One Step Further Towards the Next Generation Training Systems

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ABSTRACT

The Net-centricity and Global Information Grid (GIG) visions enable systems to be interconnected to support multi-lateral, civilian and military missions. The constantly changing environment requires the commanders to plan for missions that allow for units from various nations, agencies etc. to join or separate from the team, depending on the situation, as the mission unfolds. The uncertainty of the actual mission and that the potential for agencies and organizations to support the mission after it is underway, leads to a vast number of potential scenarios that civil and military personnel need to train in individual and collaborative training environments.

It is not feasible to train for every possible mission and every possible combination of teams. The Next Generation Training Systems need to manage this complex and dynamic environment. The simulation support needs to be unified such that training performed at home stations and in mission training/mission rehearsal that may occur just days, hours or even minutes before the actual missions are as interoperable as possible. It is becoming more important to adapt to the latest doctrine of the adversary. This need to adapt coupled with the specific intended concept of the operation must drive the civil and military agencies, organizations, and units selected for the mission at hand. The need for rapid mission rehearsal capabilities drives the requirement to transform to simulation infrastructure that includes interoperability mechanisms that enable a more agile, dynamic and adaptive interconnection of heterogeneous simulations.

In this paper a step towards the Next Generation Training Systems is presented. The concepts, ongoing research and standards are described and the role of the Coalition Battle Management Language as one of the key enablers for the Next Generation Training Systems is presented. Methods and tools used in demonstrations to show fast integration between heterogeneous Live, Virtual and Constructive simulations with Command and Control Systems are exemplified.

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INTRODUCTION

Technology, social acceptance, change of threats and political will are all parts that play a significant role in the ongoing network-centric transformation of military and civil organizations. In (AAP-6, 2007) the *continuous and proactive process of developing and integrating innovative concepts, doctrines and capabilities in order to improve the effectiveness and interoperability of military forces* is termed transformation.

Until recently transformation in the Command and Control domain has more or less been focused on situation awareness and the processes to establish a Common Operational Picture and to gain Information Superiority, Knowledge Superiority and Decision Superiority. In the Swedish project "ROLF 2010 - A joint Mobile Command and Control Concept" (Alm et al., 1998) and in the recent book "Planning Complex Endeavors" by (Alberts and Hayes, 2007) the collaborative environment is in focus, i.e. getting networked in the social and informational domains and establish collaborative planning and decision making processes.

With the networked-centric approach literally all systems can be combined together enabling new abilities and capabilities to be explored. The operational systems are required to be configured and used in an on-demand fashion that lives up to the visions presented in the "Joint Vision 2020" (Joint Chiefs of Staff, 2000) and in the "Swedish NBF Vision Ledning" (Skogsberg, 2004). Together with the increased uncertainty of the actual mission at hand and the potential for participating agencies and organizations to join the team late, leads to a vast number of potential operational scenarios, i.e. *The only stable state is constant change* from the "Art of War" (Tzu, translated by Cleary 1988).

However, it is not practicable to train for every possible mission and every possible combination of teams. Training performed at home stations and in mission training/mission rehearsal just days, hours or even minutes before the actual missions requires that the Next Generation Training Systems can adapt to meet the requirements of this complex and dynamic environment.

A key capability of the training systems is the ability to establish connectivity faster than the current methods and mechanisms can. The challenge is to establish interoperability shaping mechanisms and method that enables multiple-protocols and multiple-information exchange models to co-exist in the system of systems environment and thereby provide a more agile, dynamic and adaptive interconnection of heterogeneous operational systems and simulations.

Those with a capability to adapt to new system structures will then have a better foundation to use the methodological and operational benefits of systems of systems, whereas others will not.

Outline

The outline of this paper starts with a background of *interoperability* followed by a résumé of *system integration today* and its problems. In *one step further* promising research and standardization to the identified problems are presented. In *Next Generation Training Systems* a proposal utilizing the research and ongoing standardization is presented. Then the paper ends with *future work* and a *summarization*.

INTEROPERABILITY

The word interoperability has many interpretations. In the book "Interoperability in Multinational Operations"[1] (Sjöblom, 2004) a walk through interoperability in Sweden, NATO and US is presented. In short, the Swedish focus is on international interoperability and the split-up into physical and logical interoperability. Physical refers to the equipment, systems and IT-systems. Logical refers to concepts, terms, rules, methods, protocols and message formats. The NATO view of

[1] Interoperability in Multinational Operation is the translation of the Swedish title "Interoperabilitet i mutinationella operationer"

interoperability is *the ability to operate in synergy in the execution of assigned tasks* by compatibility, interchangeability, commonality, common user item, force interoperability, military interoperability and standardization (AAP-6, 2007). In the Joint Vision 2020 (Joint Chiefs of Staff, 2000) interoperability is said to be *"…the foundation of effective joint, multinational, and interagency operations … especially in terms of communications, common logistics items, and information sharing."* Also in the Joint Vision 2020 the focus is not only technical "*Although technical interoperability is essential, it is not sufficient to ensure effective operations. There must be a suitable focus on procedural and organizational elements, and decision makers at all levels must understand each other's capabilities and constraints."*

To deal with the various levels of interoperability the Layers of Coalition Interoperability (LCI) (Tolk, 2003), (Figure 1), is used to describe and establish a model for the interoperability needs between systems.

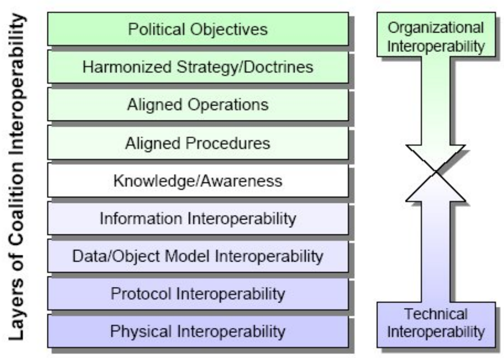

Figure 1 - Layers of Coalition Interoperability

The LCI is a complementary model to the "Level of Information Systems Interoperability" model (LISI) and the NATO C3 Technical Architecture (NC3TA) Reference Model for Interoperability (NMI). The lower levels deal with the layers of technical interoperability, i.e., the ability to collect, manipulate, distribute, and disseminate data and information. Knowledge and Awareness addresses Common Operational Picture, harmonized views of operation, i.e. the intersection between the organizational and technical view. The higher levels deal with tactics, data and knowledge bases, the coalition partner's processes and on the top are the political values and objectives of the coalition.

The Levels of Conceptual Interoperability Model (LCIM) (Tolk and Muguira, 2003, Turnitsa, 2005) focuses on Information, i.e. Data, Information and Knowledge in the LCI model (Figure 2). In the description of the model the requirements to fulfill a level is expressed together with examples of current implementations.

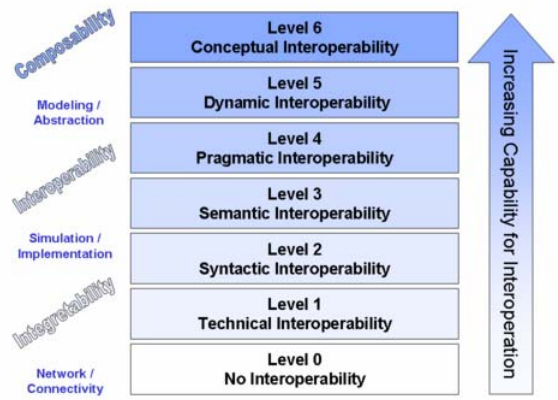

Figure 2 - Level of Conceptual Interoperability

The overall characteristics of the LCIM are presented since the model specifies that to reach a flexible and agile interoperability level we need to build the appropriate mechanisms on each level in the model. The following is derived from the paper by (Turnitsa, 2005).

Level 0: Stand-alone systems have No Interoperability.

Level 1: On the level of Technical Interoperability, a communication protocol exists for exchanging data between participating systems. On this level, a communication infrastructure is established allowing systems to exchange bits and bytes, and the underlying networks and protocols are unambiguously defined.

Level 2: The Syntactic Interoperability level introduces a common structure to exchange information; i.e., a common data format is applied. On this level, a common protocol to structure the data is used; the format of the information exchange is unambiguously defined.

Level 3: If a common information exchange reference model is used, the level of Semantic Interoperability is reached. On this level, the meaning of the data is shared; the content of the information exchange requests are unambiguously defined.

Level 4: Pragmatic Interoperability is reached when the interoperating systems are aware of the methods and procedures that each system is employing. In other words, the use of the data – or the context of its application – is understood by the participating systems; the context in which the information is exchanged is unambiguously defined.

Level 5: As a system operates on data over time, the state of that system will change, and this includes the assumptions and constraints that affect its data interchange. If systems have attained Dynamic Interoperability, they are able to comprehend the state changes that occur in the assumptions and constraints that each is making over time, and they are able to take advantage of those changes.

Level 6: Finally, if the conceptual model – i.e. the assumptions and constraints of the meaningful abstraction of reality – are aligned, the highest level of interoperability is reached: Conceptual Interoperability.

The next section is an overview of system integration today and why it is not sufficient for the future.

SYSTEM INTEGRATION TODAY

Traditionally, systems and applications are connected directly to one another. To integrate more than one application, there is a need to establish several connections. Each application may use a different communication protocol, a different information model, and perform differently. For a connection to work, each application has to be upgraded to be able to understand and function together with the other. As a result, a lot of the integration effort is diverted towards technical platform details.

Application Centric Integration

Application Centric Integration is illustrated in Figure 3 and is best suited when there are only two systems to be integrated. It requires that each application is individually adapted to the selected protocol. These adaptations are usually also restricted to a minimum in terms of the information being exposed. The full capacity of each application will therefore not be available. The integration points are at each end and are usually hard coded into each system.

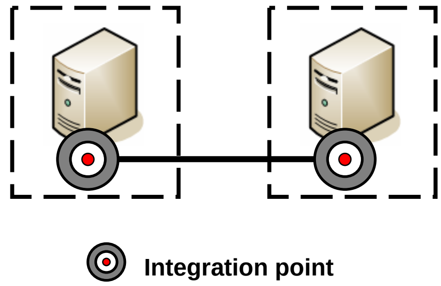

Figure 3 - Application Centric Integration

Interface Centric Integration

When more than two systems are connected together the common solution is to identify a set of data elements in an agreed format with an agreed meaning using a specific protocol. In Figure 4 an illustration is presented.

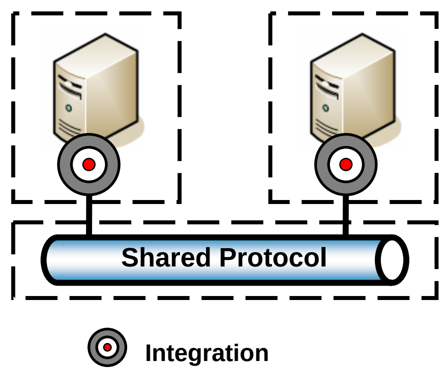

Figure 4 - Interface Centric Integration

Two commonly used standards used are the Distributed Interactive Simulation (DIS) specified in IEEE1278, and High Level Architecture (HLA) specified in IEEE1516. The DIS uses the well defined Protocol Data Units (PDU) that holds the syntax and semantics. HLA is more flexible than DIS and the Object Model Template (OMT) is used as the common syntax to describe the meaning of all object and interaction classes within the Federation Object Model (FOM). Overall the focus is on the interoperation of systems and to exchange data and every system agrees to map their information exchange to the common information exchange model.

The integration points are still at each application's end and usually hard coded. Each application will still need to be adapted to the shared protocol which usually restricts the information being exposed to the shared protocol. The full capability of each application will still not be exposed.

Common Integration Problems

Common problems that arise using the above integration methods are:

- **Complex Integration:** To integrate a new application, it may be necessary to upgrade several existing applications. The more applications that are integrated, the more complex it becomes to integrate an additional application. Further, when upgrading an application, existing functionality may be affected, requiring even more work. This complexity makes it hard to adapt to new protocols.

- **High Costs:** Each additional application that is integrated potentially requires more integration work than the last one. This makes integration costs increase exponentially. The integration becomes more and more complex for each application that is integrated. Further, since each additional application that is integrated may affect several other applications, life-cycle costs will also remain high.

- **Long Time-to-market:** The time-to-market is how long it takes to create a new function by integrating a number of applications that together satisfies a new need or sudden requirement. Since integration is complex, the time-to-market will be long.

- **Rigid Integration:** To change the way a number of applications are integrated may require re-integration of the applications all over again because of the interdependency between the applications. Integration is rigid, and inflexible.

ONE STEP FURTHER

Whilst focusing on technical platform details makes system and application integration rigid and hard to change. Future requirements on training environments include the ability for quick changes, as pinpointed in the introduction. There will be a need for fast responses to new requirements. Changing an existing integration must be quick and easy.

To be able to make that transition, it is necessary to switch focus from protocols to flow of information. Part of it is to understand that all training systems do not have to be integrated by one common communication standard or protocol. Since no single communication protocol will solve all problems, it should be possible to combine systems that use different protocols. In no way does this disqualify any current or new communication protocols. It is only a change of focus. What the systems need to have in common is an understanding of what information to exchange. By focusing on the information, the systems will be interoperable on the information level rather than the more technical protocol level.

Information interoperability is when computer systems and applications can exchange information efficiently, regardless of used technologies.

An example of information interoperability is when you send a phonebook contact from one mobile phone to another. It does not matter what type of phone you or your receiver has, nor does it matter what type of protocol you use to send the contact to the other phone. You can use IrDA, Bluetooth, e-mail, MMS, WAP, or send it as a SMS, and it will still get through to the other phone. This is because they use the same information model. The communication protocol is only used as information carrier.

Ontological Representation

To stretch the focus on information further a top down view of the usage of information, business rules and the participating systems are also essential. Such top-down analysis need to be captured and described in some conceptual model, so that data, information and the usage of the information is described, i.e. the higher levels of the LCIM model (Turnitsa, 2005). In the later work by Tolk and Turnitsa they present ideas in how the usage of an ontological framework may *allow systems to exchange information based on self-organizing principles using what they can exchange and not on mandated specifications of what they should exchange* (Tolk and Turnitsa, 2007).

Model Based Data Engineering

For data and a bottom-up approach it is a necessity that it aligns with the conceptual top-down results. In Model Based Data Engineering (MBDE) the idea of a Common Reference Model (CRM) is introduced that captures the meaning of data and their relations (Tolk et al., 2007). The CRM supports data engineering that consists of four parts: *Data Administration* answer the questions: “Where are the data? In what format? How can the data be accessed?” *Data Management* answers the question: “What do the data mean?” *Data Alignment* answers the question: “Can all needed data be obtained?” and *Data Transformation* answers the question: “How to transform/mediate data?” The introduction of a CRM supports the process of Data Engineering. When a CRM is used data alignment is an easy task to fulfill since it becomes just a comparison of mappings. After target and source are mapped to the CRM, it is possible to compare the mapping of the source model to the CRM with the mapping of the target model to the CRM. If every information element of the source and target model is mapped to an element of the CRM, the models are aligned.

The ontological representation and Model Based Data Engineering provides with the methods and processes needed to establish information alignment in an agile manner. The CRM consists of *Data Elements* that are the basic containers for data as used in data models. *Value Domains* comprise the allowed values for an associated data element. *Conceptual Domains* define sets of categories where the categories represent the meaning of the permissible values in the associated value domains. *Data Element Concepts* describe the contextual semantics. They comprise the contextual information on the conceptual level.

Common Reference Models

Bellow three Common Reference Models are presented in brief.

- MIP JC3IEDM: Multilateral Interoperability Program (MIP) has developed the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM) that provides interoperability at level 2 almost level according to LCIM.

- Civilian IEDM: Civilian ongoing standardization efforts to produce a similar product as the JC3IEDM but more lightweight. The authors recognize the effort to deliver interoperability at LCIM level 2.

- BML IEM: Battle Management Language (BML) Information Exchange Model is intended to deliver interoperability according to LCIM. At level 3 and 4.

MIP - JC3IEDM

The JC3IEDM is an internationally developed and maintained data model which allows for the exchange and storage of command and control information. JC3IEDM divides up the data describing an object into static, type-oriented data (OBJECT_TYPE in JC3IEDM). Likewise, the model captures the data concerning single instances of an object, such as a particular unit, or an individual vehicle or soldier (OBJECT_ITEM. in JC3IEDM). For information exchange this is extremely useful, as it allows for single transfer between systems of the static data and intelligent linking for efficient transfer of the instance data as required.

Civilian Information Exchange Data Models

In the civilian domain three main initiatives to establish information exchange data models are present.

OASIS-Open CAP and EDXL

The OASIS (the Organization for the Advancement of Structured Information Standards) has developed the Common Alerting Protocol (CAP), which have the purpose to be a simple but general format for exchanging all hazard emergency alerts and public warnings over various types of networks. The CAP is using XML and consists of four segments: alert that contains the purpose, source and status of the message; info that describes the category and textual description of an event together with information of its urgency (time available to prepare), severity (intensity of impact) and certainty (confidence in the observation or prediction); resource segment could be an image or audio file; and area that describes a geographic area connected with the info segment. The EDXL is intended to be used at any time (including preparedness and recovery) for asking for a specific resource or a more general “capability”, and for answering such a request.

CEN WS/ISDEM TSO

Within the work of OASIS-FP6 (not the same as OASIS-Open) there is a standardization process going on to identify a Tactical Situation Object (TSO) that will enable exchange of information. The

TSO is one of the cornerstones of the OASIS-FP6 project. The TSO provides the capability to exchange pieces of information which participate to the Common Operational Picture, but it is not intended to provide all detailed information. So it reflects some choices for trying to have it as simple as possible while being relatively complete.

Societal Security ISO TC/223

The ISO/TC 223 focus is on methods and tools for interoperable information flow, information models and shared situational awareness for all key phases of crisis management. The ISO/TC 223 have the CEN WS/ISDEM TSO output as its foundation.

Battle Management Language

The Battle Management Language (BML) was formally defined in (Hieb et al., 2001) as "…*the unambiguous language used to command and control forces and equipment conducting military operations and to provide for situational awareness and a shared, common operational picture*". (Figure 5)

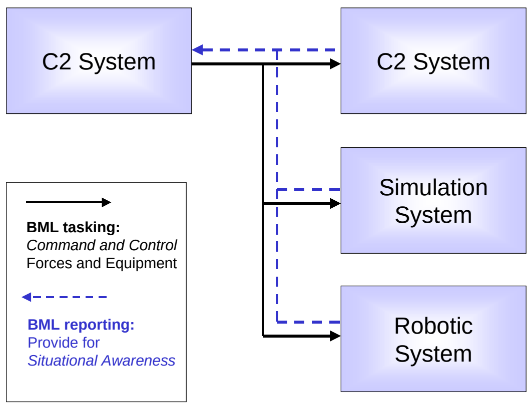

Figure 5 - BML Tasking and Reporting

Using BML, it should be possible for C4I systems, simulation systems, and emerging robotic forces to communicate unambiguously with any of these other types of systems. Such system-to-system communication is demanding enough when it involves systems within the same organization. It grows even more complex and demanding incorporating other organizations and nations.

Guiding Principles of BML

There are four guiding principles that must be followed in order for a BML implementation to function correctly. (1) BML must be unambiguous; (2) BML must not constrain the full expression of the commander's intent; (3) BML must use existing C4ISR data representations when possible; (4) BML must allow any elements (that is, some live, constructive, or robotic entity) to communicate information pertaining to itself, its mission and its environment in order to create situational awareness and a shared, common operational picture across all elements. These principles are very difficult to simultaneously satisfy, as they conflict with one another to some extent. Many (if not most) systems that convey a commander's intent do so by allowing free text comments to accompany a data transmission. In this way, natural language messages can be employed by the commander to express his ideas. The difficulty here, of course, is that natural language messages are very difficult to disambiguate, especially when relaying those messages to constructive or robotic forces for automated interpretation. To satisfy all of these requirements, a battle management language must be rich enough in structure to accommodate system interoperability for a complex domain. That richness is achieved by approaching the requirements from three perspectives:

Protocol: The protocol that is currently being adopted is the Extensible Markup Language (XML) together with Web Services. It is flexible and well understood, it is easily extensible to accommodate all data needs that might exist (numeric elements, text strings, database cells, and others), and its structure and reliance on simple ASCII characterization make it easy to adopt as a means for data interchange by nearly all systems and across many countries.

Representation: The third principle of BML requires that existing C4ISR data representations be used for data interchange. Clearly this is a problematic requirement, as the number of diverse systems, data elements and situations germane to C4ISR is very large. For international coalition exchange, the best option is the well-established JC3IEDM briefly described above.

Doctrine: To provide the ability to represent the commander's intent and to accomplish all interoperability communications in an unambiguous manner, require the use of very clear language elements. In order to make BML operationally sound, those language elements need to align with the business rules of the military organization that is using the BML for communications. Those business rules are found within the published doctrine of military organizations.

Command and Control Grammar

From the initial work with BML grammar in (Schade and Hieb, 2006) they present tasking and reporting grammars and in the continued work (Hieb and Schade, 2007) they present a general approach to a Command and Control Grammar providing intention, report and task support. The basic structure is the usage of context-free grammar (CFG), the principal approach used in the field of computational linguistics for automatically processing sentences in a written or spoken language.

Starting with the 5Ws of the BML concept (Who, What, When, Where, Why), the initial work focuses on defining a tasking grammar to create basic phrases relative to the *orders* aspect of the C-BML grammar. In short the grammar is expressed in terms of an activity, spatial coordination, and temporal coordination. An example of the structure is:

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S → A* Spatial_Coord* Temporal_Coord*
A → Verb Tasker Taskee (Affected|Action)
Where Start-When (End-When) Why Label (Mod)*
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NEXT GENERATION TRAINING SYSTEMS

In the introduction it is declared that The Next Generation Training Systems need to allow fast integration of systems for the purpose of doctrine development, training and exercises. The first step in any process is to define the purpose of why systems shall be interoperable. Then find out if and how they can be made interoperable. The later part can be made easier by carrying out an Information Needs Analysis using the Model Based Data Engineering and a Common Reference Model with transformation, mediation and mapping tools and utilities so that a separation of protocols and information can be provided and that information can be unambiguously exchanged amongst systems.

Communication protocols will continue to evolve. How is it possible to achieve information interoperability over time?

- By focusing on the information flow between systems – not on individual communication standards, protocols, or software platforms.
- By making it possible to “connect” information from different systems regardless of communication standards and protocols.
- By making it possible to control the information flow between connected systems.

New Communication Protocols

Since there will be new communication protocols, will they be able to solve all current problems? Will they be able to reduce both complexity and costs? The short answer is no. Even if a new protocol would solve all present problems, it cannot be prepared for all future problems. And what if a legacy system cannot be adapted to use the new communication protocol. That system would no longer be useful. Also, remember that different communication protocols are designed to solve different problems. Using the same protocol for different systems, such as live, virtual and constructive systems, will not be very effective even if they use the same information model. In short, no single communication protocol will solve all problems. That is why it is necessary to understand the need to combine systems and applications that use different protocols and information exchange data models.

If no new protocol will solve all problems, how is it possible to achieve cost-effective training?

- By using a common training environment where different systems can work together regardless of protocols and internal object models.
- By focusing on the information that each system contributes to the common training environment - not on individual protocols, architectures or information exchange models.
- By integrating the common training environment with configuration mechanisms instead of software programming.
- By allowing the user to define the common information model.
- By integrating information instead of communication protocols.

System Integration Tomorrow

To switch the focus from technical platform details to the flow of information, it is necessary to use an information infrastructure. It will be used to collect, maintain and distribute common information. When an application is interested in some information, the application subscribes to that information. When another application has an information update, the application publishes it on the infrastructure. The infrastructure then distributes the updated information to relevant subscribers.

Information Centric Integration
Information Centric Integration offers the potential to move the system integration points into the information infrastructure giving the integrator full control of the integration. These integration points are configured and ***not*** hard coded into the information infrastructure. In Figure 6 Information Centric Integration is illustrated.

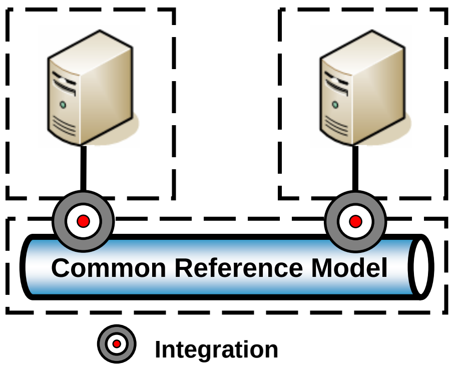

Figure 6 - Information Centric Integration

Communication Autonomy
Since the information infrastructure is responsible for translating and delivering information between applications, each application only needs to communicate with the infrastructure. This communication is preferably made using the native protocol of each application thereby exposing the full data model of each application to the infrastructure. Applications are completely autonomous.

Simpler Integration
To integrate an additional application, the information infrastructure needs to support its communication protocol. However, the other integrated applications can continue as before. The information infrastructure takes care of necessary translations. This makes it easier to adapt to new protocols.

Lower Costs
To integrate an additional application requires roughly the same amount of work as the last one. The difference is if the infrastructure has to support a new communication protocol, or not. This makes integration costs increase linearly. Further, integrating an additional application will not affect other applications. Thus, life-cycle costs remain at a lower level.

Shorter Time-to-market
To satisfy a new requirement, applications can be integrated in new ways. Since integration is simpler, this will take less time. The time-to-market will be shorter therefore operational procedures and methods can be evaluated, verified, trained early in the process.

Flexible Integration
Using an information infrastructure makes it possible to configure how applications are integrated. To satisfy a new requirement by changing the integration, the only change is the configuration. There is no need to modify and thereby integrate the applications all over again. Integration is flexible.

Easier to Create New Capabilities
Since integration is flexible, it is easier to create new capabilities. Instead of creating a totally new system, or changing existing systems, it can be sufficient to combine information from existing systems in a new way. All that is needed to do is to create a new configuration.

Re-use Systems and Identify Gaps
Combining information from existing systems may not be sufficient. But, combining existing systems will provide the ability to identify missing parts. By re-using systems less additional information is needed than starting from scratch.

Easier to Exchange Information
Since systems only need to communicate with the information infrastructure and the Common Reference Model, they no longer need to be aware of each other. This makes it easier to exchange information. All a system needs to concern itself with is what information to provide to the infrastructure, and what information it is interested in. A system will deliver updated information to the information infrastructure, but need not concern itself with who receives that information. The infrastructure delivers the updated information to any system that is interested in it. However, those systems need not concern themselves with who initially delivered the updated information.

Easier to Replace Systems
Since systems are unaware of each other, it is easier to replace a system, add a new system, or remove an old system. As long as the relevant information is available via the information infrastructure, it does not matter which system supplies it.

IMPLEMENTATIONS

The Next Generation Training System will enable fast integration between heterogeneous systems using the recommended process described by Tolk and Diallo in (Tolk et al., 2007), in combining a top down and a bottom up approach. The Coalition Battle Management Language is the most appropriate Common Reference Model for the military domain, because it uses the JC3IEDM, maintains semantic information and is unambiguous. The grammars as proposed by Scahde and Hieb in (Scahde and Hieb, 2006, Hieb and Schade, 2007) provide us with a unified representation mechanism that enables a modular approach to the underlying data representations, i.e. that the JC3IEDM can be replaced with civilian counterparts, i.e. the Common Alert Protocol (CAP) from Oasis-Open and/or the model, when it is available, from the ISO/TC 223 Societal Security standardization.

In demonstrations, the bits and pieces have been showcased by numerous of research programs and initiatives, such as NATO-ET16, NATO MSG-048 (Pullen et al., 2006), Joint Battle Management Language (JBML) (Pullen et al., 2007) and so forth.

The author's organization is participating and establishing its own experiments to develop an integration platform that can handle data and information mapping focused on a Common Reference Model of choice. The developed tools use XML to represent the CRM, the integrated systems information model and the actual mapping between the CRM and the system. The principle of this system is to separate protocol and data/information from each other so that when a protocol paradigm is implemented the focus is on information mapping. Experiments performed so far include protocols and information models such as DIS, HLA/RTI with RPR-FOM, Link16, Link11, MIP with C2IEDM and some Saab specific systems.

FUTURE WORK

Some suggestions for future work are:

Perform a case study to measure if Commander Intent and Situation Awareness is increased by using BML, i.e. an addition to the study in (Thomas et al., 2007).

Examine how the Information Need Analysis (INA) process can be improved by using agile visual tools for identifying and visualizing information gaps between systems and develop methods to determine if systems shall be integrated with each other or not.

Implement the BML concepts in the civilian domain as proposed in Crisis Management Language (Gustavsson et al., 2006).

Investigate how ontological frameworks can be used in establishing seamless interoperability between civil, military, private, international, non-governmental agencies and organizations following the concepts in this paper.

Present a representation of information quality (fidelity, timeliness, trust, predictability, etc.) to be used as mapping aid.

Whilst the experiments so far have been using somewhat rudimentary information mappings between systems, the ongoing BLACK-CACTUS[2] experiments between C4I-Center, George Mason University and Saab uses BML as a CRM and are intended to introduced more complex and versatile information exchange requirements over time.

SUMMARIZATION

The authors have in this paper identified the necessity of Information Centric Integration and the use of Model Based Data Engineering as well as the Battle Management Language as methods and representations in the military domain to maintain semantic context of information between interplaying Systems. This approach enables Legacy systems to co-operate with new systems without having to change working communication protocols and information representations.

The Next Generation Training Systems need to be based on the paradigms and concepts as well as the implementations stated in this paper so that interoperability is efficiently enabled to support doctrine and concept development, planning, training and exercises for military and civilian organizations and personnel.

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As a prime component in the enhancement of the WISE platform, to provide semantic connectivity, our

[2] BLACK-CACTUS – **B**i**LA**teral **C**ollaboration and **K**onwledge exchange – **C**ommand **A**nd **C**ontrol **T**o **U**S and **S**weden

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