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Advances in Systems and Technologies Toward Interoperating Operational Military C2 and Simulation Systems

Topics
Experimentation, Metrics, and Analysis
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Names of Authors
J. Mark Pullen
George Mason University C4I Center

Lionel Khimeche
Direction Générale pour l'Armement (DGA)
France

Point of Contact
J. Mark Pullen
4400 University Drive, Fairfax, VA 22030
703-993-1538
mpullen@c4i.gmu.edu

ABSTRACT

Since 2003, a community focused on interoperation of command and control (C2) systems with simulation systems has developed a new area of technology known as Battle Management Language (BML). Their vision is a future where military organizations can link their C2 and simulation systems, without special preparation, in support of coalition operations. This paper reports on systems and technology developments of the last ten years, which have made great progress toward achieving that vision, as part of the work of the NATO Modeling and Simulation Group (MSG).

The technology used in these projects to achieve effective operational use of C2 with interoperating simulations is based around a shared understanding of information, defined in an XML schema and implemented in each participating system. Interoperation is facilitated by an agreed upon definition of the information to be shared, recently supported by two coordinated standards: Military Scenario Definition Language (MSDL) and Coalition Battle Management Language (C-BML). The paper will review the history and current status of systems and technologies, including the standards, C2 systems, simulation systems, and server systems employed. The conclusion addresses next steps to achieve operational deployment, based on emerging commercial products and military systems.

1. Introduction

The year is 2025, and somewhere in the vicinity of the North Atlantic a need has arisen for a military force to perform a peacekeeping mission. NATO has agreed to deploy a Multinational Brigade for this mission, and three of its member nations have agreed to provide forces. The designated military organizations promptly connect their command and control (C2) and simulation systems over a secure network and begin training together for their new, common mission. Each nation's forces are commanded by their own C2 system, which they understand well from long experience; also each nation's forces are represented in virtual engagements by their own simulation, which reflects accurately their personnel, equipment, and doctrine. As a result, the coalition force is able to prepare rapidly for its new mission, learning to deal with the unique aspects of each national force while preparing those forces to work together toward their shared mission.

The above vignette represents the vision of an international group of warfighters and technologists that have spent the past decade pursuing the technology of Coalition Battle Management Language (C-BML) and its operational relevance. While there is no guarantee this vision will become reality by 2025 (if ever), great progress has been made in defining, developing, prototyping, and testing C-BML. If current progress continues, the vision very well may be realized in that time frame.

The C-BML technology enabling C2 to simulation (C2SIM) interoperation has as its goal the ability to exchange C2 and situational awareness information in a seamless, transparent form without building custom interfaces among the various C2 and simulation systems. To achieve interoperability, each system implements the vocabulary and syntax of C-BML as a generic interface that can work with any other system implementing the same standard.

This paper describes how, over the past ten years, participating technology teams from NATO nations have advanced C-BML from a hopeful glimmer in the mind of military operations and technical people to a usable capability that appears to be on the brink of winning advocates among operational military leaders. Successive sections below will address the roots of C-BML, its development to the point of a Proof of Principle by NATO Modeling and Simulation Technical Activity 048 (MSG-048), its further elaboration to a Proof of Concept by the successor MSG-085, and a conclusion summarizing the achievements and also describing future steps needed if C-BML is to achieve the vision described above.

2. Roots of C-BML

With introduction of modern combat simulations in the 1980's came a new capability: military organizations can "train as you fight" by using their operational C2 systems to interact with each other and with the simulation [1]. However, interaction with the simulation required an extra human in the loop: a supporting "puckster" who transfers C2 information into the simulation system and also enters situational information from the simulation into the C2 system. In a large exercise, staffing for this role became a major expense. Furthermore, if the person performing this role was not knowledgeable and diligent, operation of the exercise might be degraded. Therefore, automated interfaces between C2 and simulation systems were sought and in some cases implemented. However, such interfaces were implemented in an *ad hoc*, point-to-point manner and could not be extended readily to other systems.

Beyond the domain of training, the ability to couple C2 and simulation systems presented an intriguing new possibility: that simulation could support planning and preparation phases of ongoing military operations, providing course of action analysis and mission rehearsal capabilities.

These C2SIM capabilities also were implemented experimentally but also were strictly *ad hoc*, point-to-point and could not be extended readily to other C2 or simulation systems. Clearly, the C2SIM area was ready for development of a more generic, consistent approach to interoperability.

2.1 SIMCI BML Experiment 2003

The first, important step toward a general approach to C2SIM interoperation was taken by the United States (US) Army Simulation to Mission Command Interoperability (SIMCI) program, using the approach shown in Figure 1 (which is still in use today for C2SIM) [2, 3]. The emphasis of this effort, which also survives as a fundamental principle in C-BML, was to remove ambiguity at the C2SIM interface by replacing the free text of military orders and reports with a standardized vocabulary. An experimental interface was built using the approach:

- Build in the vocabulary contained in US Army FM 101-5-1, Operational Terms and Graphics and BML-1 as data tables.
- Incorporate a corresponding doctrinal base into the US Department of Defense (DoD) Joint Common Data Base (JCDB).
- Build in the syntax and semantics defined by the US Army Universal Task List (AUTL), the Army Training and Evaluation Program (ARTEP) Mission Training Plans (MTP) and the other related field manuals. Doing this allowed specific items to be aligned with echelon and type unit as relationships in the data tables.
- Create data oriented messages that eliminate or reduce the free text currently in use.

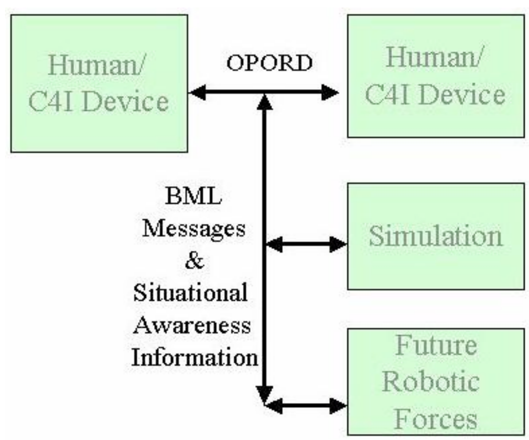

Figure 1: Scope of SIMCI Experimental BML in 2003

2.3 Extensible Modeling and Simulation Prototype

Starting in 2004, the US Defense Modeling and Simulation Office (DMSO) supported a broad effort aimed at use of emerging Web technology for interoperation of simulations: the Extensible Modeling and Simulation Framework (XMSF). An important part of XMSF was re-implementation of the SIMCI BML prototype using Web Service technologies [4]. The resulting prototype was migrated in 2005 to a database aligned with the Command and Control Information Exchange Data Model (C2IEDM) [5] which later became the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM) [6] under auspices of the Multilateral Interoperability Program (MIP), closely aligned with C2 in NATO.

2.4 Early C2SIM in France: Interoperation of APLET and SICF

In parallel with growing C2SIM interest in the US, other nations were considering the problem. The *Direction générale de l'armement* (DGA) of France moved from consideration to action by interfacing the C2 *Système d'Information pour le Commandement des Forces* (SICF) to the simulation system *Aide à la Planification d'Engagement Tactique terrestre* (APLET).

APLET is a French Ministry of Defense (MoD) Research and Technology (R&T) program which aims to analyze simulation concepts of use in order to facilitate and improve Course of Action Analysis performed at Brigade or Division Headquarters fitted with the C4I system named SICF. In addition, APLET addresses the technical issues of C4I – simulation coupling.

APLET's main objectives are:

- Automate the Military Decision-Making Process for Course of Action Analysis;
- Foresee capabilities and added value given by simulation in case of close integration with C4I systems and as an example with SICF;
- Explore and solve C4I-simulation interoperability issues and propose recommendations to bridge the gap between those systems;
- Define the most suitable simulation granularity allowing Courses of Action Analysis (COAA) in a tight period;
- Propose mechanisms to automatically produce Operation Orders from a selected Course of Action

2.5 NATO Modeling and Simulation Group Exploratory Team 016

The need for C2SIM interoperation is particularly acute in coalitions. Differences among coalition partners' C2 systems make use of a single system impractical while differences in organization, equipment, and doctrine result in a situation where each national simulation system may represent only the sponsoring nation's forces well. Parties interested in C2SIM from France and the US became aware of each other's work and interests in 2005 and proposed to the NATO Modeling and Simulation Group (MSG) that a multinational Technical Activity be organized with the purpose of exploring use of the BML approach for coalitions. The MSG charted a multinational Exploratory Team (ET) to consider this possibility. France and the US were leaders in that team, which was numbered ET-016, and cooperated to provide an initial example of successful international C2SIM integration using a BML approach [8]. When demonstrated for the MSG, this example resulted in considerable enthusiasm for Coalition BML.

2.6 SISO BML Study Group

The Simulation Interoperability Standards Organization (SISO) provides a collaborative environment for exchange of information about simulation interoperability and an organization under which standards for interoperability can be developed. Various interested parties, including several ET-016 participants, formed a SISO Study Group to consider the possibility of developing a Coalition BML standard. After due deliberation, in 2005 that group produced a report [9, 10] recommending that SISO charter a Product Development Group (PDG) for that purpose.

3. Proof of Principle: NATO MSG-048 (2006-2009)

With the successful France-US demonstration concluding ET-016, Coalition BML moved from an interesting idea to a challenging problem. France and the US were joined by other NATO nations, as described below. The NATO MSG chartered Technical Activity 048 *Coalition Battle Management Language* to coordinate collaborative efforts of the nations and provide input to the SISO C-BML PDG. This section provides a synopsis of the activities of MSG-048.

3.1 Organization and Participants

MSG-048 was organized under co-chairs from France and the US and included national representatives from Canada, Denmark, Germany, the Netherlands, Norway, Spain, Turkey, the United Kingdom (UK), and the US. Meetings rotated among most of these nations, at a rate of about four meetings per year. The final meeting of each year was associated with the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) in Orlando, Florida, where a demonstration was presented in the NATO MSG booth, representing the current state of C-BML at the time.

3.2 Goals and Methods

The Technical Activity Proposal for MSG-048 stated:

> "An open framework is needed to establish coherence between Command & Control (C2) and Modelling & Simulation (M&S) type systems in order to provide automatic and rapid unambiguous initialisation and control of one by the other. To accomplish this, C2 and M&S concepts must be linked in an effective and open manner defining new, system-independent, community standards and protocols. The MSG-048 intends to explore the emerging concept of "Battle Management Language" as a component of an open framework to link C2 systems and M&S or robotic systems in the NATO context."

This charge led to a primary objective: evaluating the available specification of a Coalition BML and a secondary one: assess operational benefits to C2 and M&S communities. Since a SISO C-BML specification or implementation was not available at the time the experimentation work was conducted, the MSG-048 utilized a version of BML based on contributions from participating nations, such as the Command & Control Lexical Grammar (C2LG) [11] and the Joint Battle Management Language (JBML) project [12, 13, 14]. This led MSG-048 to work that was conducted in three main areas:

1) Establish requirements for the C-BML standard;
2) Assess the usefulness and applicability of C-BML in support of coalition operations through experimentation; and
3) Educate and inform the C-BML stakeholders concerning the results and findings of the group.

3.3 Technologies: C2, Simulation, and Supporting Software

The general architecture for Coalition BML followed by MSG-048 is shown in figure 2. It presumes that all interaction among participating C2 and simulation systems takes place by exchange of messages through a server, implemented using Web Service technology. This architecture has two major advantages:

- Simplifies a complex development environment, since each client can be tested individually using the server.
- Provides a measure of fault-tolerance since it does not require that all members of the C2SIM system-of-systems coalition are constantly available.

The components used by MSG-048 will be described in terms of their role in the architecture of Figure 2: C2 Systems, Simulation Systems, and Server [15].

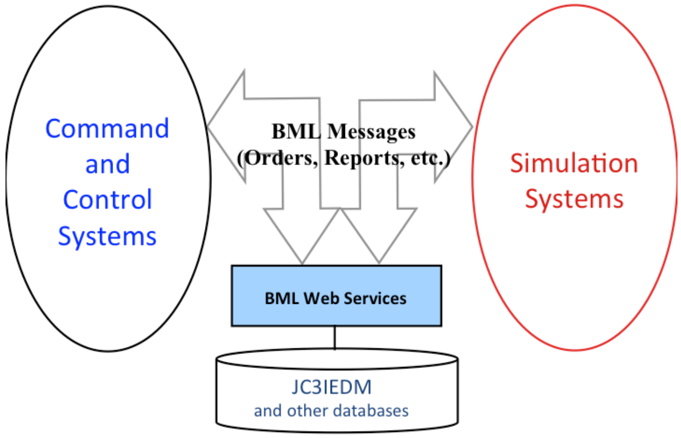

Figure 2: General Architecture for C-BML

C2 Systems: The participating national groups brought a variety of C2 systems to MSG-048, each of which was outfitted with some form of BML interface [16]:

- Canada provided Battle View, which was used to control a Predator Unmanned Arial Vehicle (UAV) for tactical air reconnaissance and fire support. An actual fielded workstation was used in the experimentation.
- France brought SICF (mentioned previously as part of ET-016), a land forces C2 system used by French Division and Brigade command posts, which also is used by French Rapid Reaction Corps and EuroCorps. SICF shortens the decision-action cycle and provides support to all staff functions.
- The Netherlands brought ISIS, the Royal Netherlands Army C2 system, which served as the opposing force C2 system in MSG-048 experiments. ISIS was able to issue fragmentary orders (FRAGOs), using a gateway and a supporting BML editor.
- Norway brought NORTaC-C2IS, the Norwegian system for tactical army operations. It supported battalion commanders performing plan development and presented status and situation reports for experiments. Its BML interface was reported to be developed easily because its orders can be expressed in C2IEDM and thus are very compatible with the vocabulary used.
- The UK brought the Integrated Command and Control (ICC) system that was developed by NATO for air operations. It provided an air operations planning tool and prepared the Airspace Coordination Order (ACO) and Air Tasking Order (ATO).
- The US brought the Army Battle Command System (ABCS), which had been interfaced using JC3IEDM to its partner simulation system OneSAF (see below); this partnership had been further extended to BML but required running an additional BML server, exchanging messages with the main coalition server, to preserve the JC3IEDM interface to the US systems [17].

Simulation Systems: The national participants brought a comparably diverse group of simulations that they had interfaced to BML:

- Canada brought UAV-SIM, which combined UAV agents with a USAV system simulation. It accepted BML orders after they were translated to the format of STANAG 4586, the NATO standard for operational UAVs. The reconnaissance reports it produced in BML were based on observation of activities in other simulations that had been exposed by the SISO Distributed Interactive Simulation (DIS) protocol.

- France brought APLET (mentioned previously in conjunction with ET-016), a simulation that is intended to support Course of Action Analysis by automating the Military Decision-Making Process.
- Spain brought SIMBAD, a constructive simulator intended for battalion-level task force training with minimal operation. SIMBAD achieved BML compatibility by means of a gateway that translated BML orders into elementary SIMBAD tasks and captured the results in the form of BML reports. Though intended for mission rehearsal, SIMBAD also was able to support coalition training.
- The UK brought JSAF, a system originally developed by the US Joint Forces Command, which they used to represent air elements (it also was capable of representing ground forces at need). JSAF interacted with the other simulators via DIS and produced BML reports in bundles for transmission efficiency.
- The US brought OneSAF, a US Army standard simulation for collective training. OneSAF was linked to the US C2 system via JC3IEDM but was able to interact with BML through a server-to-server connection, as described above.

Supporting Software: In addition to the server, an editor was found to be useful in supporting BML:

- Germany provided the C2LG-GUI, a specialized interface from Fraunhofer-FKIE that facilitates creation and editing of BML documents encoded in XML and submitting them to a server. The GUI includes a map or image display that can geo-reference location information in BML Orders and Reports. It also proved valuable as an intermediate element, accepting partial BML from a C2 system that did not have enough information to complete the Order, inserting the missing information, and submitting the Order to the server.
- The US provided the Scripted BML (SBML) server, open source software from George Mason University (GMU) C4I Center. The design of this server evolved over the duration of MSG-048, starting from a server where the parsing of the order was completely specified in Java code and emerging as a rapid prototyping tool that is configured by a script. The concept for SBML is that a BML server performs only a small number of functions, which can be specified concisely in a script. This script can be prepared rapidly and avoids many errors that are possible in the complex Java language [18, 19]. The specifics of the Integrated BML (IBML) format used at the end of MSG-048's work had evolved considerably from the initial version, but SBML was able to accommodate the changes rapidly. The server also was developed further with expanded features such as publish/subscribe and enhanced performance.

3.5 SISO C-BML

In parallel with MSG-048 investigations, the SISO C-BML PDG undertook to define a standard. This did not go as smoothly as the work of the NATO TA did. While there was progress in drafting and adopting a standard, the overall process was slower than most stakeholders found satisfactory. The standards effort went on past the end of MSG-048; at one point, the leadership of the PDG found it necessary to publish an analysis of the reasons for delay [20]. Eventually the process did produce results, as described below. In the interim, MSG-048 worked with a schema that had been developed in the US, in conjunction with an effort to increase the geospatial relevance of C-BML [21].

3.4 Final Experimentation

MSG-048 culminated in a one-week period of exploratory experimentation, conducted with operational military subject matter experts (SMEs) in 2009. Intensive preparation for this activity took place over the Internet, which at the time was a new way of working for most of the participants. In addition, two physical integration events were held: September in Portsmouth, UK and October in Paris, France. These events proved to be a successful risk reduction mechanism. The system-of-systems architecture used is shown in Figure 3.

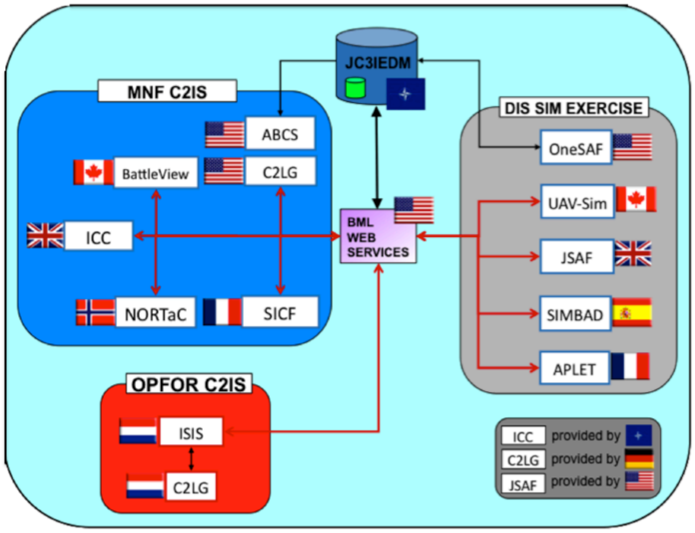

Figure 3: Architecture for MSG-048 Final Experimentation

A scenario, called "Operation Troy," was built by the SMEs that participated in MSG-048. These SMEs acted as the Brigade Staff that sent out the order to their subordinates. The exercise area was the Caspian Sea region used in earlier demonstrations. This allowed reuse of components that were prepared in 2007 and 2008. The Multinational Brigade consists of French and Norwegian battalions and a US reconnaissance element, with UK air component and a Canadian UAV company. The Mission given to the Brigade was to maneuver rapidly from an attack position along Phase Line Denver to seize objectives LION and TIGER, destroy Enemy forces in zone, and secure objectives along the international border to enable establishment of Caspian Federation (CF) regional military stability. Figure 5 displays a French Course of Action that was developed during the experimentation.

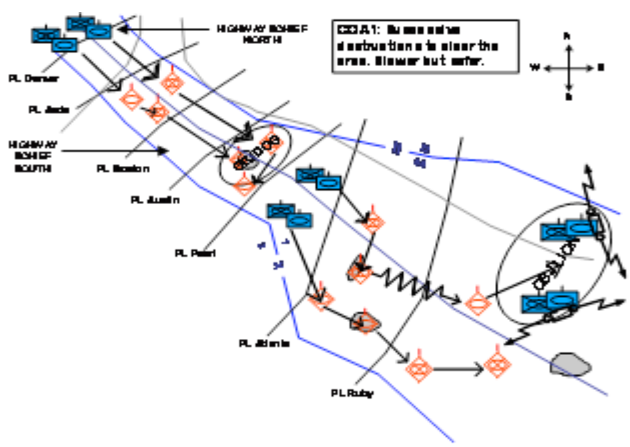

Figure 5: French Course of Action

Each of the two battalions (French and Norwegian) was assigned its own area of operation. The French had the area with objective Lion and the Norwegians had the area with objective Tiger. The US reconnaissance squadron went ahead of the other two battalions to report on the enemy. Further tactical reconnaissance and fire support was provided by an UAV under Canadian command.

3.6 Significant Results

It would not be accurate to say that all MSG-048 development went smoothly. Despite all the risk reduction, there were technical problems even during the experimentation. Nevertheless, interoperability was achieved, many of the experimentation goals were met, and we learned a great deal about how BML would need to be supported in MSG-085. Considering the complexity of the system of systems assembled (as reflected in the variety of subsystems described above) and that an entirely new paradigm was implemented, the fact that the MSG-048 final experimentation ended with all subsystems demonstrating interoperation was a significant accomplishment. As a "proof of principle," the process followed was basically successful and showed that the technologies used, and the overall BML concept, provide a sound basis for future work. This was confirmed by the participating SMEs, who were not part of the MSG-048 development team and therefore were able to view the results objectively [22]. Evidence that others also were convinced can be seen in the fact that MSG-048 received the NATO Scientific Achievement Award in 2013.

4. Proof of Concept: NATO MSG-085 (2010-2014)

As MSG-048 was preparing for its final experimentation, the NATO MSG considered a charter for a follow-on Technical Activity. It was clear even before the experimentation that Coalition BML was a very promising approach, so a new charter was approved with no hesitation. The new Technical Activity 085 was named "Standardization for C2-Simulation Interoperation" and focused on assessing the operational relevance of Coalition BML while increasing its Technical Readiness Level (TRL) to a point consistent with its operational employment. Consistent with this charter, MSG-085 has been, to a large extent, a process of maturing the technical and operational basis for coalition use of standardized C2SIM.

4.1 Organization and Participants

MSG-085 began in 2010. France and Canada were designated as co-chairs. Nations participating included the original nine from MSG-048 plus Belgium and Sweden, with interest also expressed by Italy and Australia. (In NATO context, Australia and Sweden are Partner Countries but not committed to its collective security; the Partner Countries are welcome in MSG-085 and many other NATO activities.) With increased focus on operational relevance came more participation from operational military and their support staffs. To use this new talent effectively, MSG-085 divided participants into an Operational SubGroup (OSG) and Technical SubGroup (TSG). The OSG developed methods for validation of operational relevance while the TSG continued the MSG-048 tradition of collaborative technology development, increasingly conducted via the Internet. In 2012, this organization was enriched by an orthogonal division into Common Interest Groups (CIGs) for Autonomous/Air Operations, Land Operations, Maritime Operations, Joint Mission Planning, and MSDL/C-BML Infrastructure (see below) [33, 34, 35].

4.2 Goals and methods

An important finding of MSG-048 was that, for an effective operational capability, the SISO C-BML focus on Orders, Requests and Reports must be supplemented with another SISO standard: the Military Scenario Development Language (MSDL) [23] to provide effective initialization. Accordingly, in its first year MSG-085 pressed its members to implement MSDL in the simulation systems they had made BML-capable under MSG-048. This implementation was effective but it illuminated another problem: although SISO policy called for MSDL and C-BML to work together, the two were developed independently and there was no "roadmap" telling how to use them together. As a result, considerable effort went into exploring alternatives [24, 25, 26] before a path forward was adopted [27].

4.3 SISO standards

Late in 2012, the SISO C-BML PDG completed balloting of the Phase 1 C-BML standard, including two subschemas: the "full" subschema is intended to address a very wide range of possible data representations, as broad as the complete JC3IEDM, while the "light" subschema is intended to facilitate rapid implementation of C-BML for the large majority of cases that do not need such complexity. Final editing of the C-BML Phase 1 document took place late in 2013; official standardization is expected to occur early in 2014, a long-sought event.

However, this result came so late that some MSG-085 member nations had not converted to C-BML from the IBML schema used in MSG-048, and in the absence of a C-BML standard other member nations had enhanced IBML and some others had adopted an enhanced version. Thus, there were four different schemas that might be used in the MSG-085 final demonstration, and there was not adequate time and resources to converge on a single schema. The resolution to this problem will be described in the next section, Technology Advances.

4.4 Technology Advances

While progress continued on all parts of the C2SIM system of systems as MSG-085 progressed, for C2 and simulation systems it was incremental, without significant breakthroughs. However, in the area of servers, significant advances occurred.

Document-based Server: The SBMLServer used in MSG-048 worked by parsing every BML transaction into a JC3IEDM database. While powerful and flexible, this was slow. The Virginia Modeling and Simulation Center (VMASC) of Old Dominion University, in support of the US Joint Forces Command, implemented the CBMS server approach, which does minimal parsing and serves each transaction as a single document. This allows much higher performance [27].

MSDL Server: In order for various members of a coalition to interoperate the C2SIM systems, they need to assemble a single, consistent MSDL Scenario file. The SBMLServer was extended to automate this process and then serve the resulting MSDL file as part of the initialization process. The CBMS server, while it does not automate merging the MSDL Scenarios, also is capable of serving the combined coalition MSDL Scenario.

Translating Server: The original server developer, GMU, focused on the problem of multiple schemas that was fragmenting MSG-085 operations, taking advantage of the fact that the SBMLServer parses all BML transaction and reassembles them for publication. Since the four possible schemas were largely equivalent semantically, they arranged for SBMLServer to reconstitute the parsed document in any of the four representations, acting as a translating server [28].

Web-based System-of-Systems Coordination: The envisioned mode for future use of C2SIM is distributed, not requiring the participating organizations to come together physically. As MSG-048 experienced strongly in its final experimentation, this requires an effective means of synchronizing operation of the various participating systems. GMU has developed a capability, based on normal webpage technology, to coordinate first the initialization and then the operation of a C2SIM coalition.

Commercially-based Server: While the translating SBMLServer offered a potential way to interoperate the multiple schema versions used by MSG-085 nations, its performance would not support a meaningful coalition in that mode. Happily, the Saab Corporation, a Swedish company, had offered MSG-085 access to its Widely-Integrated Systems Environment (WISE), which offered a high-performance way to implement SBMLServer. Saab further chose to provide limited support to GMU to enable transition of SBMLServer from open source Java that works with JBoss to open source C++ that works with WISE. The resulting WISE-SBML server has roughly 100X performance over the original and is on a path to future commercial support. Saab also made available a BML-enabled version of its battalion-level C2 system 9LandBMS [30, 31] for use by MSG-085; it was used as a surrogate US system because security issues precluded use of the US C2 system that has been developed for use with OneSAF.

Linked Servers: Ultimately it will be necessary to combine the power of multiple servers in support of larger coalitions. MSG-085 determined that it had a near-term need for such a capability, to interoperate the US/UK OneSAF/JSAF/ICC/9LandBMS coalition (using C-BML Light and IBML schemas) with the France/Germany coalition (using enhanced IBML schema). The France/Germany coalition used a hybrid server, developed by Fraunhofer-FKIE, based on the original open-source SBMLServer. GMU and Fraunhofer-FKIE collaborated to develop a capability to link their servers, using a "back to back client" in the middle [32]. Figure 6 shows the linked server architecture.

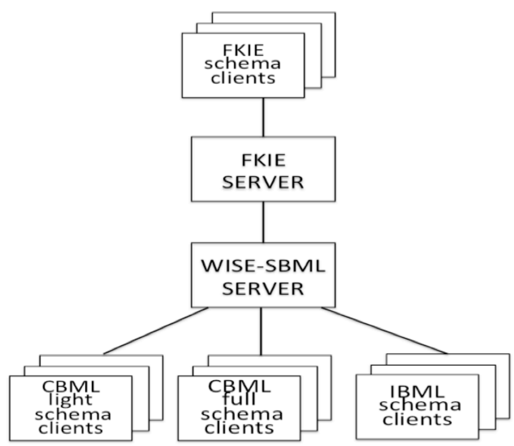

Figure 6: Linked Server Architecture

4.5 Final demonstration

The final demonstration of MSG-085 took place at Fort Leavenworth, Kansas in December, 2013. MSG-085 partnered with the US Army Mission Command Battle Laboratory there to engage in a short integration session. The featured capability was Joint and Combined Mission Planning. The architecture of the demonstration system-of-systems that was assembled is shown in Figure 7. The consensus of participants was that this demonstration confirmed the operational relevance of C2-simulation interoperation for the Joint and Combined Mission Planning area [38].

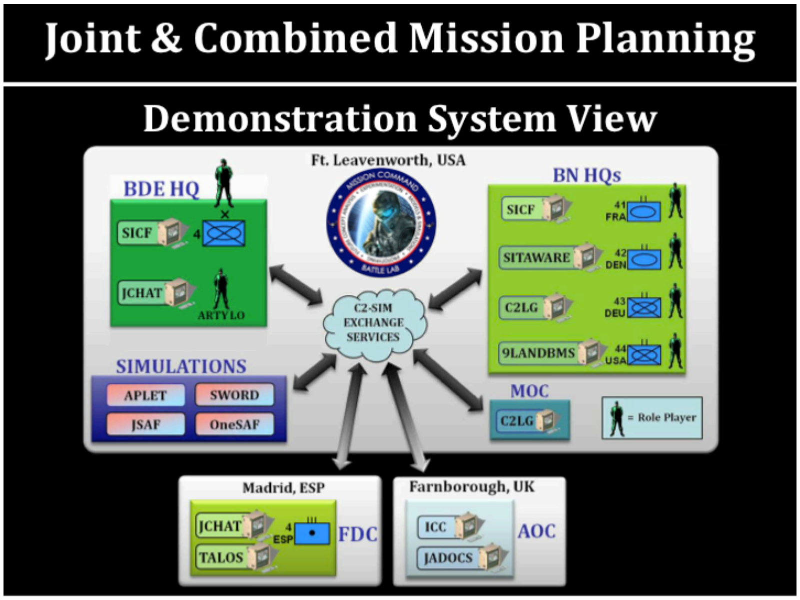

Figure 7: MSG-085 Final Demonstration System of Systems

While the complexity of the MSG-048 and MSG-085 final events is roughly similar, there were some striking differences:

- *Network sophistication*: The MSG-085 network included two remote participants and operated with two linked servers and three schemata (C-BML Full, while available on the WISE-SBML server, was not used by any of the systems). This models the sort of operation expected in operational BML use.
- *Setup process*: The MSG-048 setup was somewhat chaotic, with some of its capabilities becoming usable only on the last day of experimentation. By contrast the MSG-085 systems came together smoothly. There were a few problems but mostly they "just worked".
- *Audience impression*: The MSG-048 final audience got the message "We have an exciting new capability. It's not working very well yet but it has great potential for the future." In contrast, the MSG-85 final audience got the message "We have an exciting new capability and it works very well to improve some unmet needs of coalition C2, using interoperable simulations."

4.6 Significant Results

In short, where MSG-048 succeeded in proving the principle that C2SIM could be used effectively in coalition operations, MSG-085 succeeded in a harder goal: proving the concept that C2SIM in the form of MSDL and C-BML is ready to be tested in real coalition operations.

5. Conclusions and Way Forward

This paper has reviewed the inception and steady progress of C2-simulation (C2SIM) interoperability as a standardized capability that can improve the decision-making and training in coalition military operations. Starting with an exciting concept, the community involved in C-BML, both in NATO and SISO, has made continued progress toward the goal that, in the not too distant future, military coalitions will be able to come together and benefit from interoperating C2 and simulations across all nations participating.

While commendable progress has been made toward the vision motivating the vignette that began this paper, much remains to be accomplished. The feasibility of C2SIM was demonstrated by MSG-048 and the utility of C2SIM has been demonstrated by MSG-085. What remains is to engage the operational military community in the various NATO nations and provide them compelling evidence, in the form of well-supported training events, that C2SIM should be an integral part of NATO and national C2 systems [36].

In addition, to work with the operational community, there is much technical effort remaining to improve C2SIM. Both MSDL and C-BML need to have a next generation developed to facilitate both their working together and the scope of the interoperability they are able to achieve. MSDL should meet the needs of a wide range of national systems, while C-BML should improve both the sophistication of what it can represent and ease of using it to represent sophisticated situations [37]. Based on success thus far, we believe this is entirely achievable if the C2SIM community continues a coordinated effort toward the goal.

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