Next Steps in MSDL and C-BML Alignment for Convergence

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Two SISO technology threads are associated with the general area of C2-Simulation Interoperability: the Military Scenario Definition Language (MSDL) and the Coalition Battle Management Language (C-BML). The two have been developed independently since 2005, with the understanding that, for full effectiveness, they must operate together. Previous papers by various by ourselves and other authors have addressed principles necessary for the two to function effectively. This paper expands on previous work by defining a specific mechanism, in the form of a mechanism by which the MSDL scenario file can refer to C-BML order/report files. This mechanism will enable all known points of shared operation to be defined crisply and unambiguously. This approach was worked out in the Common Interest Group (CIG) on Infrastructure of NATO MSG-085 "Standardization for C2-Simulation Interoperation." The paper includes a description of supporting software services developed for MSG-085 to use this approach.

1. Overview

Two of SISO's standards developments, the Military Scenario Definition Language (MSDL) and the Coalition Battle Management Language (C-BML) are in the process of converging to yield a powerful, standardized technical specification for command and control (C2) systems to interoperate with simulation systems, a capability long sought to support a range of important military operations. The authors and others have contributed previously to the understanding of how MSDL and C-BML can work effectively together [1-4]. This paper expands on previous work by defining a specific mechanism, in the form of a mechanism by which the MSDL scenario file can refer to C-BML order/report files. This mechanism will enable all known points of shared operation to be defined crisply and unambiguously. This approach was worked out in the Common Interest Group (CIG) on Infrastructure of NATO MSG-085 "Standardization for C2-Simulation Interoperation." NATO Technical Activity MSG-085, *Standardization for C2-Simulation Interoperation,* which is working to develop an experimental operational environment where multiple national C2 and Simulation systems can interoperate using MSDL and C-BML.

The sections which follow in this paper summarize previous definition of the ways in which MSDL and C-BML must function together, followed by a description of the specific mechanism we have adopted in our work supporting MSG-085. We conclude with a description of our implementation in C2, simulation, and server software to support MSG-085 experimentation infrastructure.

2. MSDL and C-BML

This section summarizes the history and status of the two standards.

2.1 MSDL

The Military Scenario Definition Language [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 consumed 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) construct. The Study Group concluded that there was a community-wide need for a standardized military scenario format to reduce development time and cost, and to enable sharing of valuable scenario products. 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.

In 2006, the formal SISO MSDL standard Product Development Group (PDG) was established with the specific intent of producing a standard Military Scenario Definition Language data model. The PDG reviewed previous OneSAF work, expanded and aligned it with the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM). Development included adding some elements such as weather information, and a scenario identification section leveraging the Base Object Model Identification schema and removing elements that were under study or standards development such as the Course of Action structure that was equivalent to the work being pursued under the SISO C-BML PDG. Version 1.0 of the resulting SISO standard was approved in November 2008. Beyond OneSAF, MSDL has been employed by the US Army Modeling and Simulation Office (AMSO), Air Force, and Marine Corps as well as NATO activities including Spain, France, the United Kingdom, Norway, Germany, Canada, and others.

2.2 C-BML

Battle Management Language (BML) and its various proposed extensions are intended to facilitate interoperation among command and control (C2) and modeling and simulation (M&S) systems by providing a common, agreed-to format for the exchange of information such as orders and reports. 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 BML. 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 currently being adopted by the US Department of Defense and its coalition allies [6,7].

SISO's BML study group created a plan to develop a Coalition BML (abbreviated C-BML) standard in 2005 [8] and the corresponding product development group (PDG) was chartered in 2007. The approach has generally followed the Lexical Grammar approach introduced by Schade and Hieb [9,10]. Progress has been slow, for reasons documented in [11]. However, the C-BML Phase 1 Draft Standard reached the point of Trial Use in 2011 and was balloted successfully in 2012. Informing the standardization process have been multiple projects under various US DoD sponsors [12-14] and an ongoing sequence of experimental BML configurations developed and demonstrated by the members of NATO MSG-048 and MSG-085 [15-19].

3. Alignment Of MSDL And C-BML

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. These three areas and status of their current representations are described below.

3.1 Task Organization Definition

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 (1) identify the name and type of each unit (including its US MIL STD 2525C icon or NATO APP-6C; (2) identify 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. The C-BML Phase 1 schema draft contains only composite definitions (including Task, but no Task Organization); no full Order or Report is in the normative specification.

3.2 Tasking Definition

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. By contrast, C-BML has a Trial Use draft with tasking elements that supports both initial and subsequent orders, and it also provides for reports from simulations (and potentially also from humans), providing situational awareness information to be made available to C2 systems. This draft is based on experience developed in NATO MSG-048, *Coalition Battle Management Language*, the precursor to MSG-085.

3.3 Tactical graphics

Both MSDL and C-BML have data structures to support point, line, and area tactical graphic as provided in US MIL STD 2525C and NATO APP 6C. These tactical graphic data structures allow consistent sharing of a wide range of military operational concepts including but not limited to: organizational boundaries; obstacles; movement routes and corridors; no-fire areas; facilities and buildings of particular significance such hospitals, government and/or religious centers; locations where hostile or terrorist actions have taken place such as an IED attack; etc.

While the concepts for the tactical graphics within MSDL and C-BML are consistent, the specific data structures within MSDL and C-BML are different. Although this adds effort during implementation to support multiple data structures the mappings between the MSDL and C-BML are straightforward. As described later in this paper, cross-referencing using the unique identifiers for the tactical graphics or unit/platform definitions allows elements to be specified within an MSDL document at initialization and referenced within a C-BML document at initialization time or within a C-BML phrase during run-time.

3.4 Requirements for combined use of MSDL and C-BML

Currently, members of both the MSDL and C-BML PDGs are experimenting with ways to reference C-BML instance documents at initialization time within MSDL documents so that plans and orders can be provided and are consistent with the task organizations and tactical graphics as defined within a MSDL document. Our work in MSG-085 is intended to provide practical experience supporting that process.

The alignment of the standards should take into consideration that C-BML is designed to support tasking and reporting (C2), while MSDL targets simulation initialization in general.

For convergence, C-BML and MSDL both need to have a common way of referencing and defining elements in the task organization. MSDL is primarily used to define the organization elements utilized in a scenario, while C-BML usually is used to tailor different organization structures to the needs of a particular set of tasks.

For example, in Course of Action Analysis (COAA) the task organization is an integral part of the plan and the impact of variations in the task organization may be analyzed. In other use cases, the task organization might come from an external source with respect to the C2IS. One example could be Command and Staff Training, where the task organization is developed by the exercise planners.

The task organization may be dynamic throughout an operation as a result of attachments and detachments of units. These changes will normally be issued using a Fragmentary Order (FRAGO). This also may be reflected in MSDL when storing snapshots of a running scenario.

MSDL and C-BML both should allow defining the task organization from aggregated units to specific equipment. Currently MSDL only provides for describing the general categories for units and type string for equipment, e.g. "main battle tank" for units and "M1A1 Abrams" for equipment type. Especially for coalition interoperability, where a range of different equipment is being used, constructs are needed to describe specific unit and equipment types. This requirement is also present in C-BML reports where units might be recognized at different levels of detail, from general unit type down to specific equipment. On the other hand MSDL must allow extensions in order to provide custom initialization data for units and equipment as needed by specific simulation systems.

While neither MIL STD 2525C nor JC3IEDM has predefined unit equipment enumerations, the JC3IEDM allows for specific types to be defined and shared dynamically within a federation of systems.

From the above it is apparent that that alignment of MSDL and C-BML must provide for information to be interchangeable while allowing flexibility, based on a common way of referencing and defining elements in the task organization.

3.5 Specific Mechanism for Alignment

We have been working on a general referencing approach that addresses the needs of both the MSDL and C-BML as recognized by their Product Development Groups. This approach has been evaluated in individual simulation federates (e.g., OneSAF) and also in coalition-based federations within MSG-085. The concept is for organizations and equipment as well as tactical graphics that are initially defined within MSDL to be referenced by their unique identifiers within C-BML instance documents used for initialization (planned execution) and follow-on (orders, commonly referred to as FRAGOs, task, requests, and reports). The MSDL instance document available for initialization will provide reference by document/file names to any associated C-BML instance document necessary for initialization. Initial results show this referencing relationship has utility in providing a general approach to supporting multiple plans (C-BML documents) for a single MSDL scenario and allows the C-BML orders to reference and leverage tactical graphics established and distributed during initialization within the MSDL document.

4. Initial Implementation

We have assembled an initial coalition capability as part of our work in the MSG-085 Infrastructure CIG.

4.1 C2 System: 9LandBMS/WISE

Saab Group of Sweden has made its WISE interoperability software available for MSG-085 experimentation. Coupled with WISE is the Swedish Battalion/Brigade level C2 system 9LandBMS. GMU has worked with Saab to make 9LandBMS/WISE interoperable with C-BML. A forthcoming paper, planned for the International Command and Control Research and Technology Symposium 2013, will describe this capability in greater detail [20].

4.2 OneSAF

The USA Army Modeling and Simulation Office funded a MITRE effort to integrate MSDL and C-BML data models into a working OneSAF solution. OneSAF is an entity-level simulation developed by the Program Executive Office for Simulation Training and Instrumentation (PEO STRI) and used across the US Army for analysis, experimentation, testing, and training. OneSAF is under active evolutionary DoD and government open-source development (available under USA Foreign Military Sales) 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, a number of enhancements were initially implemented within OneSAF Version 5.1.1 and then integrated and refined within OneSAF version 5.5. These enhancements provide OneSAF with an implementation that fully complies with the MSDL standard while allowing for local extensions and also support the C-BML draft standard now in balloting. Finally, 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 is 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 document from the Coalition Battle Management Services web-server and the Scripted Battle Management Language Service webserver.
- New capability to reference one or more C-BML files within an MSDL file for use during OneSAF initialization to populate the OneSAF mission editor.
- New capability to cross-reference units and equipment tasking between MSDL and C-BML documents using unique identifiers.

The ability to identify and reference files external to the MSDL instance document without modification to the MSDL standard is one of the most significant design contributions provided by this effort. This design allows for not only one or more C-BML files to be used during initialization time, but it also allows for other types of information to be referenced and used by a simulation importing an MSDL file. These referenced files may contain additional detail and/or simulation specific information not included within the MSDL file. Figure 1 provides a graphical depiction of the MSDL reference design.

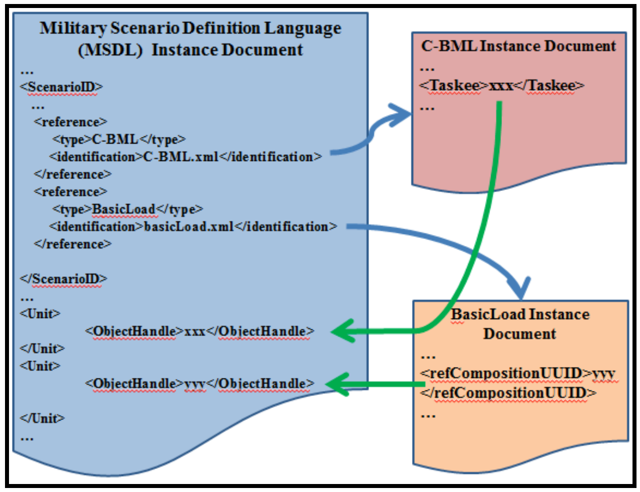

Figure 1. MSDL Reference Design Pattern

Simulation developers and users across the community have expressed an interest to update and extend the MSDL standard for other information types to include: unit and equipment basic load information: fuel levels, munition types and counts information; additional electronic order of battle information, maritime and air and civilian domain information; data element to simulation apportionment information; as well as other simulation specific data elements such as model performance and characteristics information. With the implemented “reference” design the files containing additional data can be defined and created using XML or other data modeling technologies and referenced within the MSDL file. The importing simulation can then use the referenced data to augment the information in an MSDL file.

This design pattern has the additional benefit of allowing local extension files to be independently defined, used, matured, and shared between simulation and Mission Command federations when appropriate. Over time, as these referenced files and associated data models are shared and gain community acceptance, they can be proposed for integration into the core MSDL standard. The standardization process itself is quite lengthy and with community inputs these data models are likely to change as they are integrated into the standard. Although the changes are a necessary and valuable part of the process they mean software and import level changes to existing users and producers of data. The advantage of the "reference" design pattern is that it allows users to manage when and how to step up to the new MSDL standard. Users can either step up to the new MSDL schema and associated data elements, or continue to reference the files within the new MSDL standard schema, or use a legacy MSDL schema with the legacy reference files.

Although there is more work to be done for OneSAF, this effort has demonstrated the value of being able to share standardized scenario and order-based in a WS environment between different and multi-national simulations and Mission Command devices.

4.3 MSDL/C-BML Server

The George Mason University C4I Center, under management of US Army PM OneSAF and in close cooperation with MITRE and QinetiQ personnel, has developed a set of services that provide infrastructure to support implementation of MSDL/C-BML in MSG-085 C2 and simulation systems. The top-level architecture of a C2-simulation coalition using these services is shown in Figure 2. These implementations are available at http://c4i.gmu.edu/OpenBML as open source software.

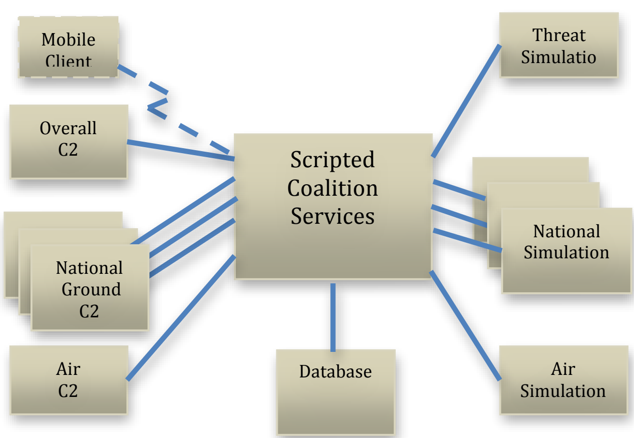

Figure 2. Overall Client-Server Architecture

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: namely, 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 implies 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 [21] 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 XML). While the scripted approach may have lower performance when compared to hard-coded implementations, it 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

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. With a simple addition to SBMLServer, we were able to implement the required logic in CSL scripts. The various clients push their MSDL documents into the SBMLServer, and the XML structure is validated during this process. At any time, any client can pull an aggregated MSDL document for the whole coalition assembled up to that time. Upon signal from the master controller, via the Status Monitor and Control service described section 4.4 below, 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.

The MSDL scenario is the element that binds together the components to be used for a particular exercise. 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

Transactions are edited as they are received to insure correct format, unique unit and equipment names and object handles, and valid references between components.

Once all organizations have submitted their data and signaled their status to the master controller, the master controller will submit a publish transaction for the scenario being used. This will cause the transmission of the full MSDL XML data to all subscribers to the MSDL Topic. Clients not using the publish/subscribe service can alternatively execute a query and retrieve the same information. This query may also be used by organizations joining the exercise after the MSDL data has been published.

All the elements submitted by clients under a single scenario are aggregated in to a single MSDL document. It is assumed that clients have submitted complete components: Units, Equipment Items, Installations, Overlays and Graphics. The aggregated MSDL document will then consist of the data entered during initialization and the complete components entered by the individual transactions submitted by the clients.

New units and equipment may be discovered after the exercise has started. This generally will be enemy units or equipment. In this case an update will be published on the MSDL topic detailing the newly discovered unit or equipment item. An overview of MSDL aggregation is shown in Figure 3.

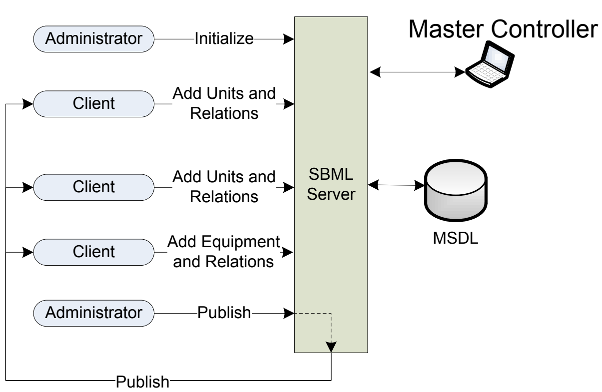

Figure 3. MSDL Server Operation

6. Conclusions

Work in C2-simulation interoperation, using emerging SISO standards, continues to make progress as described in this and companion papers. Practical implementation by MSG-085 team members is leading to understanding of how military operations can be supported effectively by this technology. National implementations in both C2 and simulation systems, coupled with supporting open source server software, make the feasibility of this approach clear. This work has two commendable results: the interoperating systems will support operational experimentation now being planned by MSG-085, and also will continue to provide the experience needed for SISO MSDL and C-BML product development groups to produce effective standards, based on technical approaches that have been demonstrated to be effective.

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