the ability to change the service rapidly reduces cost and facilitates prototyping
- the script provides a concise definition of BML-to-data model mappings that facilitates review and interchange needed for collaboration and standardization

An early version of SBMLServer was used extensively in NATO MSG-048 [3] to support an antecedent of C-BML, called IBML09. The GMU C4I Center has continued to evolve SBMLServer as an open source software product [19], available at http://c4i.gmu.edu/OpenBML. In 2012 they added two new capabilities to SBMLServer:

- Ability to translate XML documents between various XML schemas, which avoids the need to modify C2 and simulation systems to work together, if they were originally implemented under different schemas.
- MSDL support capability: When multiple systems participate in a coalition, it is necessary to merge their MSDL files. Some parts of the merge process consist simply of concatenation, but other parts require functions such as the largest of a group or the total count. This is described further below.

With a simple addition to SBMLServer, it became possible to implement the required logic for merging MSDL elements in scripts. The various C2 and simulation clients push their elements of MSDL documents into the SBMLServer (the XML structure is validated during this process). At any time, any client can pull from the server an aggregated MSDL document for the whole coalition assembled up to that time. Upon signal from the master controller, the SBMLServer publishes the aggregated MSDL document to all participating C2 and simulation systems. Information from the aggregated MDSL file also is used to initialize the units and control features in the SBMLServer database. If the MSDL documents of the client systems are extracted automatically, this assures that all participating systems have available globally correct initial information. Transactions are edited as they are received to insure correct format, unique unit and equipment names and object handles, and valid references between components. New units and equipment may be discovered after the exercise has started (generally, these will be enemy units or equipment, since friendly ones normally are known in advance). In this case an update will be published on the MSDL topic detailing the newly discovered unit or equipment item. An overview of the MSDL aggregation process is shown in Figure 2.

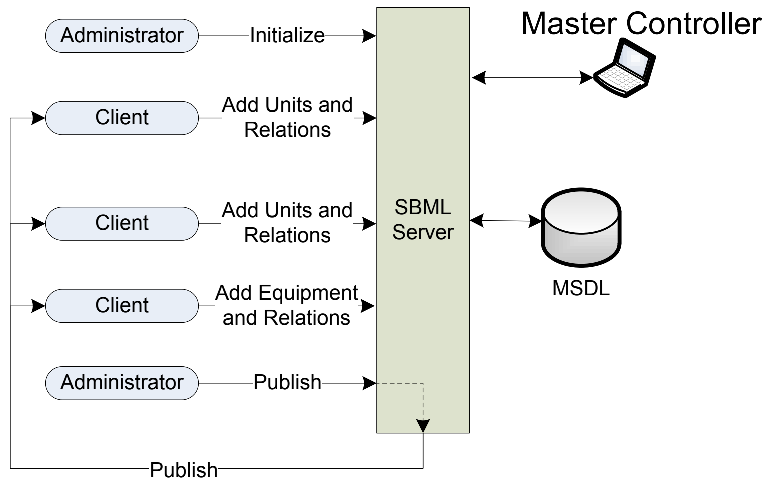

Figure 2. MSDL Operation in SBMLServer
(Client can be any C2 or Simulation System)

4. WISE

Saab Corporation is in the business of providing software for military command and control. They have been active in the Swedish delegation to NATO MSG-085 and have offered use of their Widely Integrated Systems Environment (WISE) for experimentation support. In 2012, discussions between the GMU C4I Center and Saab concluded that the general approach used in SBML could be productively re-implemented in WISE. WISE supports a robust, high-performance information switching capability with a graphic setup editor that provides and improves upon the advantages associated with the scripted approach of SBMLServer. This capability enables fundamental research at GMU, which is prototyping a new generation server that is expected ultimately to transition to operational military use.

Figure 3 shows the architecture of the WISE-SBML server. The “BMS” system in Figure 3 represents the 9LandBMS or other interfaced C2 system (see next section). WISE appears to SBML as an in-memory, non-persistent database. This approach enables a great improvement in performance over the existing SBMLServer and is suitable for deployment in the high-performance cloud computing environment. To build a server based on WISE, the GMU team had to complete two important steps:

- Build a WISE driver, shown in green on the figure, for each major information flow to be interfaced: C-BML/MSDL Web service (one for each schema version); publish-subscribe service; persistent recording interface; and the 9LandBMS WISE interface, adapted for C-BML/MSDL.
- Use the WISE graphic editor to specify all information flows between the WISE data repository and these drivers.

These configuration elements must be maintained as changes to the schema occur. It is noteworthy that the second step in particular can be achieved more quickly than developing an SBML Version 2 script. It also is noteworthy that the WISE architecture is well suited to operation in a cloud.

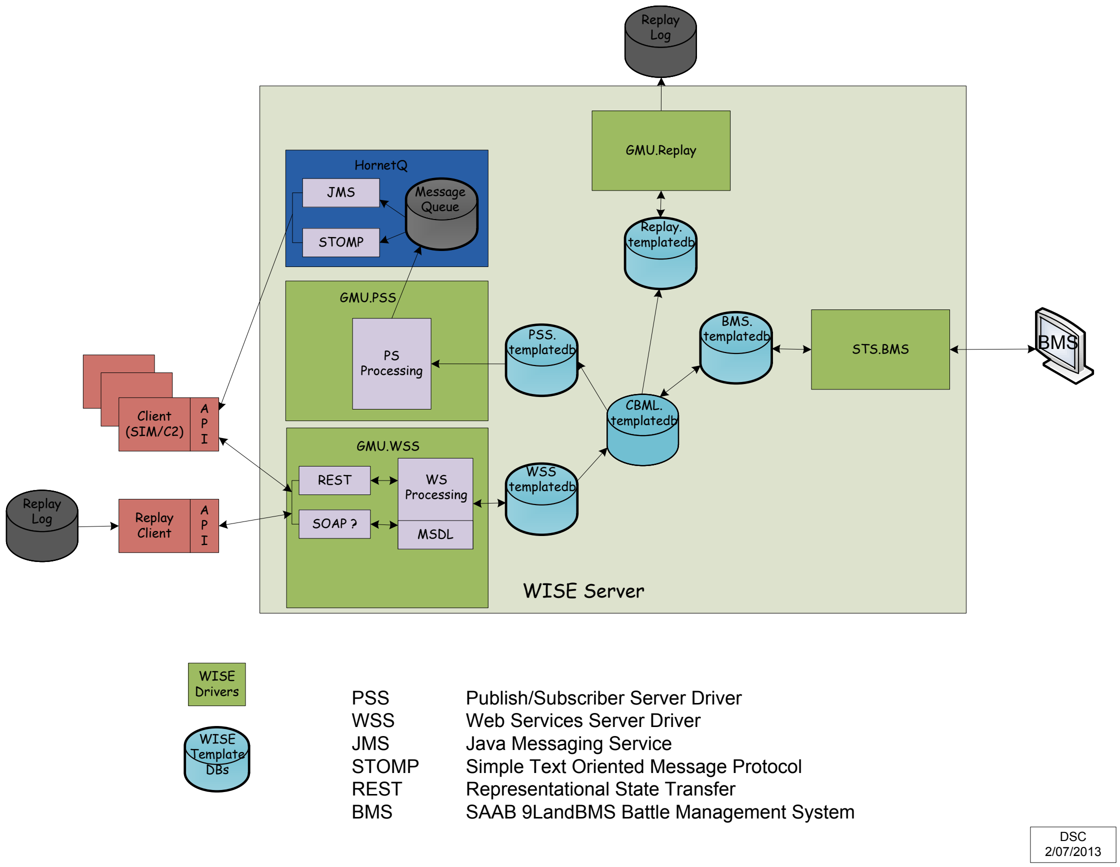

Figure 3. WISE/SBML Architecture

5. C2 for Initial Demonstration

The 9LandBMS (Battle Management System) is a tactical command and control system from Saab that is built to enable the user to utilize the full potential of his forces by increasing the level of awareness and to enable real-time mission flexibility by supporting transverse collaboration between arms, in time and space. The 9LandBMS support echelons from brigade down to platoon commanders and staff in their Command and Control processes. The Command and Control methodology that 9LandBMS is built to support is put forward in Integrated Dynamic Command and Control (IDC2) [20] and the fundamental Planning Under Time Pressure (PUT) [21]. Related concepts are presented in [22-24].

The core concepts of 9LandBMS are that (1) the system's perspective is based on the role of its user, and (2) it should be workable to use in a wide range of environments, from inside a vehicle with protective gloves on the hands to brigade HQ where the system is used instead or together with large maps. In NATO MSG-085, the use of 9LandBMS is of interest since it is a fielded BMS, it is available for experimentation use, and one of its core functions is to produce orders with structure similar to the grammar used in C-BML. The core support functions of 9LandBMS are:

- Tracking containing Blue Force Tracking, Reporting and Reports, Alarms and Alerts and navigation and Route Management;
- Integrator which integrates sensors and weapons in vehicles into a complete platform BMS; and
- Net Commander which provides Planning support, decision support, Logistic Support, Mission management, Evaluation support, 3D views and data information Interoperability. One interoperability standard of interest is the C-BML.

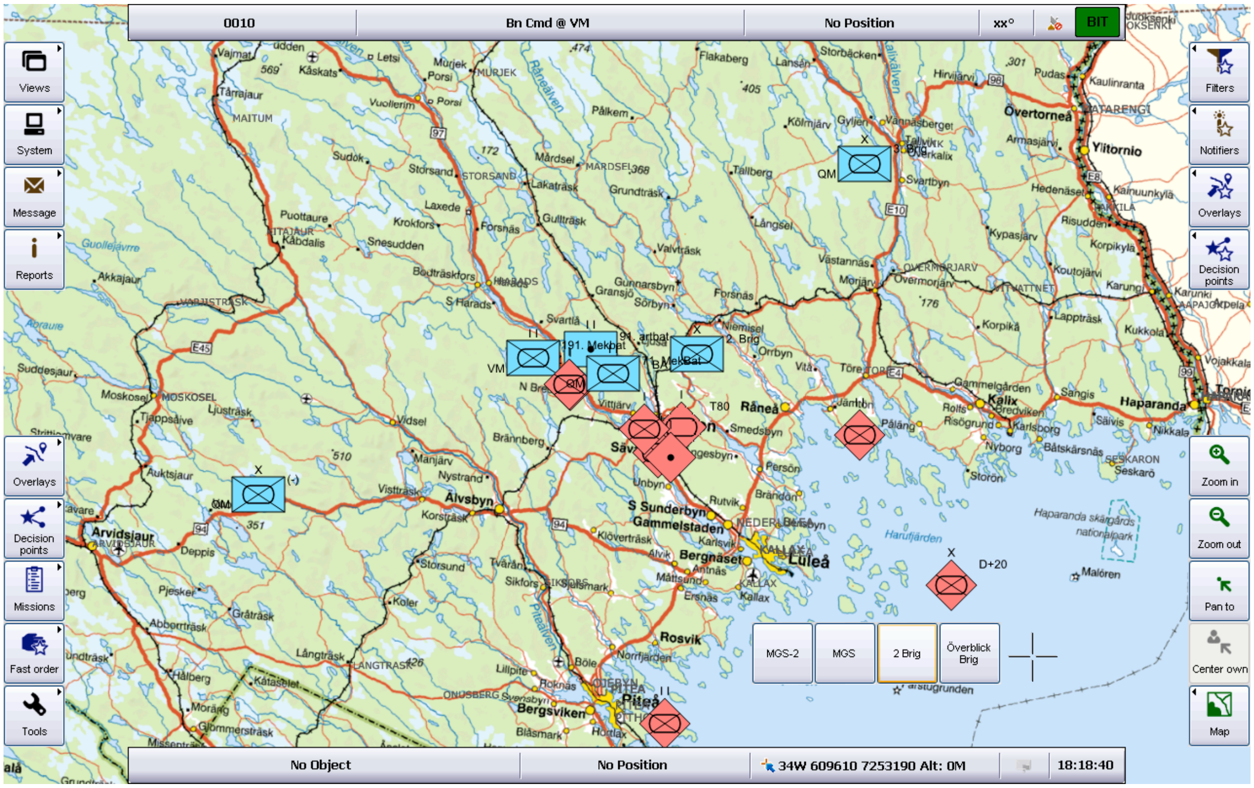

Figure 4. 9LandBMS User Interface

In an alternate configuration, the NATO ICC system with JADOCS and the JSAF simulation system, operated by QinetiQ UK, have been demonstrated interoperating with 9LandBMS and OneSAF. The importance of this configuration goes beyond the breadth of systems and the international coalition involved: the UK systems were using the IBML09 schema from MSG-048 [14], which is semantically consistent with C-BML but different syntactically. This was accomplished using the translation feature of the WISE-SBML server and shows a way to enable experimentation across the variety of systems and schemas employed by the participants of MSG-085.

6. Simulation for Initial Demonstration

As described in [25], the US Army OneSAF simulation system has been adapted under a MITRE effort to integrate MSDL and C-BML data models. OneSAF is an entity-level simulation developed by the US Army Program Executive Office for Simulation Training and Instrumentation and used for analysis, experimentation, testing, and training. OneSAF is under active evolutionary DoD and government open-source development, is available under USA Foreign Military Sale, and is delivered as a simulation toolkit that can be tailored by end-users for their specific purposes.

To support an integrated MSDL and C-BML OneSAF capability, enhancements to OneSAF Version 5.1.1 were provided in order to fully comply with the MSDL standard while allowing for local extensions and also support the C-BML Phase 1 draft standard. The effort provided a OneSAF import and export for a limited set of the Full and Light data elements associated with the C-BML standard. A summary of the enhancements follows:

- Enhanced MSDL document validation and 2525B symbol code use for unit/platform type and associated echelon;
- Enhanced capability to map 2525B symbol code information to a specific OneSAF unit/entity composition and then persist and reference the mapped unit/platform in subsequent MSDL imports.
- New capability to import Full and Light C-BML orders "move", "attack", etc. and post to the OneSAF Mission Editor as orders to OneSAF units and/or platforms;
- New capability to export orders from the OneSAF Mission Editor to C-BML Full and Light phrases.
- New capability to connect to the web-based coalition-monitor tool provided by George Mason University; and
- New capability to send and receive MSDL and C-BML documents from the Coalition Battle Management Services server and the Scripted Battle Management Language Service server.

The straightforward way in which OneSAF was able to interoperate with 9LandBMS shows the power of MSDL and C-BML and the utility of the WISE-SBML server.

7. Conclusion

We have described the current state of BML in terms of ongoing NATO technology integration by MSG-085 and ongoing SISO standardization as MSDL and C-BML. This work shows great promise to significantly enhance coalition command and control by providing routine availability of simulation for uses such as collective training, planning support, and mission rehearsal.

Operational use of C2-simulation interoperation will require a BML server as part of the net-centric information architecture. Flexibility to assemble coalitions "on the fly" will be greatly enhanced if that server also can translate among different schemas that may have been implemented in the participants' national systems. The open source SBMLServer was developed to deal with these issues in an experimental environment and has been used productively for that purpose. This paper has reported on a project to implement the advantages of SBMLServer using commercially-produced software suitable for military operations. Saab intends to maintain such an implementation in their WISE environment and also to make a version without operational capabilities available at no cost to developers in the BML community.

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