Enabling Network-Centric Operations with Semantic Web Technologies

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Network Centric Operations (NCO) involves the application of the tenants and principles of Network-Centric Warfare (NCW) to military operations across the spectrum of conflict from peace, to crisis, to war. NCW is the Department of Defense's (DoD) visionary approach for conducting future warfare and consists of networking the war fighting enterprise – shooters, decision makers, and sensors – to translate information superiority into combat power by "effectively linking knowledgeable entities in the battle space."[1]

Net Centric Operations will result in improved shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and self synchronization that leads to an overall increase in combat power.

The architectural implications of Net Centric Operations are an enterprise based on a Service Oriented Architectural (SOA) approach. The USAF Command and Control Constellation (C2C) is being designed and implementing using an SOA based enterprise architecture. However, key challenges still exist in the areas of service orchestration and data interoperability across the enterprise.

As stated in wc3.org: "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries."

"The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation." [2] We believe Semantic Web Technologies provide a critical capability to the USAF C2C to enable a solution to these challenges and to help the coalition of forces around the world.

This submission is to present two key use cases of Network-Centric Operations and how Semantic Web technologies can be applied to these use cases.

Use Cases[3]:

1. **Semantic Information Discovery and Sharing**

Large quantities of information across the Military and Government resides in nearly impenetrable silos. These silos of information have usually each been built one at time and most importantly with that Community of Interest's semantics. Additionally information resides in data stores that are protected by various levels of security and/or privacy. Finally some of this information is truly unstructured and often very large (e.g. satellite images) and cannot be easily and/or freely disseminated with or without security and privacy issues.

Today, the semantic heterogeneity of each of the Communities of Interest and even within a COI inhibits the ability to have situational awareness about potentially relevant information. We believe that Semantic Web technologies can help overcome this barrier.

The first step is to be able to associate semantically interpretable meta information (metadata) to each of the disparate heterogeneous information repositories. While it will be very difficult to have a single semantic ontology for all the data stores it must be possible to do semantic mediation of the metadata describing the information.

The second step is to create a ubiquitous Enterprise Service Bus (ESB) that supports brokered Publish and Subscribe (pub/sub). Then one or more topic ontologies can be created, preferably managed externally to the bus, allowing the meta information to be semantically published to relevant topics. In addition to the core pub/sub brokerage services, the ESB will provide additional services to support the semantic brokering of the metadata thus allowing the knowledge of potentially relevant information to be published across and within Communities of Interest.

The final step is to create a set of [Web] services that provide "intelligent" push and pull services that act on the information behind the metadata. These services can semantically "cache" (push) and semantically provide (pull) the actual information from the individual silo/data store. Note that the semantic push/pull operations would be to take into account QoS, network bandwidth, latency, situational relevance of the information, the user, the user's situation, security, and more.

2. Semantic Based Service Discovery & Orchestration

This use case includes:

- dynamic discovery of both services and service location
- semantic orchestration of services in a business process.

Service discovery is needed when services are incorporated in the development of a business process, when that process is deployed, and finally when the process is actually "executed". Semantic discovery will actually take on different meanings in each of these states.

At development time, the ability to discover the existence of a service based on the needs of the business process can be enhanced by Semantic Service Discovery. At deployment time, the ability to semantically understand how the process will be used and how the services in the process are used can assist in assuring the existence of at least one instance of a deployed service that can meet the needs of the process. And finally, at process execution time, the ability to locate the most appropriate instance of each deployed service, based on the semantics of the user, the venue, and even the physical constraints can result in a much more effective and efficient value proposition to the situation.

Services themselves can be instantiated by a number of processes; services can even be instantiated multiple times by the same process, each time with varying needs. Each time

a services is instantiated its semantics will define the specific needs and requirements of how it will be used, its relative importance to the invoking process, and other non-functional needs that can include Quality of Service, responsiveness, and more.

When a service is instantiated and is described semantically rather than in absolute terms, its capabilities required can as a result be derived semantically resulting in

- Improved discovery and understanding of data and services
- More agile integration and interoperability of information and services
- Better support for intelligent, adaptive applications.

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[3] Semantic Web Service Oriented Architecture Innovation Grant, Henry Bayard, Brian Blake, Ann Cady, Amy Kazura, Leo Obrst, Frank Petroski, Mary Pulvermacher, Len Seligman, MITRE Corporation,