Proceedings of the 2011 Winter Simulation Conference
S. Jain, R.R. Creasey, J. Himmelspach, K.P. White, and M. Fu, eds.

TRANSITIONING TO THE NEXT GENERATION (NEXTGEN) DEFENSE TRAINING ENVIRONMENT (DTE)

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ABSTRACT

Department of Defense (DoD) closed architectures and proprietary solutions limit the ability to provide the warfighter gaming, semantic reasoning and social networking capabilities employed by industry and readily available in the open source community. Exorbitant sustainment costs of legacy solutions are unjustifiable and significantly inhibit transition to enhanced solutions. Additionally, legacy solutions leave a dependence on an aging workforce of static-centric modeling & simulation (M&S) subject matter expertise (SME) to promote reuse, while budget cuts increase attrition among junior-level technical staff. This paper describes challenges and recommendations for changing the DoD M&S training paradigm to facilitate interoperability, incorporate emerging semantic web technologies, and provide a knowledge base to promote reuse. Two ongoing R&D projects will be used to illustrate innovative strategies and their potential to alleviate many legacy system interoperability issues while transitioning to a Defense Training Environment (DTE) where US and Coalition Command and Control (C2) and M&S systems seamlessly interoperate to train as we fight.

1 INTRODUCTION

The M&S community needs to evolve capability to meet the increasing complexity of integrating simulations with battle command systems on a globally distributed scale. Many methods for data alignment and data exchange are anchored in static document-based structures. Existing technologies enable point-to-point integration, and are resource-intensive when changes are required to the federation. This design concept is insufficient to meet requirements outlined in the next generation Defense Training Environment (DTE) (DoD 2010). Events require the integration of multiple heterogeneous systems in a timely manner. To perform rapid systems integration, processes and technologies must be dynamic. There is relevance of utilizing the Semantic Web, ontologies, and cloud computing for realizing the next generation dynamic, adaptive and agile DTE.

1.1 Underlying Potential Technology Solution

The DTE is envisioned as a government enterprise with the goal of providing an environment where C2, Intelligence, Surveillance and Reconnaissance (ISR) systems, training ranges, and simulation systems seamlessly communicate across departmental, agency and multinational boundaries in accordance with security and privacy regulations and laws. DoD net-centric environments have been conceptualized over the past decade (e.g., Global Information Grid (GIG) and Net Centric Data Strategy (NCDS) (DoD 2003)); however, only minor successes have been fully realized. Stable well-tested technologies and ontology resources, which did not previously exist to enable the NCDS, are now readily available in the open source community. What is still missing? DoD acceptance, documented best practice, open source implementation strategy and trained personnel.

During the past decade, the web continued to develop via open community practices and collaborative efforts. One such development was the Semantic Web. Semantic Web technologies are inherently extensible and modifiable, and collectively provide the common framework for data to be shared and reused. Unfortunately, because information technologies and acquisition processes being utilized in the DoD sufficed, the development and arrival of the Semantic Web and open technology development (OTD) practices largely went unheralded in DoD programs until recently.

Research has shown that many government, Service, and international organizations are beginning to transition to semantically-driven infrastructures, utilizing OTD processes and realizing information exchange in cloud computing environments. The benefits of these technologies and methods include rapid data generation and alignment, collaborative development opportunities, reuse, and distributive interaction. However, common vocabularies and ontologies to share this data are even more critical. If the various practitioners develop vocabularies and ontologies in a vacuum we will end up creating interoperability alignment issues that will plague our ability to build a robust DTE. Similar to the issues we experience today due to the development and integration strategy utilized in our current acquisition approach of major information management systems.

Ontologies and OTD processes enable systems to communicate natively by generating meaningful data that is exchanged machine to machine. Perception data, in the form of ontological representations, improves event fidelity and enables more effective event management.

It is the opinion of the authors of this paper that the Semantic Web and OTD practices offer the most promising direction for a scalable and dynamic solution. A well-managed, open, and transparent program that incentivizes contributors should be implemented to encourage Services' and agencies' cooperation and participation. Adopting semantic technologies, ontologies and cloud computing is the best course of action to realizing an agile and effective DTE.

As depicted in Figure 1, the DoD M&S community is in a malaise state. There has been no significant leap in M&S technology since the mid 1990's when High Level Architecture (HLA) was created. In effect, M&S is still at 1.0 while the internet is moving toward 3.0 and beyond. The internet has continuously reinvented itself through OTD practices, which foster innovation and development through communities of practice (COP). Many of the new technologies and capabilities developed through the internet have been produced by the generation "x" and "y" digital natives. In order for the DoD to realize their DTE strategy and move M&S toward the next generation, they must institutionalize OTD and sustainment processes within the acquisition system and bring digital natives into the workforce.

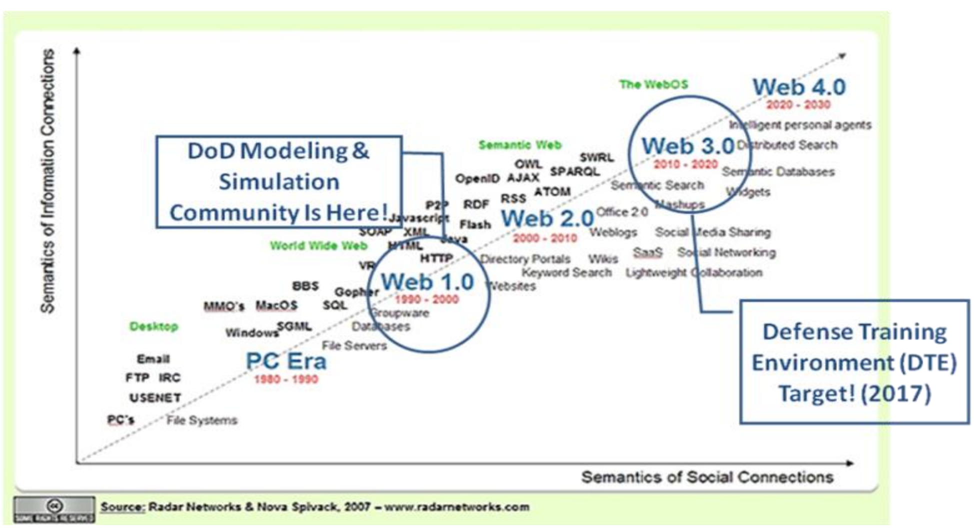

Figure 1: Internet Evolution

1.2 DTE Development Challenges

To create joint scenarios, multiple types of data must be combined together. Data initialization of disparate systems is complex and lengthy. Currently, interoperability problems arise because of misalignment between multiple kinds of data (geospatial, order of battle, messages, events, etc.) due to:

- No common oversight or documentation as to data formats.
- No common mode of access to relevant content.
- No common framework for data retrieval and reasoning.
- No common authoritative or non-authoritative data.
- No common vocabulary.
- No generally applicable strategy for combination and alignment.

DTE development efforts focus on increasing interagency, intergovernmental, and multinational integration of solutions through developing common approaches, producing and sharing data, applying common standards, and emphasizing re-use. The most promising direction for a scalable and dynamic solution incorporates the effective use of Semantic Web technologies and best practices (e.g., accurate use of ontological representations, robust semantic descriptions, and adherence).

Semantic Web technologies, cloud computing and OTD practices are inherently extensible and modifiable at all levels and during any phase of a system's lifecycle. Data exchange benefits can be realized, and content can be generated automatically on an as-needed basis to provide an operational perspective. This enables greater agility in development, improves interoperability between diversified systems, and provides high-level fidelity of real-world warfighting operations to facilitate rigorous and realistic collective defense training.

"Ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents" (Gruber 1992). The use of a common ontology, or a common suite of ontology modules, along with a well-documented governance process, reduces redundant efforts, and results in highly discoverable, composable data with improved:

- Understandability
- Reusability
- Extensibility
- Discoverability

The US Government has been progressively adopting Semantic Web technologies, developing ontologies, incorporating cloud computing instantiations and espousing OTD practices to improve net-centric communication. Representative organizations and their work include:

- US Government Executive Branch (www.data.gov/semantic). The purpose of data.gov is to increase public access to high value, machine-readable datasets. Data.gov uses web semantic technologies to develop data mashups, the combination of data, presentation, or functionality from two or more sources to create new services. This site provides access to over 3,000 public Resource RDF datasets generated by the Executive Branch.
- National Cancer Institute (NCI). NCI is part of the National Institutes of Health (NIH) and is one of eleven agencies that are part of the US Department of Health and Human Services. NCI coordinates the US National Cancer Program, and conducts and supports research, training, health information dissemination, and activities related to the causes, prevention, diagnosis, and treatment of cancer, supportive care for cancer patients and their families, and cancer survivorship.
- Networking and Information Technology Research and Development (NITRD). "The NITRD program is the nation's primary federally funded source for revolutionary breakthroughs in advanced information technologies, such as computing, networking, and software" (NITRD 2011). It is the framework for the collaborative efforts of the fourteen member federal agencies and many other research and development agencies to coordinate efforts.

- National Aeronautic and Space Administration (NASA). NASA has a variety of initiatives based on Semantic Web technologies. The most well known is the Semantic Web for Earth and Environmental Terminology (SWEET). SWEET has over 200 ontologies cumulating in over 6,000 earth science concepts.

A prerequisite to moving the DTE to the Semantic Web is to classify, organize, and catalogue data in a machine-readable format. The Semantic Web builds on the Extensible Markup Language's (XML) ability to define customized tagging schemes and the Resource Definition Frameworks (RDF's) flexible approach to representing data. Adopting Semantic Web technologies and practices as part of the DTE infrastructure will result in a more efficient and cost-effective training enterprise with significantly improved US-US and US-Coalition interoperability. The Semantic Web is not owned by any single or group of commercial organizations. Much of the technology, standards, and techniques developed are managed through open source and open specification programs and projects. Best practice is usually defined as agreed upon by the leading practitioners of the World Wide Web Consortium (W3C).

2 OPEN SOURCE DISCUSSION

James Carter of the National Security Agency (NSA) was directly involved with NSA's SELinux project. SELinux was NSA's initiative to get some of the more critical security enhancements into computer operating systems. Open Source (OS) provided them a means to test and provide security enhancements to both the OS community (i.e., Linux) and proprietary OS developers. On the SELinux effort, James Carter said,

> "The barriers for us involved the rather long process of getting approval from all the relevant stakeholders, such as our General Counsel and Public Affairs offices. The process we went through was specific to our agency, so you would have to determine who the relevant stakeholders are for your project and determine what they would require for approval. The benefits we have seen are those of any OS project: our project is available to be used and studied (as a research organization, one of our goals), many external developers have contributed code and ideas, and we've been able to have far more impact than we would have otherwise."

Paul Byrne of Sun Microsystems was asked about the additional overhead associated with OS. He said that he doesn't see a significant amount of overhead. Sun has a policy to develop all of their software, both directly OS and proprietary, with an "open" philosophy even if "no one is listening." For all intents and purposes, the number of developers working on the core of an OS project is rather limited. Deep in the software stack, there are little there that directly impacts substantive users of the product and hence the interest of the majority of user-developers will remain at the higher levels of the software stack. This is good because corporate focus (and some good geek help) can be placed at the lower levels of the stack thereby maintaining a semblance of control.

Paul also offered what drives a good OS project. He said leadership was very important and he was careful to point out that "leadership" is probably not one person. He said it's important for the leadership to be completely frank with the community throughout the process. Additionally, he offered caution on development forks. The threat of a fork helps keep forks to a minimum. Forks are VERY expensive for the group initiating the fork. Forks, in fact, are a relative rarity in the OS community. He said if the leadership is open and honest, then you're probably not going to see a fork. If you spot another initiative that's close to your own, you need to build a relationship with that other project. They have to understand your vision/goals...and if they do, they are more likely to align with your cause.

Finally, Paul provided some thoughts on benefits of OS. He said OS provides a great mechanism for identifying people to hire. He said that training for newcomers happens 24/7 because everyone in the particular OS community takes an interest. He said that one of the biggest advantages of OS is that there are virtually no delays in testing intermediate releases. Because the source is open, when a new feature, etc., is introduced, the community is very quick to start thrashing on it. Lastly, open source "can't go away." That is, if the sponsoring organization loses interest in that particular project, the project will continue and its products will not be lost on some out-of-date server in corporate bowels.

One of the challenges with OS is that developers will borrow code from one OS project and use it in another. This can cause problems if the licenses for two OS projects are incompatible. Black Duck has developed a number of products to help manage OS projects. Their Code Center product has a database of billions of lines of OS code. It also has the legalese for approximately 1400 different OS licenses. Code Center scans incoming code for OS reuse. If it finds code-in-common, it checks license compatibility and alerts the OS project leadership about the code's inclusion and the legal implications. Black Duck did a quick study in 2008 on the value of OS. They concluded that if OS was a country, its GDP would be the 77th largest in the world (the list had 190 countries on it at the time). Approximately 4.7 million lines of OS code get generated every day.

3 ONTOLOGY BASED STRATEGY

Past efforts in DoD has resulted in lack of coordination in the presentation and handling of data, which has significantly hampered interoperability. An ontology-based approach is recommended to address the complexity of initializing and operating multiple heterogeneous systems as will be required in the DTE. The creation of consensus-based ontologies, which are controlled structured vocabularies that can be used for consistent presentation of data, enables more effective retrieval and reasoning of data.

A four-step strategy for ontology creation using OTD processes, as outlined in William Mandrick's C2 Core Ontology Study Report, is recommended. (Mandrick 2010)

First, *leverage* previous work in DoD. The foundation is The Universal Core (UCore) (Wikipedia 2011) which is a US Federal Government information sharing initiative that is supported by the US Departments of Defense, Energy, Justice, Homeland Security, Intelligence community, and other national and international agencies. The UCore vision is to improve information sharing by defining and exchanging a small number of important, universally understandable concepts across a broad stakeholder base to improve data interoperability between known and unanticipated users while achieving cost and time savings through standardization, modularity, and reuse. Its current form is the UCore 2.0 that serves as a central hub designed to maintain a broad community perspective. The long-term goal is that these common terms will create a common reference platform allowing data from diverse domains to be understood across various systems The Army NCDS (ANCDS) (DA 2011) Center of Excellence created UCore SL to supplement the semantics of UCore 2.0. The UCore 2.0 taxonomy does not include relations with domain and range declarations or disjointness, equivalence, and union axioms. These additional logical resources are provided as extensions of UCore. UCore SL employs the W3C's Web Ontology Language (OWL) to enable semantic validation of both individual extensions of UCore as well as the combined set of all extensions. It provides for logical decomposition of terms and definitions, the ability to reason logically on the basis of the content of these definitions, and thereby enhanced support for the creation of consistent extension modules. Finally, C2 Core (USJFCOMLive 2010) is a DoD ontology currently being developed to provide a level of interoperability between C2 systems unachievable with data dictionaries and custom schemas. It ensures the meaning of information between systems will retain its context and meaning. C2 Core ontology is represented using OWL and is extended from the UCore. The objective of C2 Core is to develop an open standard supporting extensible markup language (XML)-based C2 data exchange. The C2 Core follows the same approach as UCore insofar as it identifies a set of terms that is core across the C2 domain. C2 Core has logical consistency through a top- down extension of UCore 2.0 terms, logically defined using the resources of UCore SL, and applying the result to create a C2 conceptual data model called C2 Core Common Data Model (CDM), which contains over 200 high-frequency terms that define the C2 domain. These terms pertain to situational awareness, structuring a military organization, planning and assigning tasks, decision making, and assessing progress. Examples of potential targets for extensions of the existing C2 Core include sub-domains such as Strike, Unit Readiness, Planning and Operations, and the Military Decision Making Process (MDMP). The DTE must be developed following the operational community's foundational concepts and descriptions.

Second, *develop* a small consensus-based controlled vocabulary to serve as the basis for the description (e.g., tagging) of data. This ontology will use best practices and standard operating procedures for ontology development, including automatic realization of the net-centric approach since data annotated with an ontology becomes automatically identifiable through the corresponding Uniform Resource Identifiers (URIs). It should rest on a strategy of *maximal realism*: seeking not a *data model*, but a *reality model* that is based on the Joint Operating Environment (JOE). The ontology is based on military doctrine, using the common terms used by the warfighters themselves. It draw's wherever possible on existing ontology efforts, and strives for consistency with current initiatives.

Third, *emphasize* an adaptive modular plug-and-play approach. Create custom extensions for specific domains. The suite of extensions will include a generic ontology that consists of terms of common interest to all endeavors, along with more specific extensions ranging across various domains. Core ontology extensions should be created for specific operational domains of interest such as Close Air Support, Human Social Cultural Behavior, Intelligence, Humanitarian Assistance, Logistics, Missile Defense, Counterinsurgency, Incident Management, etc. The goal is to have each COP with a unique data annotation to embrace a single, incremental strategy of synchronized development of extensions. Establish a governance process to ensure change management, coordination, availability of authoritative data sources, and to provide dedicated cross-community training and pilot testing initiatives.

Fourth, *incentivize* the use of the ontology and its network of extensions. The goal is to create a situation where use is by all major participants along the data chain. Leaders of the relevant communities must be incentivized to contribute to the maintenance of the ontology (because coherence of one's own work depends upon it being of high quality, including needed terms, and being up-to-date). The assumption is that, as the benefits of the core and extensions approach become manifest, more resources will accrue to the project.

4 BENEFITS OF AN ONTOLOGY-BASED APPROACH

The availability of a C2 Core Ontology and of an expanding set of authoritative data sources will allow realization of the DTE. Developers and integrators of the DTE must collaborate with ontologists in creating a DTE-C2 Core Ontology, the common platform for the new approach to data initialization, scenario development, and event execution made possible by current and future net-centric and internet technology, in which the continual need for investment of manual effort in data preparation and exchange will be substantially reduced. Certain factors must align for this to happen. There needs to be a concerted effort to enhance coordination for effective ontology development work and description of data across a large population of domains. The division of expertise must be exploited. A strategy of orthogonal modules will allow exploitation of the division of expertise on the part of different COIs and subject-matter experts that ensures consistent interoperation of the whole. Training of the workforce is paramount. The ontology-based approach provides more effective use of resources in the creation and application of software as the standard operating processes for ontology development and application for data use is similar and can be adopted across domains. Personnel can be trained once, and their expertise used multiple times.

Following best practices in the creation and application of ontologies will facilitate a DTE solution that can rely on software resources that are standards-based, lightweight, scalable, secure, and deterministic that utilizes efficient development, integration, test, and configuration resources. The ontology-based approach provides an incremental strategy for quality improvement of the data flowing from the warfighting community to the training community. Annotation with common ontologies allows authoritative data to be maintained in ways that make it discoverable, retrievable, and useable in the DTE. Data silos (or data cemeteries) is avoided because the ontologies themselves are based on doctrine, are well disseminated, and are used at every stage in the data pipeline. Reuse of data across multiple domains results in enhanced realism because ontologies are based directly on operations-based ontologies, the approach will bring greater realism to the DTE. XML Schema, often used in DoD message standards, is better suited for specifying the format and structure in which data is exchanged (data model) than specifying the meaning of the data (reality model). The ontologies provide a cleaner separation of issues of presentation (data models) from issues of meaning (reality models). Ontologies developed to support the DTE will be thoroughly net-aware and made available through industry best practice web services, thus presenting data in terms of DTE ontologies guarantees an automatic adoption of the net-centric approach. The ontology-based approach allows for more effective governance of the creation and use of the authoritative data sources formulated in their terms. Finally, the easy combinability of ontologies and data resources will create, for the training domain, an environment in which plug-and-play modules for different types of scenarios can be developed and reused through automation, significantly reducing manual input. This creates greater flexibility, and a more rapid response in addressing mission planning and rehearsal needs.

5 ILLUSTRATIVE R&D PROJECTS

The Coalition Battle Management Services (CBMS) and the Live, Virtual, Constructive Framework (LVCAF) R&D projects illustrate innovative strategies and the potential to alleviate legacy system interoperability issues while transitioning to the next generation DTE.

5.1 CBMS

Warfighter Need: The coalition community lacks a standard to exchange information and data between various C2 and M&S systems. Coalition C2 community is focused on communicating plans, orders and reports while Coalition M&S Community is focused on replicating the Operational Environment. Today, Coalition forces lack the ability to effectively simulate plans, orders, and reports. Current data exchange strategy for Coalition C2/M&S systems is peer-to-peer. It is too rigid, expensive, and unreliable. It requires significant system-specific knowledge and effort.

Solution Description: CBMS is a technical infrastructure that enables the exchange of resources between C2 and M&S systems, and robotic forces. Initial use cases include:

- Exchange of orders, reports, and requests between fielded legacy C2 and M&S systems using the Simulation Interoperability Standards Organization (SISO) Coalition-Battle Management Language (C-BML).
- After Action Review (AAR) support, and visualization capability to support a Common Operational Picture (COP).
- Data distribution management (DDM) to ensure the right message is sent to the right system at the right time.
- Persistent store (XML data store) with respective metadata to provide resend/replay capability.
- Time management to track and synchronize message passing for improved situational awareness.
- Parametric search/filtering to locate and provide relevant-only information.

Innovative Strategies: CBMS uses an open architectures/OS design philosophy. It will be accessible via any commercially available web browser and uses only next generation XML-based technologies in its implementation as depicted in Figure 2.

Language schemas supported by CBMS include, but are not limited to, SISO Coalition Battle Management Language (CBML), Master Scenario Definition Language (MSDL), Geospatial Battle Management Language (GEO-BML), Joint Command, Control & Consultation Information Exchange Data Model (JC3IEDM), and C2 Core. It is system-independent, allowing each consumer or producer system to map their respective system language to another language. SISO standards committee is currently reviewing the CBMS enterprise architecture. CBMS leverages only open source web technologies:

- Xbase for document persistence and XQuery processing
- Atmosphere Framework for HTTP-based messaging
- Jersey for RESTful web servicing

- xLightweb for client-side HTTP processing

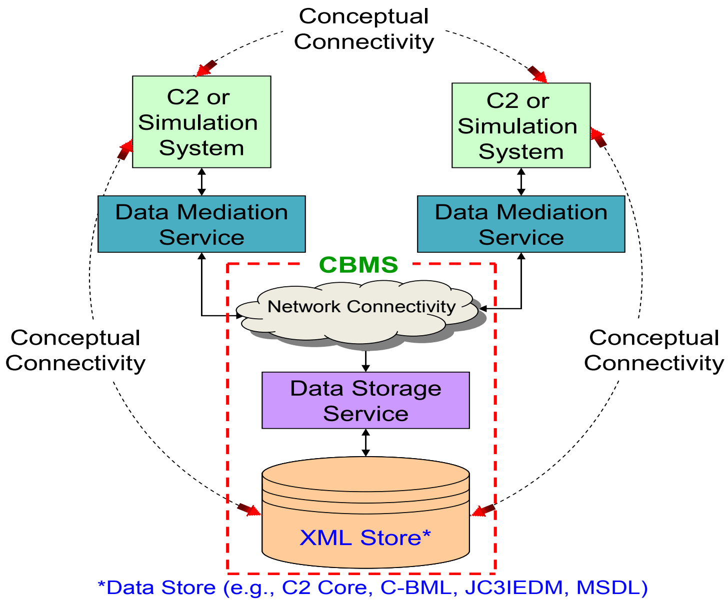

Figure 2: CBMS Diagram

CBMS uses standard web transport protocols and services to transfer data: It is a transport infrastructure that is system and language agnostic and uses HTTP methods: GET, POST, PUT and DELETE.

In contrast to the kluge of disparate architectures, bridges, gateways, and data sharing strategies currently used by the M&S community, CBMS is a decoupled collection of composable web services that can be orchestrated to support the needs of a particular federation. This design facilitates rapid technology refresh and encourages reuse.

5.2 LVCAF

Warfighter Need: DoD simulation needs for test, experimentation, training, and analysis require multiple models built by experts that represent complexities of various disciplines understood from their unique points of view. These models have inherent incompatibilities stemming from the differences in the disciplines, object models and the environments in which they are developed. Bringing federations of these components together is an extremely technical and labor-intensive process. LVCAF is an integrating capability that reduces the repetitive and redundant manual labor requirements for expensive, high demand technical expertise and enhances the quality of the result.

Solution Description: LVCAF is a framework that supports search, discovery, and composition of federation components from multiple architectures while providing linkages to functional mission capabilities. It uses ontologies as a common vocabulary to facilitate machine-to-machine communication and a knowledge base to simplify reconciling models and promote reuse. LVCAF translates object models between the following disparate DoD M&S training architectures:

- High Level Architecture (HLA) Federation (1.3, 1516 and 1516 evolved)
- Test and Training Enabling Architecture (TENA) Logical Range
- Distributed Interactive Simulation (DIS) Protocol Data Units
- Common Training Instrumentation Architecture (CTIA) object models

LVCAF stores semantically matched components in composed data exchange models (DEM) with linkages to mission thread components.

Innovative Strategies: LVCAF utilizes standard Semantic Web formats:

- eXtensible Markup Language (XML)
- Resource Description Framework (RDF)
- OWL

LVCAF leverages only open source web tools and development techniques:

- Archiva for repository management.
- OntoWiki for project collaboration.
- Mercurial for code versioning.
- Protégé for knowledge representation.
- JIRA with Greenhopper for project management, managing scrum backlog, planning sprints, and release tracking.
- Agile software development methodology with scrum.

LVCAF reduces reliance on the DoD M&S SME by capturing event planner, developer and systems engineer expertise in ontological representations of conceptual models and training assets for reuse as shown in Figure 3. Ontological representation currently includes mission threads, joint uniform tasks, joint capability areas, and training assets.

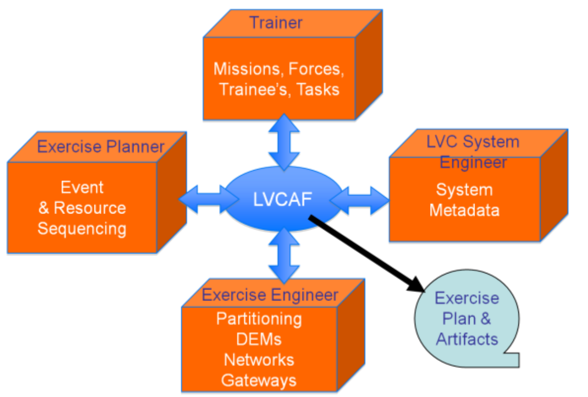

Figure 3: LVCAF Diagram

LVCAF provides an object model comparison capability to reduce manual resource intensive object model reconciliation by the DoD M&S SME.

6 DTE STRATEGY MOVING FORWARD

The strategy for improving the ability of DTE software practitioners to realize the Global Synthetic Environment (GSE) and integrate data from disparate sources into an internally consistent and well-formatted package is to initiate a three-pronged approach. The community should focus on the data initialization process, a robust runtime architecture framework, and coordinated Governance implementation.

The following is offered as a potential solution to bring about the following:

- Identify and align authoritative data that can be annotated (i.e., described, tagged) using the common suite of C2 related ontologies and DoD M&S Steering Committee (MSSC) Rapid Data Generation (RDG) High Level Tasks (HLT) Open Source (OS) development activities.
- Develop a common suite of realistic C2 and related ontologies for describing warfighting situations in a common architecture framework through OTD practices that facilitate development of the DTE.

- Implement a governance process that allows ontologies to evolve and expand in a maximally consistent and useful way across all domains through an open and transparent process.

The first issue to be addressed is one of rapid data generation for initialization. "How can we integrate as rapidly as possible the many different kinds of data needed within a given scenario?" Currently, these data cause problems for the scenario designer, because they are derived from disparate sources, differ in format, rely on heterogeneous and often poorly structured vocabularies, are redundant, and require ad hoc manual resolution. This limitation produces independent data solutions that increase cost, and inhibit discovery, reuse, visibility, and interoperability. Consequently, current scenario data integration efforts are time and resource intensive, lasting from months to years.

A Service-Oriented Architecture (SOA) approach to assist with the discovery, use, and re-use of data will benefit developers across the Department by reducing both costs and timelines for data development and integration. The objective of the RDG HLT is to reduce the time and cost of producing and sharing (reuse) of high-quality (well-maintained) data to initialize systems across the DoD M&S enterprise. The RDG program will implement a cross-cutting Common Data Production Environment (CDPE) that aligns with DoD enterprise processes to progress towards a Department level enterprise solution that provides the means to rapidly produce ready data. The RDG effort will use a common set of ontologies, maintained by domain experts committed to the acceptance of tested best practices and vetted by a community of authorities in a well-documented governance process, which reduce the overall cost of integration efforts and significantly reduce initialization time and increase flexibility and realism. The objective is to improved understandability, reusability, extensibility, and discoverability. The intent is to use a common suite of ontology modules designed for interoperability – along with an effective governance process that brings about a network effect (Weber 2004) where the value of the ontology exponentially increases as more people use it to describe their respective data. When combined with the employment of open source technologies and practices – a legal and technical framework to reduce cost and waste – the result is a web-oriented architecture within which data services, tools and resources of importance to data initialization become more discoverable, composable, and increasingly re-used.

Moreover, to achieve a more efficient, well-tested, and sustainable interoperability solution the training community must transition from static to dynamic data management. DoD should employ Governance, Resourcing, Education, Architecture, Incentivization, and Training (GREAIT – pronounced GREAT):

- Governance – Responsibility for developing semantic representations (i.e., ontologies) of core domains must come with authority; otherwise, a new problem is introduced through proliferation of competing models. Authority is needed at both the design and authoring stage of these resources and at successive stages of version management.
    - Ensure reference and domain ontologies are based on need, grounded in representations of the real-world JOE, and align in order to avoid the creation of information stovepipes.
    - Coordinate the development of consistent extensions, identify and document best practices, and ensure that they are being used through control for quality, relevancy, and usability of products.
    - Standardize and facilitate COIs activities, establish governance to review proposals for change, and ensure dissemination of the ontology and best practices.
- Resourcing – To guarantee quality, organizations must be identified and resourced to develop and maintain ontologies.
- Education – DoD expertise in open source development processes, Semantic Web technologies and best practices and cloud computing is minimal. Education programs must be designed and institutionalized to develop career and vocational specialists to effectively support the DTE needs.
- Architecture – DoD should be provided a best practice architecture that demonstrates how consistent and high availability runtime systems can be implemented to support DoD missions.

- Incentivization – DoD should incentivize organizations to follow OTD and Semantic Web best practices, manage a domain, maintain solutions, and coordinate with other domains in an open and transparent collaborative process.
- Training – Institutionalized training in OTD practices, cloud computing and semantic principles, technologies, and best practices should be established to increase awareness at all management levels and encourage revolutionary transformation of the DTE. To mitigate consequences of multiple contracting agencies and software service contractors working independently on the DTE, it is important to create a cadre of software engineers who share a common understanding of tested best practices in semantic interoperability who will work with the Services, Agencies, and Multinational partners in coordinating activities. A training program should be initiated to address this short-term need. Long term, as semantic interoperability in particular and the NCDS in general, become more ubiquitous to data operations in DoD, we believe that the DoD should create an academic center for OTD, ontology and cloud computing training.

7 SUMMARY

Today's training environment is predominantly a paradigm of fixed training sites and large-scale integrations. This paper discusses the potential for Semantic Web technologies, cloud computing and industry best practices to enhance operational and training data and systems interoperability into a harmonized dynamically evolving framework. The next generation DTE will need to look at new modes of training, including further exploitation of W3C standards to align M&S and C2 architectures (beyond data exchange to semantic understanding).

The movement of the DoD to Semantic Web is inevitable. All of the services have their own initiatives underway; however, there does not appear to be any department wide coordination or single view of the progress towards a common semantic vision. It is imperative that leadership provide direction and governance to ensure that efforts are accomplished in a coordinated, transparent, and visible way. The organizations that develop capability to form the next generation DTE need to take advantage of the techniques and technologies made available through the W3C and the many communities of interest that are developing technologies and data products that have direct applicability to not only training but also operations. The end state must be a common C2 and M&S enterprise grounded in the operational domain. In some cases, the best of breed efforts may require incentivization to ensure supportability and continuity.

ACKNOWLEDGMENTS

The authors would like to acknowledge Mr. Mark Phillips (Lockheed Martin, Inc.), Dr. Barry Smith (University at Buffalo), Mr. Scott Streit (Intervise, Inc), and Dr. Lowell Vizenor (Alion Science and Technology) for their invaluable input through their work on the *Independent Study of the Semantic Web, Ontologies, and Initiatives for Realizing the Next Generation Defense Training Environment* published 21 February 2011, sponsored by the United States Joint Forces Command. In addition, we would like to thank Ms. Capri Huzi for her superb technical editing efforts.

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