BML Enabled Information Exchange Framework in SES Ontology for C2

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Abstract—**This paper explores the Information Exchange Framework (IEF) concept of distributed data fusion sensor networks in Network-centric environment. It is used to build up integrative battlefield pictures through the Battle Management Language (BML) and System Entity Structure (SES) ontology for C2 systems. The C2 process requires multi-level information to assess the current situation in a sound manner. Superiority of information is critical factor to win battles. The SES is an ontology framework that can facilitate information exchange in a network environment. From the perspective of the SES framework, BML serves to express pragmatic frames, since it can specify the information desired by a consumer in an unambiguous way. We explain the idea of information exchange in the SES ontology via BML and demonstrate pruning and transformation processes of SES with proof-of-concept examples.**

Keywords-component; SES; Ontology; Information Exchange Framework; BML; Pragmatic Frame; Data Fusion

I. INTRODUCTION

Networking, including Web services, offers opportunities as well as challenges for Network-centric Warfare (NCW). Although it supports increased data availability, it requires a new paradigm for operation in a network-centric environment. In this paper we seek a new approach to exchange data in a distributed sensor network based on Service Oriented Architecture (SOA) [1] concepts. The System Entity Structure (SES) Ontology organizes information in a hierarchical manner [2]. It gives a way to exchange data messages by tailoring their structure according to requirements specified in a pragmatic frame. This pruning process reduces communication traffic since pruning minimizes the information volume. Reference [3] investigated the SES pruning process in network traffic analysis.

Battle Management Language (BML) is being developed to increase interoperability between real C2 systems and simulated troop operations [4][5][6][7]. The main objective of BML is to fill in the gap between human language, more specifically used by military people, and machine understandable language through defining an intermediate language which can be understood by both sides. BML is a well formalized language and part of the multinational operational language called Coalition BML. Some efforts to apply BML are discussed in [9][10]. BML is capable of expressing the user's requirements in an explicit way. Because of this it can be exploited as a tool for pragmatics.

This paper explains the idea of using BML as a pruning enabler and how to obtain information from information sources using the pruning process in the SES context. First this paper introduces the advantages of networking and integrating all sensors for C2. The SES ontology is reviewed in the following section. Then we explain the proposed distributed multi-sensor network architecture based on a SOA approach. Next we propose a new Information Exchange Framework (IEF) obtained by using BML and SES in a data fusion network. Finally, we discuss future works and conclusions.

II. C2 AND MULTI- SENSOR NETWORK

Commanders need to have the right information about the environment to take appropriate action. From this perspective, gathering valuable information from all the available data is a critical process for C2 that may be achieved by networking all of the available sensors and fusing their information. The sensor networks are able to cover broader areas with more precise resolution.

A Data Fusion (DF) system is a system to combine data from multiple sensors in order to improve interpretation of these data [10]. Several models such as Joint Directors of Laboratories (JDL), Waterfall, and Omnibus have been proposed. JDL is a well-known DF processing model for application to military domains. It defines several functional levels from 0 to 4. Level 0 is a pre-processing step on the sensor level. Level 1, Objective Refinement, concerns refining the representation of individual objects. Level 2, Situation Refinement, describes the current relationships among objects and events. Level 3, Threat Refinement, projects the current situation into the future to support choice among alternative courses of action. Level 4, Processing Refinement, concerns monitoring and controlling other processes [11].

The architecture of a DF system is divided into two categories. Multi-sensor Data Fusion (MSDF) and Distributed Sensor Network (DSN) [11]. The first presumes there is a MDSF fusion center which collects raw data or tracks and fuses them in a central manner. Another approach assumes there is a network composed of multiple sensor nodes. Each node can communicate with others and acts as a fusion center.

So they maintain their own track data and send the data to others via communication channels. The concern of this paper is for DSN architectures with the objective of improving level 1, 2, and 3 process performances.

III. SYSTEM ENTITY STRUCTURE ONTOLOGY

A. System Entity Structure (SES)

Ontology is a study concerned with the nature of existence of things and their relationships [2][12]. It contains classes (elements), attributes of the classes, and relationships between classes with which to represent or model knowledge of a certain domain. System Entity Structure (SES) is an ontological framework to represent the elements of a system (or world) and their relationships in hierarchical manner [2]. It provides a model to describe knowledge of a domain in the structural way. Figure 1 shows the basic representation elements of the SES.

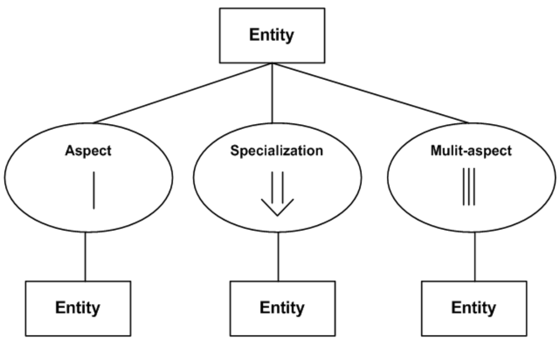

Figure 1. Basic SES representation

Entities represent things that have existence in a certain domain. Aspects represent ways of taking things apart into more detailed ones. Multi-aspects are aspects for which the components are all of the same kind. Specialization categorizes things in specific forms that it can assume. Entities can have variables which can be assigned a value within given range [2].

B. Information Exchange Framework in SES ontology

We have an interest in the Information Exchange Framework (IEF) [2] in both static and dynamic situations. Especially, we emphasize the roles of users or information consumers in information exchange scheme, called pragmatic frame, and how it works in a real DF system.

First, we describe the procedure of information exchange in a general way. A producer generates and provides the information. A user or consumer needs some information and requests the information, which may cause alteration of the ontology. In SES concept, a producer designs a master SES ontology which represents the available information of a domain, and a consumer wants to know specific information which is contained or implied in the master SES structure. This requirement, formalized as a pragmatic frame, can lead to some processing on the SES that results in a sub-SES which is tuned to the consumer's requirements [2].

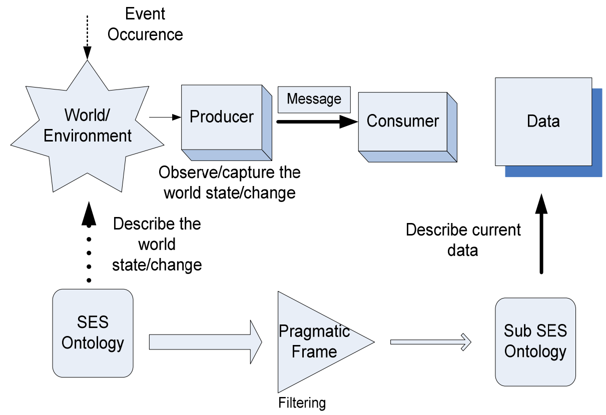

Figure 2. Information Exchange Framework (IEF)

The SES operations causing structural change to extract specific information are pruning, restructuring, and transforming [2]. Pruning is an operation to cut off unnecessary structure in a SES based on the specification of a pragmatic frame. More specifically, it includes processes a) to assign particular values to variables of entities, b) to trim the SES and get the minimal SES for end-users by picking specific elements from multiple choices. Restructuring is a mapping process within the same domain and may result in the alternative structures. Transforming is also mapping process, but from one domain to another domain. This paper primarily focuses on pruning.

C. SES on the Implementation Level

The SES Builder is a tool to design a SES ontology from natural language input [12]. The natural language for RadarSES is shown in Figure 3.

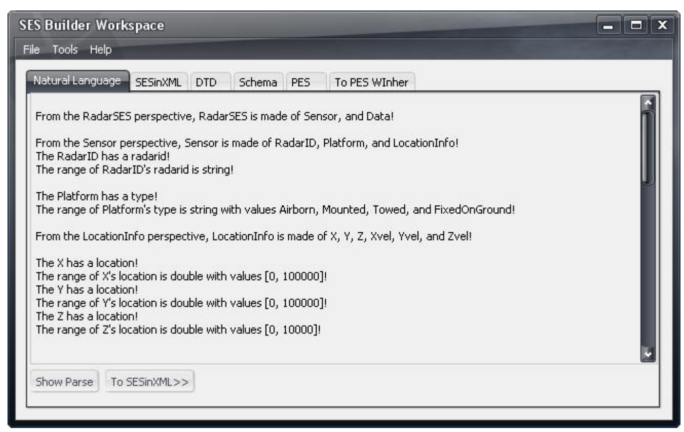

Figure 3. Natural language description in SES Builder

Subsequently, the designed SES can be displayed in tree structure diagram such as Figure 4.

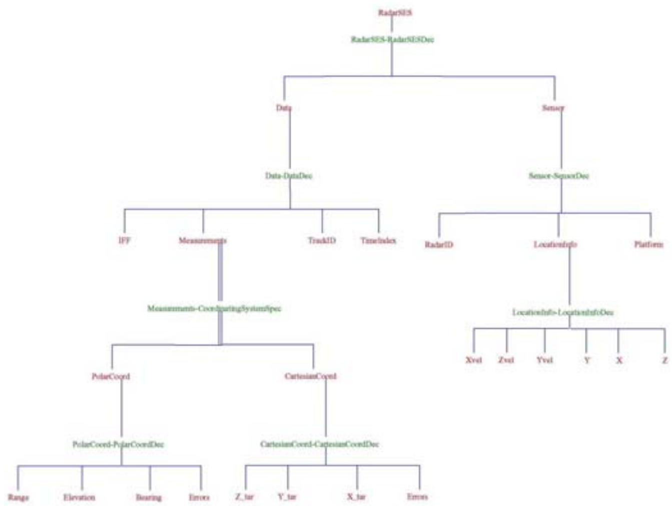

Figure 4. SES tree representation of Radar data

A SES is represented in XML format. XML is an appropriate markup language for SES representation since it can easily add user-defined tags which can describe them without any restriction [14]. It is natural to represent hierarchical structure as well.

A set-theoretic specification of SES structure is suggested in Figure 5 (See [2] for details).

$$
\begin{aligned}
&SES =< Entities, Aspects,\\
&Specializations, rootEntity,\\
&entityHasAspect, entityHasMultiAspect,\\
&entityHasSpecilization, aspectHasEntity,\\
&MultiAspectHasEntity, specializationHasEntity,\\
&entityHasVariable, MutiAspectHasVaraible,\\
&VariableHasRange >
\end{aligned}
$$

Figure 5. SES structure components

The pruning process reduces selections of *entityHasAspect*, *specializationHasEntity*, *MultiAspectHasEntity* relations above. After completing pruning, there should be no choice left in the above relations. Moreover, at the implementation level, a pragmatic frame is able to choose anything in the ontology. For example, an information client might request to be continually updated on a one entity variable value like the current time. Then that pragmatic frame results in a simple sub SES structure with one end-entity.

IV. SERVICE-ORIENTED DISTRIBUTED DATA FUSION SYSTEM IN MULTI-SENSOR NETWORK

A. *Service Oriented Architecture (SOA) and multiple sensor network*

Service Oriented Architecture (SOA) is a methodology with which a new application is created through integrating existing and independent processes which are distributed over networks [1]. SOA considers a message as an important unit of communication so can be regarded as "message-oriented" services. One of the implementations of the SOA concept is web services which is a middleware system for communicating between a client and a server over a network with XML messages called Simple Object Access Protocol (SOAP) [15]. Web services architecture [16] is based on exchanging messages, describing web services, and publishing and discovering web service descriptions. Web services are described by Web Services Description Language (WSDL) [17] which is XML-based language providing the required information, such as message types, signatures of services, and a location of services, for clients to consume the services. Publishing and discovering web service descriptions are managed by Universal Description Discover and Integration (UDDI) [18] which is a platform-independent and XML style registry.

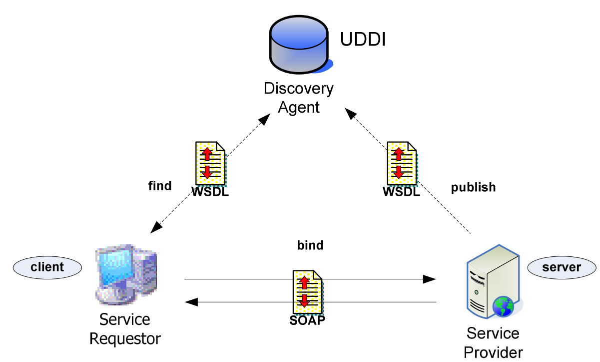

Figure 6. Generic Web Service architecture

The Net-centric Warfare (NCW) concept seeks to connect all possible resources and forces for more competitive and efficient war-fighting advantages. All nodes of the network can communicate with each other and have certain functions that can affect other nodes. Each sensor can be a fusion center and play as a node of network, which means it has a fusion function like tracking of targets and transfer the local tracks to other nodes, which, in turn, has its local tracks and can carry out a fusion function like track-to-track correlation to form shared common pictures of battlefield for C2.

The design concept of the data exchange architecture in the distributed multi-sensor network we propose here is based on web service concept. Each distributed fusion center covers a part of battle field and maintains the local air-pictures by communicating with other fusion nodes. The center provides services relating to the battle area pictures to users in a manner akin to that of web service producers. If the node is not available for the request then it returns information of an available fusion center to the requester according to register profile which contains others' information availability just as the discovery agent in web services does. Therefore, a local fusion center is not only a service provider but it is also a service broker.

The dynamic situation is understandably more complex than the static case. When a consumer or a provider changes its spatial position with respect to time, the information availability of the provider gets different state so that each fusion center has to update its register profile with other fusion centers' reports on a regular basis. In fact, web service concept is more efficient and powerful in dynamic situations since we are easily able to add or remove services.

Another advantage of this service-oriented architecture is that it can improve a higher level of data fusion process such as level 2 or level 3 along with ontological description of the information. Levels 2 and level 3 are more related to information of user's circumstances. A threat can be critical to a location of some units, but not to others. The SES information exchange framework is another enabler to achieving high level fusions.

V. SES Information Exchange Framework via BML

A. *Battle Management Language (BML)*

BML is *an unambiguous language used to command and control forces and equipment conducting military operations and to provide for situational awareness and shared, common operational pictures* [5][6][7][8]. It bridges between real C2 systems and simulated forces and perhaps, robotic forces in the future. BML is dedicated to express commanders' intents, request, and command in formal grammar and enhance the interoperability between real and simulated systems. It developed based on Command and Control Information Exchange Data Model (C2IEDM) and it is intended for Joint operations called Coalition BML (C-BML) under Simulation Interoperability Standards Organization (SISO) as an effort to develop a standard.

B. *The grammar of BML*

BML grammar arises from 5Ws (WHO, WHAT, WHERE, WHEN, and WHY) concept. The capability and limitation of 5Ws as a BML grammar is evaluated in [5]. The advanced step to a formal grammar is presented in [5][6][7][8]. BML can be applied to various types of military communications. Orders, requests and reports are supported in the BML grammar.

Orders and requests have identical syntax, But the relation between taskers and taskees in hierarchical rank of military make them different. In an order, the tasker with commanding authority mandates the task to the taskees, while the taskees are in the position of taking an order from the tasker in a request. The ordering and request syntax is shown in the followings:

$$\text{OrderingParagraph} \rightarrow \text{CI OB* C\_Sp* C\_T*}$$

where CI is command intent, OB means ordering basic expressions for tasks, C_Sp means spatial coordination expressions, and C_T means temporal coordination expressions. The asterisk means there are arbitrarily many expressions for these parts.

The general rules for OB is given like;

- OB → Verb Tasker Taskee (Affected | Action) Where Start-When (End-When) Why Label (Mod)*

Additionally BML allows us to generate several types of reports such as task reports, event reports, status reports and position reports. Task reports are related with military activities. Event reports, the other hand, include non-military activities beyond the task reports. Status reports pertain to current situations of own, allied, and enemy troops. The basic syntax for reports is given by

$$\text{Report} \rightarrow \text{RB*}$$

where RB means reporting basic expressions.

The general rules for RB is

- RB → ***task-report*** Verb Executer (Affected | Action) Where When (Why) Certainty Label (Mod)*
- RB → ***event-report*** EVerb (Affected | Action) Where When Certainly Label (Mod)*
- RB→ ***status-report*** Hostility Regarding (Identification Status-value) Where When Certainty Label (Mod)*

In the paper, we place our attention on the request and status reports because the information exchange processes are not for tasking. It is process of ask and answer simply. It is also about shared common snapshot of a concerned area.

C. *Pruning and Transformations process in SES ontology via modified BML for information Exchange*

The commanders use BML to express their intent and orders [6], which are executed according to intended semantics by machines. As we indicated before, the SES ontology includes pruning by pragmatic frames which specify information a consumer's intent or request. In the military domain consumers' requests can be represented by BML so that BML drives the message exchange processes between C4I systems and simulated systems.

1) *High level information and pragmatic frame*

The information that a commander requests includes not only simple object information (Level 1) but also higher level derivations (Level 2 and Level 3). The more refined information is closely related to the relations between users and targets. Such relations are defined by features such as relative distance, targets velocity, and targets moving direction. For the higher level information, users have to give their own information as well as specific requirements: user locations and the level of information that they expect from the information service providers. More generally, the user roles in DF process has been so deeply considered that a Level 5 called User Refinement is suggested in [19].

Situation Awareness (SA) is a study to recognize the relations between entities and the situations of circumstances based on the relations. It is, therefore, a study about Level 2 and for Level 3. SA based ontology has been explored in [20]. The authors define relations and situation ontology. Then they recognize specific relations between entities, which relations, in turn, describe current situation according to pre-defined rules of the relations. This paper follows a similar logical inference but in SES ontology. The Figure 7 and Figure 8 show a UserTargetRelation-SES and a Threat-SES for SA.

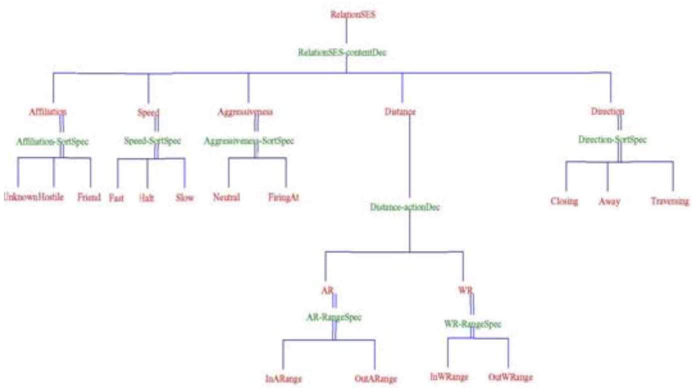

Figure 7. UserTargetRelation-SES

Figure 8. Threat-SES

2) Revision of BML paragraph

The current BML grammar for request is not suitable for our intention. Verb part of OB takes a role of WHAT in 5Ws. However, it needs to be more specific so as to describe what taskees have to report back. The following is revised version of request.

- OB → ***request*** Contents Tasker Taskee (Affected | Action) Interest-Where (Tasker-Where) Start-When (End-When) (Interval-When) Why Label (Mod)*

where "***request***" is a reserved word for a type of request. "Contents" contains the contents of report. For example, "Contents" can be one the followings for each level of information of air objects.

- AirTargetsInfo: Level 1 info
- AirSituation: Level 2 info
- AirThreat: Level 3 info

Since "Where" describes only "Interest-Where" in original BML grammar paragraphs we insert "Tasker-Where" for Level 2, Level 3 request. Another additional part is "Interval-When" which tells update time for the next information. Updated information could share some amount of information with previous one in many cases. Therefore, we can update only new or changed parts of the information to relieve the communication traffic in a real system implementation. We suggest an extended BML-SES which contains all the components of BML paragraphs in Figure 9.

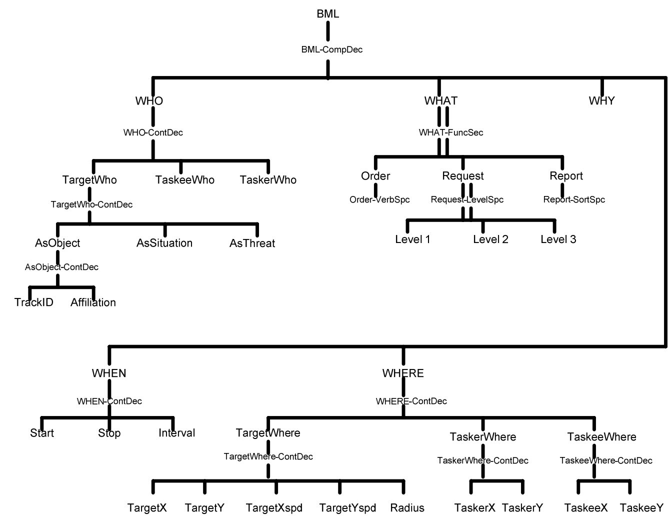

Figure 9. Extended SES for BML

A modification of report grammar is also necessary because we need to accommodate high level information in the paragraph.

- RB→ ***status-report*** Hostility (Relations/Situation) (Threat) Regarding (Identification Status-value) Where When Certainty Label (Mod)*

An XML Schema holds structural information for XML documents [21]. The SES ontology is represented in XML format and instantiated as XML documents. Therefore, an XML Schema reflects a SES structure.

3) Mapping process

Mapping processes from BML paragraphs to the Schema of the master-SES are invoked when commander or C2 systems places requests. We think of this mapping process as a pruning process in SES. BML paragraph contains the choices for SES entities, which means it determines which entities have to be chosen or not. After the pruning or mapping step a Schema instance of a sub-SES is generated and it is sent to the local fusion center (service provider) with user information. As requests of the type come in to the center, it performs SES transformation from the BML-SES in Figure 9 to the Radar-SES in Figure 4. Radar-SES describes the data of sensor systems. The transformation is another mapping process causing a pruning process in Radar-SES. The mapping relation of each entity of the two ontological representations is defined by using similar or same label names. A pruned Radar-SES is used as a reference to extract data from data base. The next step diverges by the requested information level. For the Level 1 inverse transformation occurs from Radar-SES to BML-SES and assigns the data to the entity variables of the sub-SES structure of BML-SES XML Schema. Then the XML Schema and combined data are converted to an XML document which is returned to the requesting C2 system. On the other hand, for the more refined information another pruning process of the Relation-SES are invoked by extracted features of data. The sub-SES of UserTargetRelation-SES, in turn, invokes pruning process of Threat-SES in accordance with pre-defined rules. For example, "Threat" can be driven by a collection of relations as follows:

- If a target is { [fast (or) slow] (and) [closing] (and) [Firing (or) Neutral] (and) [Hostile] (and) [In ActionRange] (and) [In WarningRange] } then the target can be a {Threat} in the near future.

The pruned relations or threat are attached under "AsSituation", or "AsThreat" entities of the pruned BML-SES. The Schema then is converted to an XML document and sent back to the commander. In both cases, they become a report BML paragraph, which are displayed on the screen. The whole information exchange architecture is shown in Figure 10.

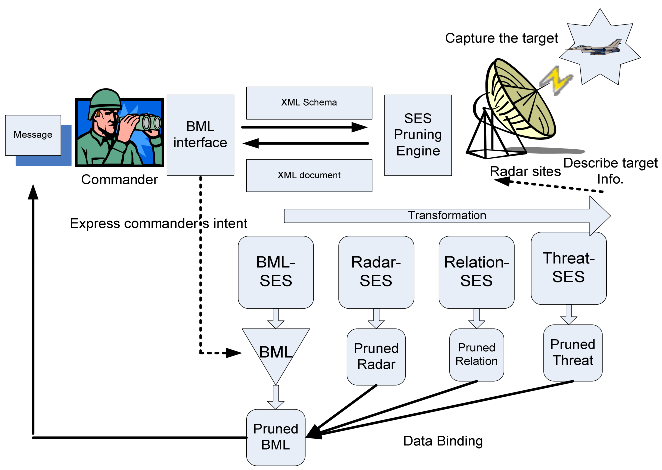

Figure 10. SES IEF via BML

D. Example 1

The commander of 01 battalion wants to receive continually updated basic information of air-targets concerning dangerous flying objects in the neighborhood of a point (Xp,Yp) in Cartesian coordinate system with radius of 4 miles, to understand current air space situation. He issues a request type to 001 radar site (fusion center) by formulating the BML request as follows:

request AirTargetsInfo 01Bat 001FC

at Xp, Yp with radius of 4 start at now label-r-001

"AirTargetInfo" invokes Level 1 process in sensor networks. If there is no interval indication the report is going to be updated in accordance with the sensor's updating interval. The pruned BML-SES is shown in Figure 11. Xp and Yp represent the location of interest in Cartesian coordinate system.

Accordingly, it produces a Schema that goes to the 001 radar site. The fusion center performs the specified transformation and pruning function based on the received Schema. The "TargetWho" and "TargetWhere" are related to the following entities of Radar-SES.

- TrackID / IFF/ X_tar/ Y_tar

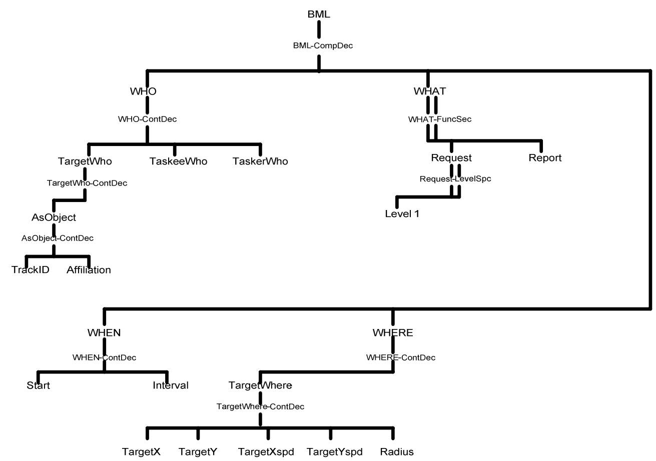

Figure 11. Pruned BML-SES for Level 1 information

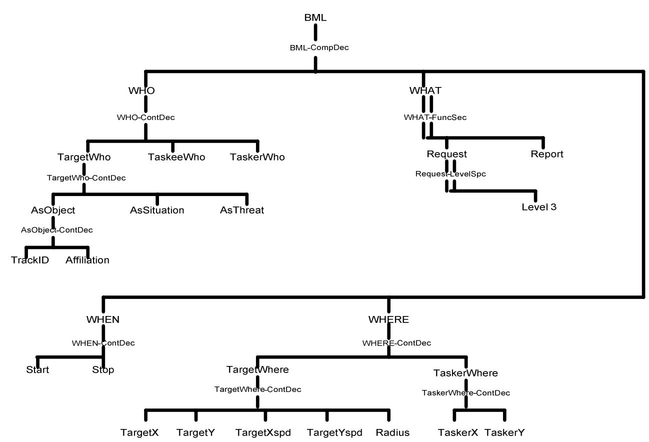

Figure 12. Pruned BML-SES for Level 3 information

At every update time, the Schema is bound with data and converted to an XML instance as illustrated in Figure 10. This instance comes back to the commander as a text message of BML report or tracks on the Track Display Screen.

- ***status-report*** one hostile interceptor

  at 30, 30 at now fact label-sr-001

E. Example 2

The same commander now wants to recognize threatening targets in the same area. He wants to determine whether or not he needs to turn the unit to yellow alert in accordance with the received threat analysis results. He puts a request using BML request as follows:

- ***request*** AirThreat 01Bat 001FC

  at Xp, Yp with radius of 4 at Uxp, Uyp

  start at now label-r-002

- "AirThreat" requests Level 3 information to sensor networks. Uxp, Uyp are, on the other hand, user location in Cartesian coordinate system. A pruned BML-SES is shown in Figure 12.

Based on relative distance between commander and targets, targets speed, targets heading, targets affiliation, and other event report about those targets we can infer the following relations from Relation-SES:

- A target is hostile, slow, neutral, away, out of warning range, out of action range from the commander.

A set of relations draws the following conclusion:

- The target is cautious.

It comes back to C2 system as a report:

- ***status-report*** one hostile cautious inteceptor

  at 32, 32 at now fact label-sr-002

Therefore, the commander could give an early notice of caution against the target. It will be not a warning.

VI. FUTURE WORKS

This work is the first step to explore the capability of a BML-driven Information Exchange Framework in SES. Therefore several follow-on studies remain. For one study, since our approach is an extension of existing BML, we need to investigate the proposed request system's compatibility with existing BML. Second, our examples show how we build up air-battlefield situation. Therefore, generalization to fabricate the whole battlefield picture should be considered. Third, a study of more interoperability issues with other message formats such as Cursor on Target (CoT) which is an XML-based message format for communication between inter-DoD enterprises currently employed by the USAF. This study will be beneficial because the CoT is dedicated to facilitate message exchange between heterogeneous systems. Finally, we need to consider the relation of our study in the Web Service SOA concept. Many information service applications such as Network Centric Enterprise Services (NCES) in the Global Information Grid (GIG) need request and answer interfaces which mediate bilateral conversations between humans and machines. The BML based information exchange framework on the SES ontology can meet this requirement in an efficient way.

VII. CONCLUSIONS

In this paper, we introduce an efficient way to exchange information based on SES ontology and BML in distributed data fusion networks. SES ontology expresses the information of a domain in a rigorous structural manner. It also facilitates message exchange in a network-centric environment. Message interchange is driven by pragmatic frames which formalize the types of requests that commanders wish to issue for information updates. BML is a communication language in the military realm, which states tasks in the clear way. Consequently, we can use BML as an interface for expressing pragmatic frames. The previous two examples show how BML enables efficient exchange of information based on the SES ontology implemented in XML.

REFERENCES

[1] Service-Oriented Architecture (SOA), [Online]. Available: http://www.sun.com/products/soa/index.jsp. [Accessed: Oct. 22, 2008]

[2] Zeigler, B.P. and Hammonds, P.E., Modeling & Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange, 1st ed, Academic Press, 2007.

[3] Taekyu Kim, Chungman Seo, Bernard P. Zeigler, "Web Based Distributed SES/NZER Using Service Oriented Architecture," SIMULATION, submitted.

[4] Simulation Interoperability Standards Orgainzation (SISO), Coalition Battle Management Language (CBML), [Online]. Available: http://www.sisostds.org/index.php?tg=articles&idx=More&article=439 &topics=102. [Accessed: Jan. 10, 2009],

[5] Schade, U. and Hieb, M.R., "Formalizing Battle Management Language: A Grammar for Specifying Orders," 06S-SIW-068, in Spring Simulation Interoperability Workshop, April 2006.

[6] Hieb, M.R. and Schade, U., "Formalizing Command Intent Through Development of a Command and Control Grammar." in 12th ICCRTS. Newport, Rhode Island, June 2007.

[7] Ms. Kellyn Kruger, Mr. Miłosław Frey and Dr. Ulrich Schade, "Battle Management Language: Military Communication with Simulated Forces," RTO-MP-MSG-056, in NATO RTO Modelling and Simulation Group Conference, [Online]. Available: ftp://ftp.rta.nato.int/PubFullText/RTO/MP/RTO-MP-MSG-056/MP-MSG-056-05.pdf. [Accessed: Oct. 12, 2008]

[8] Schade, U. & Hieb, M.R., "Battle Management Language: A Grammar for Specifying Reports". 2007 Spring SIW. Norfolk, VA., March 2007.

[9] Hügelmeyer, P., Schade, U. and Zöller, T., "Application of BML to inter-agent communication in the ITSimBw simulation environment." in Proceedings of the 2007 Winter Simulation Conference, Washington, DC, December 2007.

[10] Ulrich Schade, Joachim Biermann, Miłosław Frey, Kellyn Kruger, "From Battle Management Language (BML) to Automatic Information Fusion," in Information Fusion and Geographic Information Systems, Springer, 2007.

[11] E. Shahbazian, "Introduction to DF: Models and Processes, Architectures, Techniques and Applications," in Multisensor Fusion, Kluwer Academic Pulishers, 2000, pp. 71-97.

[12] Merriam-Webster Online Dictionary, Ontology, [Online]. Available: http://www.merriam-webster.com/dictionary/ontology. [Accessed: Jan. 4, 2009].

[13] RTSync, SESBuilder, [Online]. Available: http://www.sesbuilder.com. [Accessed: Oct. 4, 2008]

[14] World Wide Web Consortium (W3C), eXtensible Markup Language (XML), [Online]. Available: http://www.w3.org/ XML. [Accessed Oct. 4, 2008]

[15] World Wide Web Consortium (W3C), Simple Object Access Protocol (SOAP), [Online]. Avaiblable: http://www.w3.org/ TR/soap. [Accessed: Oct. 4, 2008]

[16] World Wide Web Consortium (W3C), Web Service Architecture, [Online]. Available: http://www.w3.org/TR/ws-arch/ [Accessed: Oct. 4, 2008]

[17] World Wide Web Consortium (W3C), Web Services Description Language (WSDL), [Online]. Available: http://www.w3.org/TR/wsdl/ [Accessed: Oct. 5, 2008]

[18] Universal Description, Discovery and Integration (UDDI), [Online]. Availble: http://uddi.xml.org/ [Accessed: Oct. 5, 2008]

[19] Blasch, E. "Situation, Impact, and User Refinement" in Proceedings of SPIE conference on Siganl Processing, Sensor Fusion, and Target Recognition XII, Orlando, FL,, April 2003

[20] Christopher J. M., Kenneth B., Mieczyslaw M. K., "Derivation of ontological methods in a situation awaremenss scenario." In Proceedings of SPIE conference on Multi-sensor, Multi-source Information Fusion, Orlando, FLl, April 2003.

[21] World Wide Web Consortium (W3C), XML Schema, [Online]. Available: http://www.w3.org/XML/Schema. [Accessed: Nov. 21, 2008]