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US Contribution to the C-BML PDG

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ABSTRACT: *The Joint Battle Management Language (JBML) is being developed as an unambiguous language for tasking and reporting. This paper summarizes significant US national contributions to the current Coalition Battle Management Language (C-BML) Product Development Group activities. It focuses on application of the well-known principles of BML in the joint warfighting context that will support a Joint Event in 2007. The JBML design is characterized by several layers that enable configurable solutions, not only from the information system perspective, but also from a domain-specific information exchange view. The main ideas are to capture standardized data elements (atomic services), compose the elements into meaningful objects representing data in context of a general application (composite services) and use the resulting information elements to form domain-specific information elements (domain services). The services are implemented as Web services supporting C-BML Phase 1. The domain configuration is based on a general Grammar schema derived from initial work in formal languages to support C-BML Phase 2. Finally, an initial version of the domain-specific knowledge is formalized as an initial step toward the development of ontologies in C-BML Phase 3. All information exchange specifications are tightly connected with the Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM), although the higher levels of JBML introduce abstractions that encapsulate the complexity of the underlying data model intended to make the consistent application of JBML easier for the user. The paper focuses on the JBML layered approach and how these elements contribute to the C-BML standardization activity.*

1 Introduction

The Joint Battle Management Language (JBML) activity comprises significant US efforts in support of the Coalition Battle Management Language (C-BML) Product Development Group (PDG). JBML is not “yet another BML” but intended to become the first contribution to a growing family of standards.

While JBML is being developed to solve real requirements of the Warfighter in support of exercises, a significant part of the project targets conceptual challenges and tries to find answers that can support the C-BML standard development process. Another aspect is the support of international collaboration within the Simulation Interoperability Standards Organization (SISO) as well as within the NATO Modeling & Simulation Group activity on C-BML (MSG-048). As such, JBML is a multiphase project which is just at its beginning. JBML is on the leading edge of research in this domain; decisions made in the early phases of the effort will likely be improved over time. This goes hand in hand with the decision of the C-BML PDG, which is developing the C-BML standard in incremental phases as well.

We begin in the next section with a short overview of the JBML project, focusing on the history and related BML activities to give a picture of the constraints the project works under. Section 3 describes the JBML architecture, which was developed in several JBML meetings with support of all participating organizations. The layered approach was designed to allow the evaluation of complementary or alternative prototypical implementations and will be a key factor to success of the JBML project. Section 4 describes tentative and anticipated results of the initial JBML developments. Section 5 shows the relevance for SISO: how JBML can contribute to the C-BML PDG and where additional research is needed.

2 The JBML Project

The goal of this project is to develop a standard Battle Management Language applicable to US Service and Joint Users.

The need to interface Command and Control (C2) and Modeling and Simulation (M&S) systems has been long established. However, due to limited DoD-wide work on establishing applicable standards for C2-to-M&S interoperability, almost every simulation has a unique C2 interface. The BML effort and its use of the international Multinational Interoperability Program (MIP) data standards as a system-independent community vocabulary and structure for passing plans and orders between C2 systems and simulations address this need. A central role plays the Joint Command, Control, and Consultation Information Exchange Data Model (JC3IEDM), as already identified by the SISO Study Group on Coalition Battle Management Language (C-BML) [1].

2.1 History

From its beginnings, BML was not envisioned as an exclusively technical solution but as a solution reflecting the operational needs and requirements of the Warfighter. The use of terms already defined in the command and control language, the reports, and the implementing forms was therefore mandatory. Carey and colleagues describe the overall process to show the feasibility of defining an unambiguous language based on manuals capturing the doctrine of the Armed Forces in [2]. Funded by the US Army and sponsored by the Simulation-to-C4I Interoperability Overarching Integrated Product Team (SIMCI OIPT), the first BML team started by analyzing more than 70 doctrinal manuals related to tasking and reporting, beginning with general manuals, such as the Field Manual 3-0 on Operations [3] and the Universal Joint Task List as published by the Joint Staff [4], and including the field manuals of branches of the Army, such as Field Artillery, Air Defense Artillery, Engineers, Military Police, and many more manuals down to the platoon level. As the skeleton for the analysis, the structure of an Operational Order was selected, leading to the establishment of the *5-W Structure for BML*: Who is doing What, Where, When, and Why. This work laid the foundation for all follow-on activities and was featured in a journal paper [5].

This prototype developed for the US Army proved the feasibility of the concept in 2003. Under sponsorship of the US Defense Modeling and Simulation Office (DMSO) and the US Joint Forces Command (JFCOM), the Extensible BML (XBML) project was started as a follow on to support two main objectives: *(1)* using web technology for the information exchange between the systems' interfaces to create a net-capable prototype; *(2)* using the earlier Command and Control Information Exchange Data Model (C2IEDM) as a basis to structure the information to be exchanged between the systems to facilitate international collaboration. Both of these goals were achieved and the related work was published in [6], in addition to multiple SIW contributions.

The XBML prototype was used for the first international experiments, driven by an exploratory team of NATO's Modeling & Simulation Group (MSG-ET016). Experiments and results are described in detail in [7].

In parallel, JFCOM was particularly interested in BML's potential to increase interoperability between the services. While the first efforts described above focused on land forces, the Air Operations BML (AO BML) effort evaluated if the prototypical ideas were applicable to air forces as well. To this end, the prototype developed as XBML was enriched by an interface to Air Force command and control systems. In addition, the Air Warfare Simulation system (AWSIM) was connected to receive orders formulated in AO BML. One of the results – besides that the ideas proved feasible and applicable to air warfare as well – was to understand that the C2IEDM is object/entity focused (which is the main point of interest for land systems) while the AO BML components emphasize the activity (the action of a sortie, which is the main point of interest for air operations – land entities are targets and sometimes potential quasi-stationary threats like air defense systems, but the focus of command and control interests are the fast moving air operations). While the first phase of AO BML focused on integrating the systems using web technology, a second phase was conducted focusing more on the identification of information exchange objects making up the AO BML The work is described in [8].

2.2 Related BML Research Activities

As stated before, JBML is the first in a family of BML efforts that are envisioned to share a common kernel, but individually contributing to their respective domains. The work on Ground Forces BML and Air Operations BML is described above. Other activities are the work of the Naval Postgraduate School (NPS) on a Navy BML [9] and the work supported by Army Topographic Engineering Center (TEC) on geoBML, in which the BML concepts are leveraged for terrain reasoning[10].

Schade and Hieb summarized the current BML activities in following table, which has been slightly modified from [11] by naming and adding the NATO activities related to the Exploratory Team ET-016 efforts [7] and the NATO Pathfinder Integration Environment MSG-027 experiments [14], which will be explained in section 2.3 in some detail.

Table 1 shows the relations of recent and current activities. While C-BML focuses on the specification for all services in form of reusable software services for the international community, earlier prototypical experiments focused on the proof of feasibility, hence they focused on the implementation.

JBML, as the national overarching solution for BML efforts, targets to deliver a specification, but will also be implemented and used in a joint event.

2.3 Other Related Research Activities

The main objective of BML is to define an unambiguous language for tasking and reporting. The infrastructure is web-based. These ideas are common to a series of related activities that either directly use BML results or that have the potential to contribute to BML efforts.

In Sweden, work is being conducted to leverage military command and control results for crisis management within coalition forces. To this end, the feasibility of a Coalition Crisis Management Language (C-CML) is being evaluated. Ideas and first results have been published in [12] and have been discussed in Europe as well as in the Asian-Pacific region.

As mentioned before, NATO MSG is interested in these and related activities as well. The usability of C2IEDM to enable Command and Control coupling with M&S is recognized. Besides the ET-016 activity that led to the establishment of the technical activity MSG-048, other expert groups are looking into the use of C-BML ideas as well. The NATO PATHFINDER efforts used C-BML enabling Web services as described in [13] for a successful trans-Atlantic experiment with command and control systems and simulation systems from several nations exchanging information based on C-BML ideas. The experiment is described in [14].

The work on BML has many views and contributing techniques. The necessity to align these various contributions has been documented in [1]. Current work focuses in particular on the definition of information exchange objects that build the foundation of the language and grammatical approaches that are used to build higher order information exchange constructs out of the low-level information exchange objects.

The work in defining information exchange objects by Tolk focused on the definition of atomic information objects used as minimal building blocks for BML and their formal composition and aggregation into higher BML elements [15]. These ideas were applied in the second spiral of the Joint Rapid Scenario Generation (JSRG) capability (former known as JRD3C) within the Joint Event Data Initialization Services (JEDIS), which is described in [16]. It should be pointed out that the approach of JEDIS is engineering method driven: the information to be exchanged is identified and mapped by engineers. Their result is used to configure the system-specific Web service access layers. The JEDIS services themselves can be standardized and are rooted in the JC3IEDM philosophy to structure data.

Table 1: BML Activities [11]

	Specification	**Ground**	**Air**	**Naval**	**Implementation**	**Software Services**	**International**
C-BML	X	X	X	X		X	X
ET-016		X			X		X
MSG-027		X			X	X	X
JBML	X	X	X	X	X	X	
geoBML	X	X			X		
XBML		X			X	X	X
Army BML		X			X		
AO BML			X		X		
MIP/JC3IEDM	X	X	X	X			X

Schade and Hieb have investigated the development of a BML formal "Grammar" for JBML in [17, 18]. Additional research on grammatical constraints conducted by Tolk and Diallo are documented in [19, 20].

Finally, the companion PDG Military Scenario Definition Language (MSDL) should be mentioned. While C-BML focuses on the information exchange for tasking and reporting during execution, MSDL focuses on the initialization of systems on a broader basis. The close relationship between MSDL and C-BML is documented in [21]. While the strength of MSDL is the rigorous definition of minimal structures and enumeration of attributes, the strength of C-BML is the focus on composability and configuration of information exchange elements based on grammars and ontological formalisms.

It should be pointed out that the current implementation required a common initialization of all participants, which includes in particular the applicable types for the information elements to be exchanged. The JC3IEDM requires to have object-types defined for every object-item to be exchanged via its services. These types must either be specified in the language or must be pre-populated. Both related activities, MSDL and JEDIS, target the domain of scenario generation. If MSDL or JEDIS will be used for the initialization is an open topic. In section 4, some pros and cons will be evaluated.

3 JBML Architecture

This section provides a description of the Web services being implemented as open source Java software in support of JBML. The intention is to provide a reference implementation that can serve as basic infrastructure for the project, and to offer this to the SISO Coalition Battle Management Language (C-BML) standards effort. The implementation will be based on Web service networking standards [22, 6].

3.1 The Layered Services of JBML

Figure 1 provides an overview of the Web service Architecture. The different layers will be described in detail in the following subsections.

- The BML Domain Configures Services (DCS) represent the domain-specific language in form of grammar-based schemas that are utilized by implementing Web services.

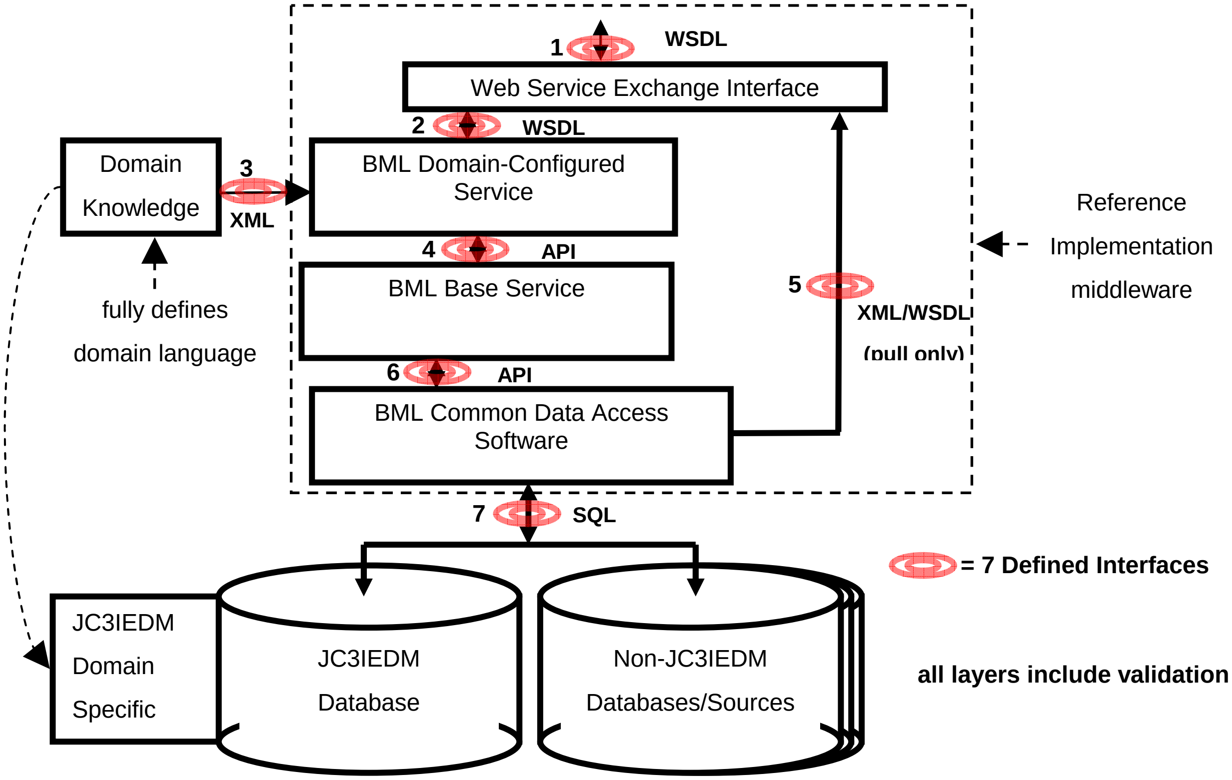

Figure 1: JBML Architecture Overview

- The grammar uses the BML Base Services (BBS) which represents the information element groups that are necessary to specify the information objects of interest, such as the 5Ws (who, what where, when, why) and other constructs of interest.
- The lowest layer represents the information exchange of information elements. This layer is normally hidden for the user. In JBML, these are BML Common Data Access Services (CDAS).

BML Domain Configured Services

DCS implement BML in a domain context. In the case of an OPORD, the transaction at this layer specifies all information about a given task (i.e., who, what, when, where, and why). For a Position Report, the transaction at this layer will include all information about the updated location (e.g., who, where, when-valid, precision, etc.).

The DCS will be implemented in the Document-Literal mode by a generic Web service that is driven by an XML schema. Schade and Hieb propose that the entire existing BML grammar can be formally described in terms of a number of primitives [17, 18]. We will define an XML format that can be used by every BML order, based on the tags given in Table 2.

Table 2: BML Primitives proposed in [17, 18]

`<command> (verb)`	`<tasker-who>`
`<taskee-who>`	`<affected-who>`
`<what> (action)`	`<where>`
`<start-when>`	`<end-when>`
`<why>`	`<label>`
`<modifier>`	

The Domain Knowledge Schema (DKS) for the DCS represents, for each distinct BML order, the grammar tags to be used, the BML Base Service transactions that will result when that order is received, and the validation conditions to be applied. The DCS has a configuration file interface (3) to the generic (domain independent) code that supports the service. The standard at this layer will define and explain all possible options for the DCS schema.

The higher level interface (2) will be defined using a Web service Description Language (WSDL) and will be XML/SOAP based. The lower level "internal" interface (4) will exercise the BML Base Service API and will be exposed as a subcategory of the higher level interface.

BML Base Service

BBS provide composite BML elements such as Who, What, When, Where, and Why. Other elements may be introduced for new and existing BML domains as required. The BBS accesses all of the database tables relating to the composite element through the software that implements the Common Data Access Services. The standard at this layer will identify the information objects exposed by the database tables to be updated for each BML information element and the validation conditions to be applied. The BBS will provide an XML-based API interface (4) to the DCS. The BBS lower level interface (6) will exercise the BML Common Data Access API.

The close relationship of BBS and the primitives in Table 2 should be pointed out. One school of thought that is aligned with the ideas proposed in [15, 19] is to use these primitives as composites, i.e., as BBS. As shown in [20] this requires independence of the primitives and unambiguous relations between them, which is topic of current research. Another school of though is to use possible configurations of these primitives to identify possible BBS. In this model, every valid composition of primitives results in one implementing service. Both ways are possible and are subject of current evaluation.

These services are usually not accessed by the user of JBML. He uses the DCS. However, in order to allow meeting special information exchange needs that are not yet covered by DCS but can be satisfied, the implementation of JBML allows a user to "reach through" the DCS and access the BBS directly.

BML Common Data Access Service

The main objective of Common Data Access Services (CDAS) is to provide a mechanism for the BBS to both read and update the database tables directly. For testing and debugging purposes, the CDAS support inspection of every database table used in any domain of BML in order to support understanding of system behavior during development. Our proposed standard at this layer will define the tables used, a standard XML format to access them, and the validation conditions to be applied to changes. Changes to the database will not overwrite the previous values but instead will mark them invalid and provide new valid values.

Within the current implementation of JBML, there are two higher level interfaces to the CDAS. One will be an internal interface (6), defined as an XML-based API. This interface is active in both directions (write and read). The second (5) will be defined using a WSDL and will be XML/SOAP based. This one-way interface is used for inspecting (reading) database tables. This interface will be included in our proposed C-BML standard. The CDAS lower level interface (7) is SQL based.

It should be noted that the role of the JC3IEDM in the C-BML specification is a matter of some debate at present. It is clear that using the JC3IEDM adds significant value as the basis for the vocabulary associated with the grammar implemented in the DCS, since the MIP has invested a very great effort in identifying the terminology of command and control. Beyond this, one school of thought is to define a standard JC3IEDM interface into C-BML-based systems, so as to enable interoperation with other systems that implement the JC3IEDM. The other point of view is to have C-BML focus the standard only on the unambiguous, grammar-based information exchange at higher layers. We have concluded that the best idea is to create specifications for all three layers in such a way that they can work together to provide a functioning BML: a grammar-based upper layer, a transaction based middle layer, and a lower layer indicating the specific mapping from the higher-level representation to JC3IEDM entities and attributes. However, we believe the standard should not mandate use of all three layers, but rather allow the system designer to choose the layer(s) at which to comply.

It should be pointed out that the cascading definition of DCS, BBS, and CDAS does not imply that the implementation is done using cascading Web services as well. As already pointed out in [15], it is recommended best practice to implement the standardized services as efficiently as possible. That means that once a DCS is identified, the access to the information exchange layer – be it driven by persistent data requirements as in the current JBML or transient data driven as the C-BML enabling Web service approach described in [14] – can be programmed directly utilizing the API's shown in Figure 1. The use of objects representing the agreed standard on lower levels, such as using Java object representing tables as described in [8], ensure the consistency in case lower layer standards are modified. However, as long as the interface standard is satisfied for the access and the information object exchange is satisfied on the lower level, the implementation details are irrelevant.

3.2 Differences from Earlier Recommendations

There are two significant differences between the JBML implementations and the concepts described in [13] and [15].

First, the JBML approach is a combination of top-down and bottom-up driven, using high-level, user-driven concepts to define the elements constituting a rigorous grammar based on the ideas captured in [17, 18] as well as the layered Web services architecture. The earlier implementations – including JEDIS – are designed bottom-up and compose information objects describing the minimal information exchange request entities (sort of the greatest common divisor of entropic elements). As such, JBML has the potential to be more flexible than earlier solutions, as long as the used grammar solutions are aligned with the underlying BML views on Doctrine, Representation, and Protocols as captured in the BML Triangle [19]. Research on how to merge the approaches featured in [17, 18, 19, 20] to the benefit of the user and the PDG is ongoing.

Second, in the current JBML implementation the BML CDAS have been streamlined to support highly efficient data access. JEDIS and related C-BML work conducted for PATHFINDER use database-independent information exchange object definitions, which also access a database in the implementation. Direct use of the same interface for immediate service-to-service communication without the use of persistent data storage is documented in [21]. While the general implementation is very flexible, the JBML implementation is more efficient with the chosen JC3IEDM database, which was specified for use in C-BML Phase 1 [1]. In other words, the current version implements a persistent data object exchange as the modus of choice. Transient data objects are not supported in this version.

It should be pointed out that persistent data objects can be seen as state of the art out of multiple reasons.

- User can "see" how the information is passed and which information is passed when and by whom.
- Databases ensure consistent information exchange based on its business rules avoiding inconsistencies resulting from bad data.
- Databases allow easier debugging.
- Databases allow easy visualization of comprised information with standard tools.
- Systems using this database (here the JC3IEDM) can directly utilize alternative information exchange means to utilize the data, such as replication mechanisms, message generators, etc.

However, in the mid term both modes of exchange – persistent and transient objects – must be supported. This may be an open point for the C-BML standard.

3.3 Example

This subsection gives some examples of services to help the interested reader work through the concepts. As the implementation is based on open source ideas, more examples can be requested from the authors of this paper. It can be seen that, in addition to creating a BML namespace, we are using the namespace developed by the MSDL product development group for location and task organization information, as a first step toward developing compatible C-BML and MSDL standards.

BML-DCS (Domain Layer)

A simple example of a DCS order input transaction is:

```
<?xml version="1.0"?>
<bml:OrderPush
  xmlns:bml="http://netlab.gmu.edu/JBML/BML"
  xmlns:msdl="http://netlab.gmu.edu/JBML/MSDL" />
  <bml:OrderIssuedWhen>00200ZJUL2006
  </bml:OrderIssuedWhen>
  <bml:TaskOrganization>
  <msdl:Units>
    <msdl:Unit>
      <msdl:Name>CoA1/100Mech</msdl:Name>
      <msdl:ForceRelation>
        <msdl:CommandRelationship>
          <msdl:CommandSuperiorName>1/100Mech
          </msdl:CommandSuperiorName>
          <msdl:CommandRelationshipType>ORGANIC
          </msdl:CommandRelationshipType>
        </msdl:CommandRelationship>
        <msdl:Affiliation>FRIENDLY</msl:Affiliation>
      </msdl:ForceRelation>
      </msdl:Unit>
    </msdl:Units>
  </bml:TaskOrganization>
  <bml:TaskerWho>1/100Mech</bml:TaskerWho>
  <bml:MultipleControlMeasures>
      <bml:ControlMeasure>
        <bml:WhereLabel>INITIAL_PL_ACO
        </bml:WhereLabel>
        <bml:WhereClass>POINT</bml:WhereClass>
        <bml:WhereValue>
          <msdl:GDC>
          <msdl:Latitude>32.00</msdl:Latitude>
          <msdl:Longitude>84.00</msdl:Longitude>
          <msdl:ElevationAGL>0</msdl:ElevationAGL>
      </msdl:GDC
    </bml:ControlMeasure>
  </bml:MultipleControlMeasures>
  <bml:Command>
     <bml:Domain>GROUNDBML</bml:Domain>
     <bml:TaskeeWho>CoA1/100Mech</bml:TaskeeWho>
     <bml:What>ADVANCE</bml:What>
     <bml:Where>INITIAL_PL_ACO</bml:Where>
     <bml:StartWhen>020700ZJUL2006</bml:StartWhen>
     <bml:Why>
       <bml:WhyAffected>BREAKUP</bml:WhyAffected>
     </bml:Why>
     <bml:CommandLabel>INITIAL_ADVANCE_ACO
     </bml:CommandLabel>
  </bml:Command>
  <bml:CommandersIntent>Force contact with enemy.
  </bml:CommandersIntent>
</bml:OrderPush>
```

BBS (Composite Layer)

An example of a BBS push input method invocation associated with the above is:

```
// ID of TaskerWho 1/100 Mech
   BBSCommand_push( “1”,
// OrderIssuedWhen         “00200ZJUL2006”,
// IF od TaskeeWho CoA1/100Mech         “2”,
// What                           “ADVANCE”,
// Where Latitude                      “32”,
// Where Longitude                      “84”,
// Where ElevationAGL                    “0”,
// StartWhen               “020700ZJUL2006”,
// Why-WhyAffected                “BREAKUP”,
// CommandLabel          “INITIAL_ADVANCE_ACO”,
// AffectedWhoID (null in this case)      “” );
```

The resulting composite input transactions updates a totel of 25tables, based on the mapping from the BML objects to the corresponding JC3IEDM tables, as indicated in Figure 2.

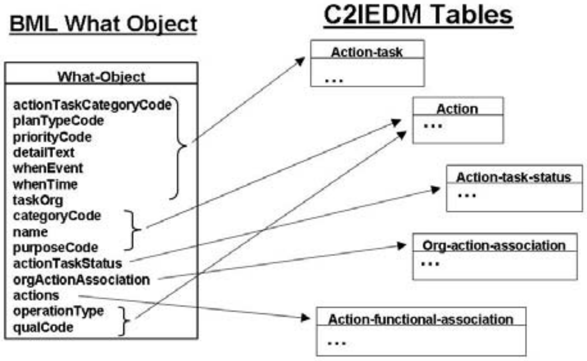

Figure 2: <what> partial object C2IEDM/JC3IEDM mapping

CDAS Web service example

An example BML CDAS transaction Web service invocation is:

```
String tableName = “act”;
String columnName = “act_id”;
String keyValue = “2265”;
String result =
getTable(tableName,columnName,keyValue);
```

This retrieves the action table row associated with the prior example. There also exists a Java method *updateTable* that is used by the BBS to update the database. It is not exposed as a Web service.

4 Anticipated Results

The JBML project has a great legacy from previous work in C2-Simulation interfaces. While much of this work has been very ad-hoc in nature, resulting in “stovepipe” interfaces, recent efforts have embraced the concept of *standards-based interoperability*. This will allow systems of systems (C2 system, simulation systems, and many other C4I systems) to be assembled without requiring custom engineering of each system-to-system interface. In the JBML project, we are moving toward that goal, by assembling a rational language standard that rests on commercial standards as described above (XML, SOAP, Web services, etc.). Moreover, we recognize that it is incumbent on us to demonstrate effective interoperation in a Joint Operational context in order to validate our results. We envision that the body of specification detail for BML will grow rapidly, given a rational structure and the expectation that any investment in compliance with the SISO standard will enable future reuse of the standardized interface.

We are focusing on the US Joint Forces Command (JFCOM) as the initial user of JBML. JFCOM possesses both a high expertise in the various military operations supported by JBML and demanding missions in joint training and experimentation that require specific capabilities. In particular, they anticipate that their new Political, Military, Economic, Social, Information and Infrastructure (PMESII) simulation [23] will contain multiple interfaces that use BML. Between PMESII and continued ongoing training exercises, there will be many opportunities to stress (and thereby improve) BML interfaces in the next few years. We anticipate continuing to broaden the scope of BML-based system interoperability, while also increasing the richness of the BML interface.

Another aspect is the alignment of C-BML and MSDL – as already mandated by the Standardization Activity Committee (SAC) of SISO – and JEDIS – as requested by the users from the JFCOM community. The main advantage of MSDL is that a standardization effort is already going on in alignment with C-BML activities. However, MSDL is not yet aligned with JC3IEDM structures. The main advantage of JEDIS is that it is based on the JC3IEDM, but it is neither a standard nor exposed so far to the SISO community. First reports, such as [16], address this shortcoming.

5 Contributions to C-BML and Summary

The immediate contribution of the JBML project to C-BML is the service architecture described above, which will provide a regular and extensible framework upon which a powerful, flexible and growing family of standards can be created. This mature approach is the antithesis of the ad-hoc, cobbled-together interfacing that has been the norm in “stove-piped” systems of systems.

In addition, SISO has provided an ideal opportunity to make BML more effective by pairing the C-BML and MSDL standards efforts, with the mandate that the resulting standards are fully compatible and thus form a cornerstone of a growing system-level standards base. As a result, we believe the information sharing capabilities of the US and its coalition partners will continue to become more effective leading to greater cooperation and collaboration.

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