A Study on the Battle Management Language Application for the C4I and M&S Interoperation in ROK Forces

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한국군에서의 C4I체계와 M&S 상호운용을 위한 BML 적용에 관한 연구

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ABSTRACT

Battle Management Language (BML) is defined as an unambiguous language intended to provide for command and control of simulated and live forces in U.S. It has been developed to connect between command and control system and Modeling & Simulation in the U.S., including NATO M&S Working Group. Its goal is to provide situational awareness and offer a path forward for interoperation of C2 systems and simulations. This study deals with BML development in U.S. that begins from army and is being expanded in multinational environment. It also proposes the BML application for C4I and M&S interoperation in the Korean forces. Recent developments of BML in U.S. have shown the potential for interoperation between C2 systems and simulations in a coalition environment. Finally, this study proposes a general BML application method and shows the example of its application to the Korea Joint Command Control System (KJCCS). It provides an architecture and a milestone for BML application in the Korean forces.

Key words : Battle Management Language (BML), Command and control (C2), Modeling & Simulation (M&S), C4I, interoperation

요 약

전투관리언어인 BML은 미군에서 가상 부대 및 실제 부대를 지휘 및 통제하기 제공하기 위한 명확한 언어라고 정의할 수 있다. BML은 C2 체계와 M&S를 연결하기 위해 미국과 NATO에서 개발되었다. BML이 개발된 목적은 전장정보를 통해 상황 인식을 제공하고, C2 체계와 M&S간 상호운용을 위한 해법을 제시하는 것이라고 할 수 있다. 본 연구는 육군에서 시작하여 다국적국으로 구성된 환경으로 확장되고 있는 미국의 BML 개발과정에 대해서 설명하고, 한국군에서 C4I체계와 M&S간 상호 운용을 위한 BML 적용 방안에 대해서 제안한다. 최근, 미국에서는 BML을 연합국으로 구성된 환경에서 적용하여 긍정적인 결과를 얻었는데, 이는 C2 체계와 M&S간 상호운용에 대한 가능성을 보여주었다. 마지막으로, 본 연구는 BML을 한국군에 적용하기 위한 방안으로 한국군 합동지휘통제체계를 중심으로 제안하였다. 이는 향후 한국군에서 BML 적용시 밑그림을 제공할 것이라고 판단된다.

주요어 : 전투관리언어, 지휘 및 통제, M&S, C4I, 상호운용

1. Introduction

Recently, the battlefield environment has changed from platform-centric warfare (PCW) which focuses on maneuvering forces into network-centric warfare (NCW) which is based on the connectivity of each asset through the warfare information system as information technology increases[1]. In particular, C4I (Command, Control, Communication, Computer and Intelligence) can be an important factor in achieving NCW (Network Centric Warfare). It is generally used to provide direction across distributed forces and status feedback from those forces.

It addition, the importance of the defense modeling

and simulation (M&S) is increasing with a view to satisfying a variety of new operational requirements.

The U.S. military distributed simulation technical community has sought the interface between C4I systems and distributed simulations for many years in order to provide more valid and realistic results and to reduce the costs associated with manual interfaces between these systems. However, the Korean military has not yet considered this type of interface.

Initial attempts along these lines created custom-built linkages that bound a given C2 system to a related simulation system. Creating such interfaces proved very expensive because of the large amount of effort required to understand the two systems and ensure that the information exchanged across the interface had the same meaning in both systems[2].

While the simulation community has established general standards for simulation, studies hoping to establish standards for C2 systems and simulations interoperation have been rare except in the U.S. and within NATO. As a result, almost every simulation has a unique C2 interface.

The initial effort to interface C2 systems and simulations was Battle Management Language (BML), which uses the Multinational Interoperability Program (MIP) data standard Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM) as a system-independent community vocabulary for passing plans orders, and reports between C2 systems and simulations.

BML seeks to manage complex interactions among Service, Joint and Coalition C2 systems and simulations interoperation by providing a common means of exchanging information that can be implemented by all C2 and simulation systems[3].

This study proposes the application of BML for C4I and M&S interoperation in the Republic of Koera (ROK) forces. Part 2 provides the background while Part 3 describes the development and recent activity of BML.

Part 4 presents an architecture for BML application in ROK forces. Finally, part 5 presents the conclusions of this research.

2. Background

BML began by the U.S. Army's Simulation-to-C4I interoperation Overarching Integrated Product Team (SIMCI OIPT). Carey et al.[4] describe the overall process used to show the feasibility of defining an unambiguous language, based on manuals capturing the doctrine of the U.S. Army.

It 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 and the U.S. Joint Staff"s Universal Joint Task List. This work resulted in definition of an unambiguous Operational Order (OPORD) using the traditional "5Ws" (who-what-when-where-why) to describe military tasks[5]. A prototype for battalion operations orders demonstrating the principles of BML is developed in 2003 by this work.

The Extensible BML (XBML) project was done to build on the U.S. Army's initial work, with two main objectives that use Service Oriented Architecture (SOA) technology for information exchange among the systems's interfaces and the MIP's Command and Control Information Exchange Data Model (C2IEDM) as a basis to represent the information to be exchanged between the systems. JFCOM was particularly interested in the XBML project's potential to increase interoperation between C4I systems and simulations. The Air Operations BML (AOBML) effort was supported by JFCOM J7 to evaluate whether the concepts of BML are applicable to air forces as well as ground forces, using Theater Battle Management Control System (TBMCS) and Air Warfare Simulation (AWSIM) systems with positive results[6]. XBML also became the basis for an international experiment, driven by interest of the Exploratory Team which was formulating the proposal that led to MSG-048, as described in[7].

The progression in U.S. work on BML is the JBML, which expanded BML into the Joint arena including ground, air and maritime domains and urban warfare.

It was successfully demonstrated in May 2007. JBML achieved considerable technical progress by creating a revised Web service schema, based on lexical grammar

and designed to facilitate expansion into other military realms, which was implemented in the open source JBML Web Services as described below[8, 9]. In parallel with JBML, the U.S. Army Topographic Engineering Center (TEC) has been developing a geospatial BML (geoBML) which will bring a wealth of geospatial data to the C2 and M&S environment[8].

The necessary theoretical basis for JBML was found in the work of Hieb and Schade[10, 11], who have analyzed the information content of BML orders and status reports. They found that every order needed in the BML system can be represented by a lexical grammar[12] using a production rule of the general form[2] :

B→Verb Tasker Taskee (Affected | Action)

<task>	<tasker-who>
<taskee-who>	<affected-who>
<what>	<where>
<start-when>	<end-when>
<why>	<label>
<modifier>	

Fig. 1. Web service design primitives[2]

```
<xsd:complexType name="GroundTaskType">
<xsd:sequence>
<xsd:element name="TaskeeWho"
type="WhoType"/>
<xsd:element name="What"
type="WhatType"/>
<xsd:element name="Where"
type="WhereType"/>
<xsd:element name="StartWhen"
type="WhenType"/>
<xsd:element name="EndWhen"
type="WhenType"
minOccurs="0"/>
<xsd:element name="AffectedWho"
type="WhoType"
minOccurs="0"/>
<xsd:element name="Why"
type="WhyType"
minOccurs="0"/>
<xsd:element name="Label"
type="LabelType"/>
</xsd:sequence>
</xsd:complexType>
```

Fig. 2. Ground domain task schema fragment derived from Hieb-Schade Grammar[2]

Where Start-When (End-When)
Why Label (Mod)*

The symbols of this production rule for the grammatical phrase B are :

Verb is an action, normally a task.

Tasker is a Who, the unit which commands the task.

Taskee is a Who, the unit which executes the task.

Affected is a Who, the unit affected by the task.

Action is another action/task affected by the task.

Where is a location phrase.

When is a time phrase.

Why is a "terminal symbol" giving the purpose of the action.

Label is given to the task in order allow it to be referred in other basic expressions.

Mod is a modifier, specific to the nature of the task.

* refers to zero or more occurrences of (Mod)

( ) indicates options

Given these grammar symbols, the JBML Web service was designed based around the primitives shown in Figure 1. The grammar provides a means of expressing the semantics of BML, while the JC3IEDM provides its vocabulary.

The grammar of Hieb and Schade was used as a basis for the XML schema because it provides a structure that has been shown to be capable of expressing the full range of BML orders and also a clear way to express those orders. An example of the resulting XML schema section for the Ground domain is shown in Figure 2.

3. BML Development

3.1 JBML Phase I

Toward interoperation between C2 systems and simulations, BML concept has been developed over the past several years in a sequence of projects beginning with the original SIMCI BML proof of principle and extending through the Joint Battle Management Language JBML proof of concept, as described in[9]. The JBML Phase I demonstrated use of BML involving ground, air and maritime C2 systems (two of them operational military systems) that provided orders to two interoperating versions of the Joint Semi Automated Forces (JSAF)

simulation[13].

It was demonstrated in May, 2007 in the configuration shown in Figure 3.

The various C2 systems were able to push their orders asynchronously in preparation for simulation, following which the simulations pulled Joint orders and executed them. The entire system was demonstrated to be fully functional[9]. The Joint Task Force was tasked with a Joint Urban Operations Order that drove an Air Battle Plan, a Maritime Operations Order and a Ground Operations Order. Each of these processed into a common, extensible and vetted JBML Web service based on an XML schema. This information was then converted and used to drive two linked Joint Semi-Automated Forces simulations.

A Theater Battle Management Core System (TBMCS) was used to produce files containing an Air Battle Plan and an Airspace Control Order for both Air Force and Navy Air missions. These files were produced before the demonstration and translated into the Command and Control Data Interchange Format and used for input to the BML Web Service.

The Ground Operations Order was created by the Combined Arms Planning and Execution System (CAPES) injector component of the Command and Control Personal Computer (C2PC) developed by the US Marine Corps. This is a Windows client/server network application that displays positional tactical track data and provides a complete geographically based situational awareness capability, including the capability to display Global Command and Control System (GCCS) data.

Air Tasking Order and Airspace Control Order information were converted to a BML compliant format.

The Ground Operational Orders were exported from the CAPES/C2PC application as an XML mission file. The mission file was then read into an XML Parser application that converted the native CAPES format into BML and used the JBML Push command to store the ground forces order information within the JBML database.

The Air, Maritime, and Ground BML information was pushed into the BML Web Service which was hosted as part of a JC3IEDM compliant server. The Air Force and Maritime Air Tasking Order information was
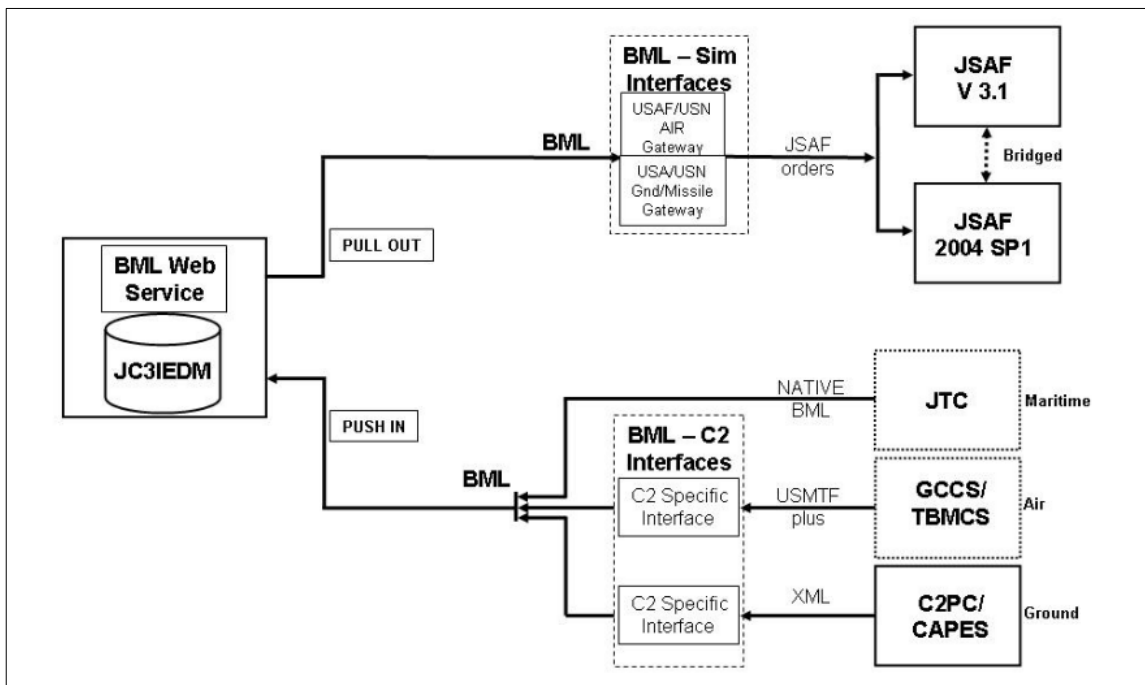

Fig. 3. System configuration for Phase 1 JBML demonstration[2]

pulled out of the BML Web Service and converted to a set of JSAF scenario files and pushed to the JSAF version 3.1. Cruise Missile Maritime Order and the Ground Operational Order information was pulled out of the BML Web Service and communicated to JSAF version 2004 SP1 by way of a customized UDP interface as Distributed Interactive Simulation (DIS) (IEEE 1278) packets.

The two JSAF systems were linked via DIS gateway applications supplied with each JSAF version. Both JSAFs displayed consistent simulation information throughout the demonstration.

It shows a major step forward in interoperation of military C2 systems and distributed simulations. It gives a general, extensible definition of orders and tasks and the JC3IEDM standard for vocabulary.

3.2 JBML Phase II

JBML achieved considerable technical progress by creating a revised Web service schema, based on lexical grammar and designed to facilitate expansion into other military realms, which was implemented in the open source JBML Web Services as described below[8, 9].

The interoperation for C2 systems and simulations is more important in coalition operations than joint operations.

Coalitions must function despite greater complexity due to significant differences among doctrine and human language barriers[14].

JBML Phase II focused on the interoperation between C2 systems and simulations in coalition operations.

This scenario is located in the Caspian Sea area and set in the 2025 time frame[3]. The region has a long unstable history in many aspects.

The fictional countries of Donovia, Minaria, Gorgas and Atropia are successor states to the Zloi Empire that collapsed in 1991. There has been a instability in some states because of ethnic tensions, economic difficulties, and weak and non-responsive governments. Traditional and emerging secular and clerical states try to control the unrest of their populaces by emphasizing external enemies and increasing the size and prestige of their militaries. Western economic interests and investments are centered on increasing the oil and gas extraction for export. The major threat to international interests is the curtailment or loss of energy exports from the region. The Ariana government, supported by Donovian rebel forces, may try to occupy and claim the (oil rich) Arzak section of Atropia.

Donovian rebels are expected to occupy the Karvi Magomed Airport to create a second front for the Atropian forces. Donovian rebel resistance is expected between the Atropicana River and the Kazi Magomed Airport.

The Commander Joint Forces Land Component Commander (CJFLCC) has decided to commit the 43rd Multi-National Brigade (43 MNB). As shown in Figure 5, it is composed of three Battalion (Bn) Task Forces (TF) to secure the Kazi Magomed Airport. The Commander 43 MNB requires the use of two of his three BN TFs to achieve this mission. He has selected 1 (USA) TF and has to decide between 2 (NLD) TF (Netherlands)

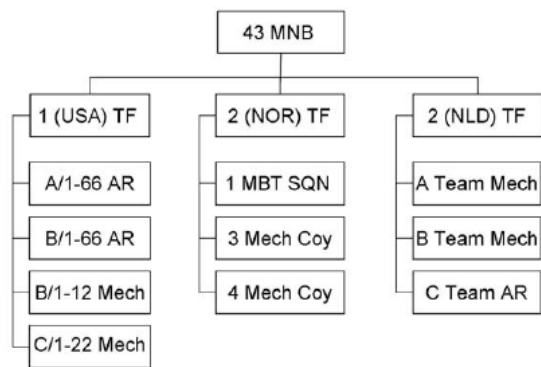**Fig. 4.** Caspian Sea Region[3]

Fig. 5. ORBAT 43 MNB[3]

and 2 (NOR) TF (Norway) for his second TF. And the commander asked both to plan for the same assignment. The outcome of the simulation based COA-analysis will support the commander's decision.

The overall plan is described as follows. On 10 August 2025, the CJFLCC orders 43 MNB to defend the Kazi Magomed Airport intact to deny the expected Donovian occupation of the airport and to deny interference by the Donovian rebels. Operation PERSEUS is planned to start at first light on 11 August. The key to success for 43 MNB is for 1 (USA) TF to seize the bridges intact and then conduct a passage of lines as the stationary force to support the onward movement of either the NLD or NOR Bn TF in order to secure the Airport. The assigned second TF will seize and defend the Airport in order to deny any Opposing Military Forces (OMF) or Donovian interference.

Figure 6 shows the elements of the demonstration : three national C2 systems, the middleware C2 Lexical Graphical User Interface (GUI) and JBML Web Services, three national simulation systems, and a JC3IEDM visualizer that was used to provide a common operating picture of the overall situation[3].

JBML Phase II provides very strong evidence in favor of the techniques employed as a basis for an SOA approach to using simulations with C2 systems[3].

First, the approach based in formal linguistics and associated Web Services, with strong semantics provided an extremely effective medium of expression for communication among the various systems[3].

Perhaps equally important, the network-centric development methodology proved highly effective, especially when employed by na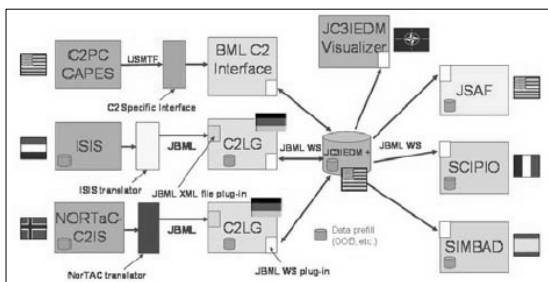tional development teams with a highly cooperative spirit, including technical developers and military subject matter experts[3].

It is only the beginning of MSG-048' development of a BML/SOA-based environment for evaluation of the potential of these techniques for coalition C2 and simulation interoperation.

3.3 Integrated BML

IBML improved over previous work by adding Reports to the previous Orders in 2008[15]. It also introduced Air C2 and simulation in addition to the Ground components previously included.

The architecture of an experiment using IBML is shown in Figure 7.

Its primary purpose was to evaluate the effectiveness of BML Reports in maintaining shared status in the C2 systems. The scenario is based on JBML Phase II.

The JBML Web Services were replaced by an improved design, the Scripted BML Web Service[5], as shown in Figure 8.
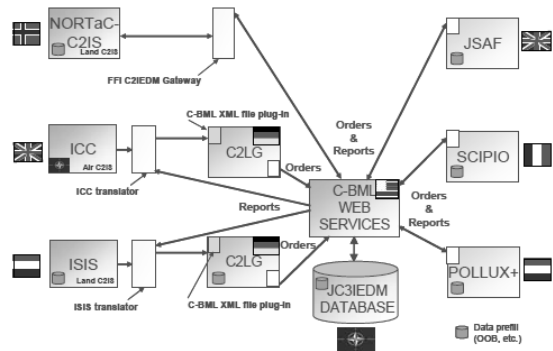
Whereas the JBML Web Services were coded in the

Fig. 7. IBML initial architecture[15]

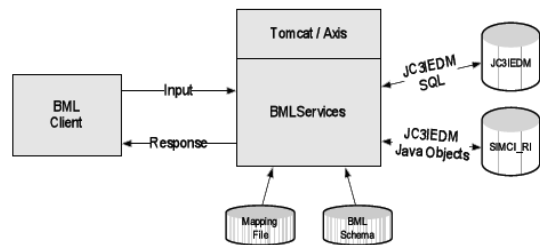**Fig. 6.** System Architecture[3]

Fig. 8. Scripted BML Web Service[15]

Java language based on IDEF1x diagrams that define the mapping process, the IBML Web Services provide a scripting environment where the mapping information is coded in machine-readable XML files.

The Scripted Web Services subsequently were used by the NATO MSG-048 Technical Activity in a particularly compelling demonstration, where three national C2 systems connected with three national simulation systems, with both Orders and Reports exchanged via BML as shown in Figure 8 and described in[16].

In principle, the C2LG that is the basic grammar of BML differentiates between three types of reports : task reports, event reports and status reports[15].

In task reports, the sender reports about an ongoing military action, e.g., the attack of a hostile force against his position.

In event reports, the sender reports about an event, an action that does not have an active animate entity that voluntary had initiated the action, like a flood, or an action of which this initiating entity is unknown to the sender.

In status reports, the sender conveys status information or information about a position. Besides position reports, there are different kind of status reports: e.g., reports about the operational status of a unit, reports about the status of an ongoing task (e.g., started, completed to 40% or completed), reports about personnel status (two soldiers wounded), and reports about materiel status (three BMP immobilized).

The grammar of position reports is described below.

(1) RB→Hostility position Who Where When Certainty Label

In (1) "RB" means basic report. In a basic report exactly one fact is reported. In principle, a sender can combine multiple basic reports under one header in order to send this complex report to the addressee as one package.

"Hostility" indicates whether this basic position report is about the position of the sender (Hostility = own), about the position of an allied unit (friend), of an enemy unit (hostile) or of some others (neutral, suspect, …).

"position" is a key word. It indicates that the basic report in question is about position.

"Who" denotes whose position is reported.

"Where" denotes the position itself, e.g., by coordinates.

"When" denotes the point of time when the position was valid (that may differ from the point in time the report is sent).

"Certainty" is about the likelihood that the report is true. Its values are fact, plausible, uncertain, and indeterminate.

"Label" is a unique identifier by which this basic report can be referred to.

An example basic position report is given in (2) in which the second company reports that they are at control point 3 (at CP3) at the time the report is sent (at now).

(2) Status-Report : own position Coy2 at CP3 at now fact label-rp-289;

In the demonstration, position reports have been sent from simulated units to the C2 systems in order to update their own position. Besides, whenever a simulated unit spotted an enemy unit (according to the reconnaissance automatons programmed into the simulation) it sent a position report of spotted enemy unit.

The grammatical representation of reports about the operational status is quite similar to position reports.

Significant developments include a geospatial BML (geoBML)[17] sponsored by TEC. GeoBML schema and services are being combined with the IBML work, also sponsored by TEC.

The goals of IBML are (1) to integrate the JBML and geoBML schemas and Web services, (2) to include support for Situational Awareness (SA) reports, and (3) to ensure that the resulting schema and Webs services are extensible and consistent with the C2LG grammar[13].

The Army BML Architecture and MSG-048 projects are planning to use the Scripted BML Web Services produced by the SIMCI-JCP[18]. As a result, future changes and enhancement to BML Web Services will require only changes to the schema and the associated XML script.

This will expedite the development process and also will simplify validation of the service design.

4. Application for BML in ROK Forces

The efforts to achieve interoperation between C2

systems and simulations in U.S. have shown that BML can potentially be applied in any system. It is also being expanded continuously, adding nations to the MIP. Thus, this section intends to propose the application of BML in ROK forces. The Korean forces have many kinds of C4I systems and simulations in operation as shown in Table 1.

However, interoperation between C4I systems and simulation has not been considered in the Korea forces as these have been developed separately. There is no standard way to create interoperation between the C2 systems and simulations. The Korean forces focus on the interoperation based on the High Level Architecture-Run Time Infrastructure (HLA-RTI) in simulations. In other words, individual systems have been interconnected. BML will have the following advantages in the improvement of this system.

1) It shares semantics between C2 systems and simulations via a common tasking and report description.
2) It enables simulation in C2 for operations.
3) It provides more realistic training using operational C2 systems.
4) It reduces the cost of training by reducing the support staff needed.

BML projects have been moving toward a standardized BML(Army BML, JBML, etc.). Hundreds of experts are being involved in this projects.

Although BML does not provide a unique solution for interoperation or the efficiency of operations, it is a reasonable method. The commander can give the proper orders, using the 5W's (Who, What, When, Where and Why) format in BML. Though it is simple, this will be a perfect order that contains the necessary information.

Therefore, it is considered that BML will be useful in military operations as well as for interoperation in the Korean forces.

The general procedure of applying BML in the Korean forces is as follows.
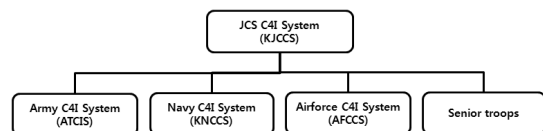
1) The efficiency of applying BML in the Korean forces must be examined. Is it worth considering in the aspects of operations, technology, and so on? According to the major expert in the U.S., applying BML in the Korean forces will not be difficult as the basic concepts and technology have already been determined. Therefore, all that needs to be established in a given system is BML interface.

2) The method of BML application must be considered in detail. Is it better to adopt a method without modifications than to develop a method independently since BML has been developing continuously in the U.S.? Which method can be used easily for the Korean forces? The major concerns here may be technical.

3) BML extensions have to be examined. Once one of the systems has been implemented, its extension will be achieved easily. This work is also being carried out steadily in the U.S.

The current report explains the application of BML in the Korea Joint Command Control System (KJCCS). Its operational concept is illustrated in Figure 9.

It is a joint level C4I system that can connect and exchange information between each military C4I system

Table 1. C4I and simulation systems in the Korean forces

		Contents
C4I	JCS	KJCCS, AKJCCS, JFOS-K
	Army	ATCIS
	Navy	KNCCS
	Air force	AFCCS
Simulation	JCS	JICM, JTLS···
	Army	Changjo-21, CALAPER···
	Navy	Cheonghae, RESA···
	Air force	Changgong, Thunder···

Fig. 9. Operational Concept of KJCCS
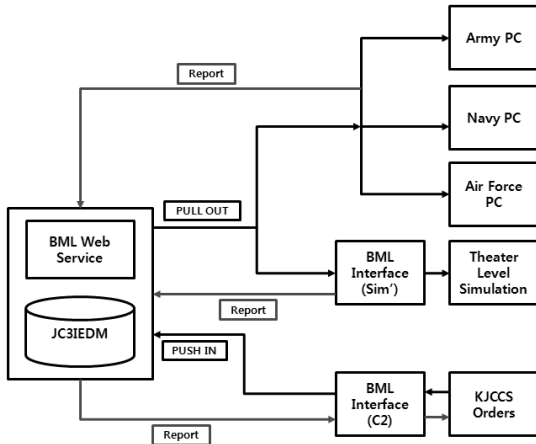
Fig. 10. Architecture of BML Application in KJCCS

Table 2. Milestone for BML application in Korea forces

	Contents
Step 1	Preliminary study about BML
Step 2	System selection and application
Step 3	BML Extension

This section gives a concrete example of BML application in the Korean forces. Although the KJCCS is chosen in this study, the system can be changed according to different factors (cost, complexity and so on).

Finally, it demonstrates a milestone for BML application in the Korean forces as shown in Table 2. The proper standards for interoperation between C2 systems and simulations have not yet been considered in the Korean forces. In addition, studies to define what this should look like are lacking. However, it will be possible to apply BML in the Korean forces if the problem discussed here is confirmed through the preliminary research.

BML is now continuously being extended to apply to a coalition environment in the U.S.

It is thought that applying BML to the Korean forces will contribute to the efficiency of operations as well as to the interoperation between C2 systems and simulations.

and the KJCCS. Furthermore, it deals with operational situations among the army, navy, air force and major senior troops. In this paper, the KJCCS will be considered and used to show an example of BML in the Korean forces since all of the systems cannot be applied at the same time.

The architecture for applying BML to the KJCCS is shown in Figure 10.

By establishing BML in the KJCCS, the intent of commander, in the form of orders, can be conveyed in the 5W format to each military department as well as the theater-level simulation. Each military department needs to report the status and results of tasks that are composed of orders.

It is not difficult to apply BML in the KJCCS since a BML Web service and the JC3IEDM have already been established in the U.S. Therefore, all that is required is a suitable interface in C2 systems and simulations whereby the BML Web service can be accessed. This means that the JC3IEDM, which involves the semantics and syntax based on C2LG, needs to be considered. The complexity of interface will be different for each system. This is a technical problem and should be considered in detail with experts at some point. It is uncertain whether this part can be solved easily or not. BML is meaningful in that it can allow the interoperation among systems to become more important in the Korean forces.

5. Conclusions

In the U.S., BML is considered to be a powerful, general approach to interoperation in a coalition of C2 systems and simulations. Thus, it is being developed steadily from JBML to Integrated BML. This has many advantages in operations and the interoperation between systems.

For example, it provides situational awareness and a shared, common operational picture.

However, the Korean forces have not yet considered the interoperation of C2 systems and simulations in detail. The BML solution is thought to be meaningful although, due to technical considerations, it is not certain whether it can be applied to the Korean forces. According to experts in this subject, this will not be a critical problem since the basic infrastructure for BML exists.

This study proposes a general BML application method and shows the example of its application to the KJCCS. It provides an architecture and a milestone for BML application in the Korean forces. The extent of the systems will be considered after the preliminary study and system selection is completed.

Establishing BML in the Korean forces will not be difficult work if the proper systems are chosen and a BML interface is created. The technical problems will be studied in detail in future research.

If BML is applied to the Korean forces, it is thought that it will be useful for operations and the interoperation. This has already been shown in case of U.S. operations, including those of NATO.

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