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Title: *"Flowing Focused and Relevant Information to the Edge through Semantic Channels"*
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"Flowing Focused and Relevant Information to the Edge through Semantic Channels"

Abstract

The Department of Defense (DoD) Global Information Grid (GIG) Enterprise Service and Net-Centric Data Strategies envision a shared market of information services across the Enterprise. The authors believe that this vision lacks an essential means for adding situational context to the services and data. Without this context, shared information in the GIG will inevitably become, like that of today's World Wide Web, increasingly difficult to research, analyze and make accessible to commanders and decision makers. The GIG information explosion will also become increasingly expensive to support in terms of bandwidth and computing capacity. The authors propose extending GIG capabilities with Semantic Channels that provide the needed context for discovery and analysis. The authors are exploring how COTS software and a standardized categorization framework can be combined with GIG service and metadata registries to yield a near-term GIG Semantic Channel solution. Initial results show significant reduction in information dissemination complexity for GIG consumers without limiting the ability to explore related information. Future steps include exploring how GIG Semantic Channels can simplify information dissemination, the insertion of caching, bandwidth compression, and synchronization technologies to efficiently and effectively extend the GIG information space to tactical edge commanders and operators.

Background

Starting in 1999, the Department of Defense (DoD) began to put in place a set of strategies, policies and initiatives intended to create an Enterprise-wide Information Environment known as the Global Information Grid (GIG). The GIG is a key ingredient to help fulfill DoD's future vision of net-centric operations and warfare articulated in the Joint Vision 2020[1] (JV2020) document. The GIG is defined as the globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing, disseminating, and managing information on demand to warfighters, policy makers, and support personnel. The GIG includes all owned and leased communications and computing systems and services, software (including applications), data, security services, and other associated services necessary to achieve Information Superiority. In short, the GIG provides information services to all Warfighters, anywhere, anytime and on the Warfighters' terms.

As illustrated in Figure 1 below, the GIG is a foundational element of incremental progress leading to the JV2020 vision. The ability to conduct network-based warfare is enabled by information services provided by the GIG. This in turn leads to enhanced access to superior knowledge and information, which leads to superior decision making, culminating in the Warfighter's dominance across the full range of military operations.

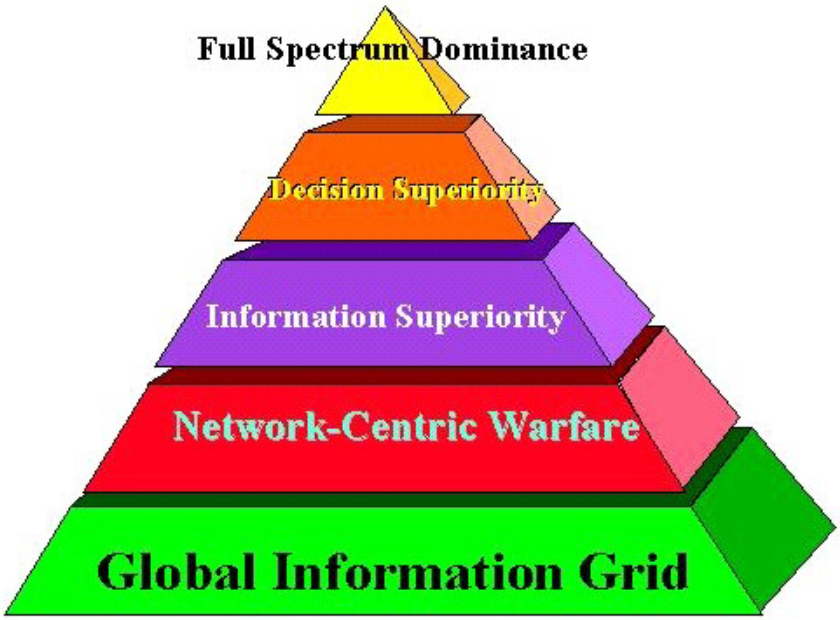

Figure 1 - GIG as an Enabling Foundation

Two strategies and related implementation plans are pivotal to DoD approach for empowering the GIG to enable net-centric warfare. In 2002, the vision of GIG Enterprise Services was introduced along with a plan for a program that would implement certain core network-hosted services for the DoD enterprise.[2] This program eventually became Net-Centric Enterprise Services[3] (NCES), and the Defense Information Systems Agency (DISA) was assigned as the program's executive agent. In 2003, a policy for making information visible and accessible to the enterprise via the GIG was also introduced[4]. Work is currently underway to refine the enterprise services strategy and better codify it as Department policy[5].

Having Too Much Information is a Barrier to Achieving Decision Superiority

One of the tenets of an Information Age is "Information Superiority", where the command and control environment leverages relevant and timely information inside the commander's decision loop, thereby enabling decision superiority. Information and decision superiority will be of little value if they come at the expense of a greatly expanded command decision cycle due to the amount of information that must be absorbed and analyzed. The ability to focus information flow is particularly vital to tactical edge commanders and operators due to limited bandwidth availability and the intermittent nature of their network connectivity.

Yet just like the Internet on which it is modeled, the GIG is on track to become an enormous and ever expanding information base. The amount of information available will thoroughly overwhelm commanders and other soldiers unless techniques are found to significantly filter and focus the information flow. The soldier's ability to make

superior decisions requires simplified and accelerated information research, discovery and analysis. To be effective, future command and control environments must deliberately and actively narrow the flow of information to events relevant to the command context.

The GIG Capstone Requirements Document[6] (CRD) recognizes this requirement when it discusses filtering information flow through profiles. According to the GIG CRD, such profiles should enable information producers on the GIG to automatically disseminate a minimum of 95% of available, needed information, with no more than 15% of the information received being irrelevant/unusable. This type of information profiling is envisioned to be an element of the GIG's User Assistant Core Enterprise Service, and is an essential service of the Information Dissemination Management (IDM) function of the GIG[7]. However, that capability is not planned to be implemented by the NCES program in its initial increment currently scheduled to be fielded between 2007 and 2008[8].

GIG Semantic Channels as a Vital Information Filtering Mechanism

To help realize the concept of information profiles sooner and simplify the task of GIG information filtering, the authors are proposing the introduction of GIG Semantic Channels. In addition to defining interests and needs of individual consumers, Semantic Channels provide a means for establishing and sharing context-driven knowledge across a group of GIG consumers. As described below, Semantic Channels can be implemented using currently available and mature information technologies.

A Semantic Channel leverages a set of filtering policies each of which restricts information flow based on some common attributes or metadata about an information context, the channel's subscribers, or both. As shown in

Figure 2 below, these attributes might include contextual knowledge about a variety of subjects such as shared missions, roles, ranks and responsibilities, geographic locations, skills and resource constraints. Based on matching attributes in a user's information profile, a consumer could be automatically subscribed to one or more Semantic Channels. Alternatively, a consumer could discover the existence of a useful Semantic Channel and manually establish a subscription. Certain Semantic Channels could be tightly controlled to ensure effective use of GIG resources such as access to limited bandwidth environments, while others are managed more dynamically to meet the demands of a broader set of GIG information consumers.

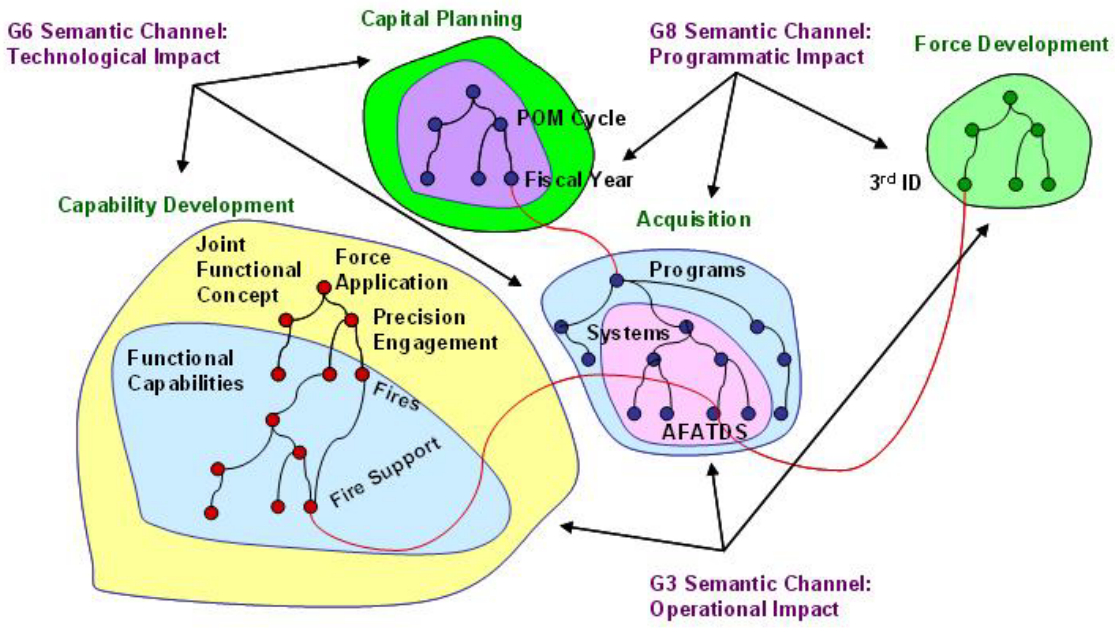

Figure 2 – Example of GIG Semantic Channel Filtering

A Near-Term Architecture for Implementing GIG Semantic Channels

The NCES vision for the User Assistant Core Enterprise Service includes intelligent agent capabilities that can search and discover information autonomously based on information profiles[9]. The field of intelligent agent technologies is both active and fertile within the Defense research community and academia[10]. NCES has plans to leverage these technologies as they mature. As these capabilities become available through NCES, Semantic Channels could also begin to incorporate intelligent agents to perform increasingly sophisticated information analysis and integration tasks.

Yet, as shown in

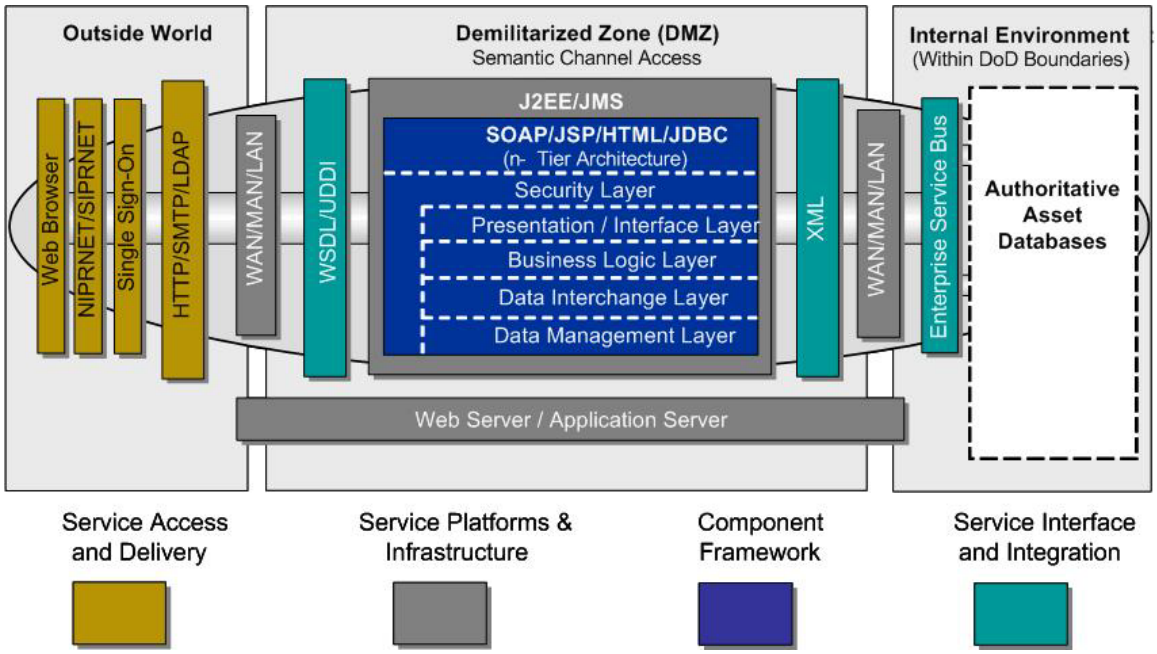

Figure 3 below, building on the DoD Enterprise Architecture Technical Reference Model[11], useful Semantic Channels can be implemented today using less sophisticated software components, Web Services technologies[12], XML[13] and relational databases. Filters supporting both information profiles and Semantic Channels for subscription and discovery can be expressed in XML and directly stored in a relational database. Information passed to the filters can either be stored directly in the same database or accessed indirectly from authoritative sources by leveraging existing and planned DoD metadata and service registries.

Semantic channels can be made discoverable and accessible to the DoD enterprise by packaging them as GIG enterprise services, and leveraging the enterprise service registry and discovery capabilities planned to be delivered in the first increment of NCES[14]. In the same manner as other GIG enterprise services, composite Semantic Channels could be created to aggregate or fuse information from multiple sources.

Unlike intelligent agents, the software components needed to implement this architecture execute under the rigorous control and security of COTS application and database servers, leveraging mature open standards. They can also leverage the distribution, scalability and failover capabilities of those server technologies. In fact, strategic distribution of semantic filtering technologies could greatly reduce total GIG bandwidth utilization by pre-selecting and fusing information closer to its source.

As such, Semantic Channel technology may be both readily achievable and affordable in the near-term. Furthermore, the immediate and strategic deployment of GIG Semantic Channels using today's technologies might significantly reduce the effort, time and cost needed to realize the value of information profiles for millions of potential GIG information consumers.

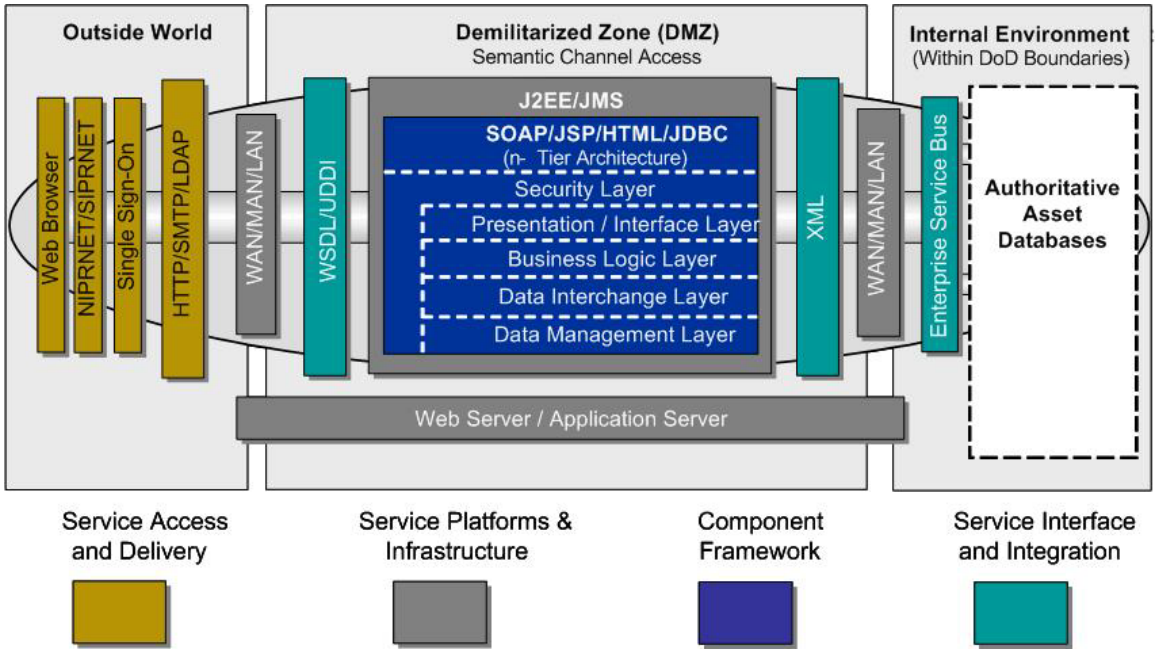

Figure 3 - A Near-Term Implementation Architecture for GIG Semantic Channels

Exploring an Initial Application of GIG Semantic Channels

Under the auspices of the CIO/G-6, Army Architecture Integration Cell, the authors are directing development of a progressive series of prototypes and pilot efforts to explore the GIG Semantic Channel concept and its applicability for managing the complexity and increasing the accessibility of architectural information. To test viability of the concept, the authors are working with an open architecture, COTS software technology that employs the near-term architecture discussed above.

The GIG CRD identifies the absence of a common cataloging scheme for indexing information as a fundamental barrier to realizing the intent of the GIG[15]. As illustrated in Figure 4 below, the authors have defined a standardized metadata framework or ontology that provides a means of organizing and classifying DoD architectural knowledge according to the roles and interests of DoD architecture consumers. This multi-dimensional ontology includes aspects such as missions, capabilities, organizations, assets (i.e. systems), geospatial locations, and timeframes. The authors are exploring the value of this ontology for organizing, accessing and filtering the Army's architecture information base, and thereby establishing Semantic Channels for architectures.

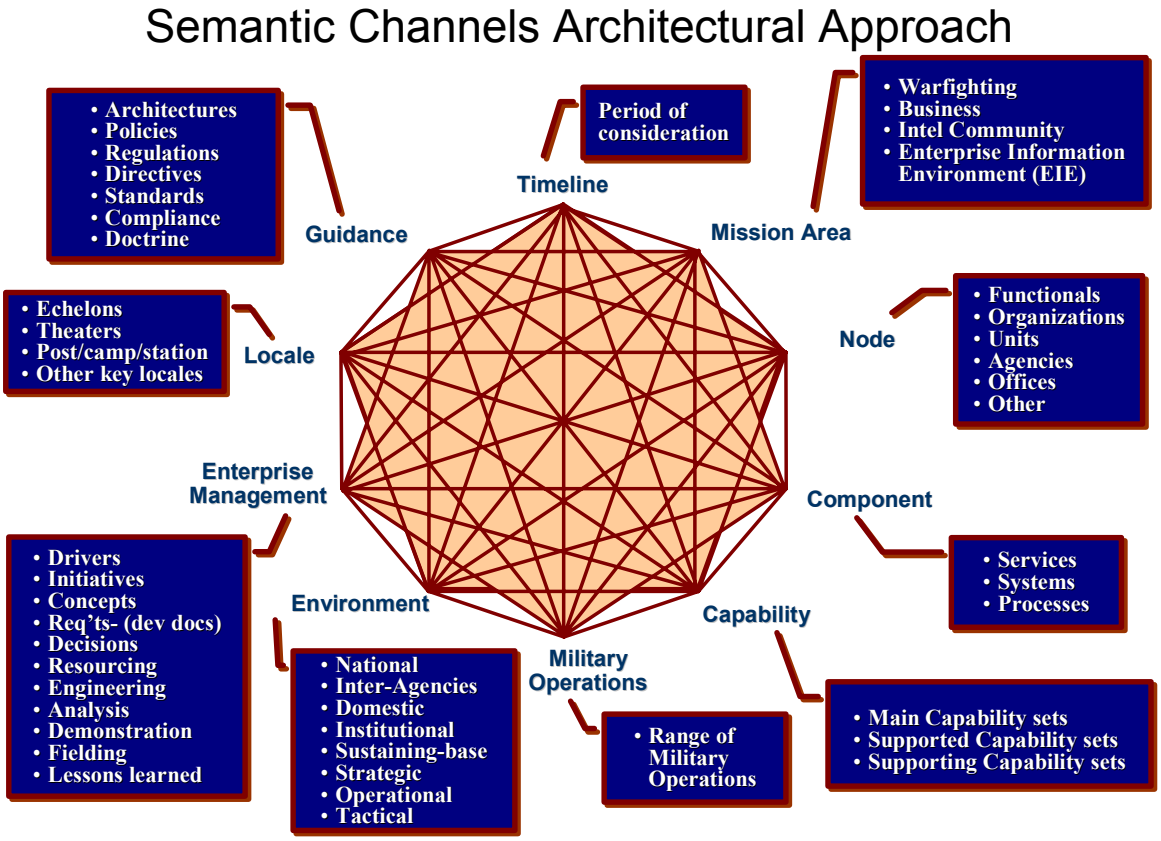

Figure 4 – Sample Ontology for Defining Architectural Semantic Channels

Preliminary Results

Initial efforts have focused on finding a means of defining a multi-dimensional information filter that could manage the complexity of the architectural ontology, yet be accessible to the average Army decision maker. Use of a number of COTS and GOTS architecture development environments were initially explored, and found to support only one-dimensional browsing. This provided a limited set of architectural information and knowledge in a manner not well suited for consumption by targeted decision makers across the Enterprise (DoD, Joint & Army).

Using a COTS asset management software technology[16], a portal-driven user interface prototype has been built that supports definition of common kinds of semantic filters, and also enables construction of more complex, multidimensional semantic filters using an advanced, aggregate query definition mechanism. The source information base has been populated with a small set of architecture data, just large enough to allow testing of the filtering capability. Usability tests of this prototype with decision makers have led to the introduction of an additional graphical navigation mechanism for constructing the semantic filter. The results, shown in Figure 5,

Figure 6 and Figure 7 below, have proven to be an effective combination that is sufficiently suitable for and accessible to Army decision makers.

The next prototype effort, just underway, is expanding the size of the source database to contain a more complete set of architectural information describing a modularized Army unit, as well as additional related information about the set of systems utilized in that unit. If this proves useful, a small-scale pilot implementation of the capability is next on the horizon.

Figure 5 - Prototype Graphical Filter Definition Interface

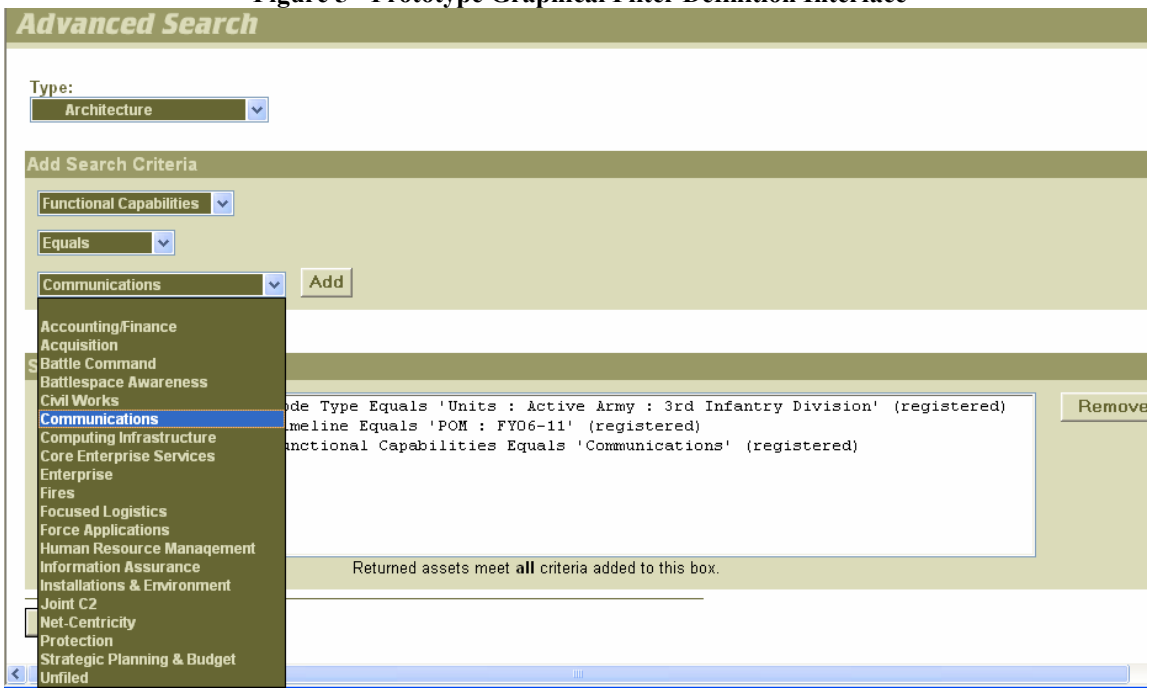

Figure 6 - Prototype Textual Filter Definition Interface

Figure 7 - Prototype Filter Results Interface

Way Ahead

In support of the architecture pilot, the authors plan to explore practical ways to insert Semantic Channel technology into the daily support processes of intended Army consumers. This will include ways to ensure automatic capture of cross-process architectural relationships and associated linkages to authoritative data sources, enhanced graphical navigation to create and access Semantic Channels, and simplified accessibility through standard Army portals. Part of this effort will involve automated linkage to Army and DoD service and metadata registries, and further work on encapsulating and reusing information profiles and Semantic Channel filters.

In addition, the authors are exploring how to combine Semantic Channels with file transformation software in support of reducing consumption of network bandwidth by files that are inherently large and therefore tactically prohibitive. Preliminary results using dissemination of compressed briefing materials have shown that it is possible to achieve 90% or more reduction in the use of bandwidth. The only loss due to compression is the ability to edit the graphics in the briefing slides. Considering the amount of network traffic utilization due to the exchange of large briefings, a Semantic Channel constructed specifically to support read-only briefing dissemination could offer substantial cost savings to the Department in terms of bandwidth, storage and tactical accessibility.

As a logical extension of this direction, the GIG Semantic Channel approach might be used to simplify the insertion of caching, compression and synchronization technologies and extend the GIG information space to tactical edge commanders and operators. The authors are working with the Future Combat System program to explore these capabilities as elements of the tactical bridge to NCES fielded services.

About the Authors

Mr. Damashek and Mr. Anderson currently provide contract support to the U.S. Army CIO/G-6, Army Architecture Integration Cell, specifically in support of enterprise synchronization and integration of the Army's architectural activities. In this position, they have been engaged as Army architectural liaisons to a number of Federal, DoD and Army-wide architecture activities including:

- The DoD Enterprise Architecture Community of Practice led by OSD-NII that is helping DoD establish and maintain alignment with the Federal Enterprise Architecture
- The GIG Enterprise Services Strategy Working Group led by OSD-NII that is codifying DoD policy on development and deployment of Enterprise Services across the GIG
- The NCES Engineering Working Integrated Product Team and Architecture Working Group led by DISA that is implementing Core Enterprise Services for DoD

- The Net-Centric Operating Environment Working Group led by the Joint Staff that is helping to synchronize a number of critical GIG infrastructure programs
- The GIG End-to-End Systems Engineering Working Group led by OSD-NII that is establishing standard technology profiles and architectures for the GIG
- The Future Combat Systems Working Integrated Product Team Working Group led by PM Unit of Action that is addressing alignment between DoD net-centric initiatives and the Army's future units of action

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