12TH ICCRTS
"Adapting C2 to the 21st Century"

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Name of Author:	John A. Sturm
Point of Contact:	same
Name of Organization:	NuParadigm Government Systems, Inc.
Complete Address:	16091 Swingley Ridge Road, Suite 160 Chesterfield, MO 63017
Telephone:	(314) 401-6850
E-mail Address:	jsturm@nuparadigm.com

Abstract

NuParadigm recently received a Navy SPAWAR contract for "Secure Legacy Application Integration with NCES" (SLAIN). As a result, we are developing prototype system models to integrate civilian and military Command & Control (C2) across a Service Oriented Architecture (SOA) network using the internet protocol (IP). Web Services and standards provide the promise of reliable, secure interoperability among disparate applications and technologies. However, integration of Command across Civilian and Military structures is as much about creating interoperability among cultures. Atkinson & Moffat (2005, pg 161) describe the nature of Command as "a function of trusts, fidelity and agility", whereas, Control is a function of rules, time and bandwidth".

Civilian Commands all work under and among state & local governments who have worked out complex trust relationships to get things done such as new roads, disaster relief, criminal pursuit across jurisdictions, etc. In this paper we will explore some of the hopes, challenges and examples of using an SOA environment to extend civilian relationships with the military. The emerging SOA approach is surprisingly adaptive and capable of supporting both communication bandwidth as well as adapting the message between sender and receiver to be understood in the local context (culture) of each other.

Introduction

To begin, it is important to observe the role of communication networks and particularly the internet in supporting the creation, self-organization and maintenance of Command & Control structures. Atkinson & Moffat (2005, pg 161) also stated, "Organizations have a choice: if they with to exert control over the battlespace, as

opposed to command, they need to provide the rules and quantitative technological bandwidth necessary. If they wish to command, as opposed to control the battlespace, they need to provide the more qualitative trusts of fidelity and agility in their people. Taken one step further, command is more associated with culture, and control with technology; and it is the effect of one upon the other that is key." The task of integrating Civilian and Military Commands is as much about respecting and communicating within the context of each participant's culture as it is about having the bandwidth and network access to assign and manage the rules of a battle.

One of the most exciting areas of synergy between the requirements for C2 and SOA internet technology is the ability to rapidly standup, support and link evolving networks across all types of organizations and cultures. Just as social networks and roads supported the expansion and maintenance of Roman rule (C2) over disparate regions for many centuries, the internet provides the virtual roads and social gathering points to support C2 across the world today. In particular, the evolution of "Random Networks" to become "Small World Networks" and then "Self-Organized Scale-Free Networks" are critical to C2 across military and civilian organizations.

The internet is surprisingly capable in supporting both types of communication exchange; however, discovering, adapting (i.e. transforming/mediating message contents) takes additional time to understand & communicate the situational awareness (and cultural awareness) of our partners as well as foes.

Network Evolution to Support C2 Environments

As mentioned, the evolution of "Random Networks" to become "Small World Networks" and then "Self-Organized Scale-Free Networks" are critical to C2 across military and civilian organizations. Random Networks usually form thru chance meetings among people that discover common interests, such as local residents that live near a harbor in the US. Providing a small amount of communications support to random networks (possibly through email access/links) can cause them to have high situational awareness of their particular area. Stephen Young, former Navy Commander and author of ***America: The Vulnerable*** (2006) points out that small groups of individuals in neighborhoods near valuable resources such as shipping ports can have a valuable contribution to Port Security through situational awareness. Terrorists must plan and conduct surveillance on a target for a considerable period of time before attacking the target and they are susceptible to discovery during this time by an informed group of observers.

Building on this example of Self-Organization of neighbors to assist with Port Security, C2 Operations Centers such as the Joint Harbor Operations Centers (JHOC) would benefit from knowledge gained by a large number of these neighborhood cells. "Self-Organized Scale-Free Networks" consist of a few nodes that have lots of links to many cells and act like "hubs". In fact Atkinson & Moffat (2005, pg 101, 111) "anticipate that Internet or Web-links between individuals will tend to lead to (Self-Organizing) Scale Free Networks." Hubs tend "to become more formal if they are to

manage their connections to concentrate and dispense their power effectively." The C2 system becomes "a network of formally defined, locally clustered cells with longer range links (shortcuts over the internet) between them: a Small World" network. In summary, "both Informal Networks and the Formal Organizational Structure are required to work well together in order to deliver the Agile Organization" for effective C2. Ultimately, the arrangement of social relationships and networks should evolve to become Complex Adaptive Systems (CAS) that are "able to dynamically co-evolve and change within, or as part of, a changing (C2) environment" (Atkinson & Moffat, 2005 pg 42).

Current SOA Technology Challenges

As networks evolve, XML messages bear the burden of larger overhead data requirements, especially for the message state recognition that is necessary for conveying context and maintaining security. This overhead includes:

- Transmission and receipt data
- Message validation data
- Tagging of meta-data content and Keywords
- Authentication and authorization data
- Activity monitoring and auditing data
- Encryption & associated De-encryption processing and related Key Management

These overhead burdens become rapidly amplified as the number of concurrent instances grows to even moderate levels. Service areas that are affected by this model include:

- Performance – memory requirements grow exponentially, placing drag on the system
- Scalability – growth in this model imposes costly infrastructure requirements.
- Resiliency – offering seamless service plus audit reporting imposes greater restrictions on the granularity of security roles and data definitions supported due to the associated cost in processing and storage requirements.
- Federation – all overhead issues are magnified when the requirements for Policy management and communication over disparate systems and technologies are introduced. Policy must in accord with the Memo of Understanding (MOU) of how organizations wish to cooperate and network.
- Situational Awareness of Content & Context – The ability to embrace and instantiate appropriate knowledge into Policy & Rules that have situational (Cultural) awareness is an essential technology partner to Combatant Commanders (COCOMS).
- Content-Aware Object Routing – Monitoring and providing content & context-based distribution/routing of information based on Enterprise-wide Policy management.

Solution Approach & Direction

The SLAIN secure object framework introduces a next-generation solution by offering security, system continuity, and reliability in a unique way: The framework routes objects through a Secure Context Object Routing Engine (SCORE) rather than routing

messages through traditional transport channels. Object state data is maintained within the service object itself instead of as system overhead associated with processing the messages related to a service. Realized benefits include:

- Reliability – achieved through context specific object message constructs
- Security - validation, authentication, and authorization are directly managed within the object
- Object monitoring – object activity is directly captured within the object as it goes through the service cycle for audit and reporting purposes
- Efficient handling - unnecessary repetitive object handling and parsing is eliminated since the full context of the data object is maintained in one place

As a result, system performance is positively impacted as transaction overhead is dramatically reduced. Realized service improvements include:

- Performance - Service management overhead grows in direct proportion to volume rather than exponentially.
- Scalability - SCORE hubs are easily distributed. The inherent independence of service objects due to internal state maintenance makes this possible.
- Effectiveness – Finer security and data granularity with detailed activity tracking are readily achieved since the objects are not constrained in their ability to store the information required to achieve this.
- Synchronization - The independence of objects also allows for ease of implementation in asynchronous access models such as publish and subscribe.
- Resiliency - Object routing also increases attack prevention capability since all objects are easily validated or rejected within the secure object framework.
- Federation - SCORE hubs are able to retain necessary context translation definitions and transparently facilitate object transfer between domains.
- Object Routing - Most importantly for network evolution to support the development of "Small World Networks" for efficient C2, the Object routing provides necessary "shortcuts" to facilitate the growth & maintenance of relationships among culturally diverse partners.

Example for Presentation: Integrated Public Alert & Warning System (IPAWS)

In addition to the Navy SPAWAR research effort, NuParadigm has received a contract from FEMA for development of the IPAWS (Integrated Public Alert & Warning System) functionality for the thirteen-state hurricane risk area of the US. The IPAWS model shown below is also under consideration by the Navy as part of their Maritime Domain Awareness (MDA) COI experiment in the Trident Warrior'07 Exercise in March, 2007. The Legacy State Computer-Aided Dispatch (CAD) and the Legacy City Computer-Aided Dispatch (CAD) systems shown in figure one are examples of potential "Small World Networks" which can be linked through the SLAIN technology of Object Routing to form the Military-Civilian Command Authority. The overall C2 network could then evolve to become a "Self-Organized Scale-Free Network".

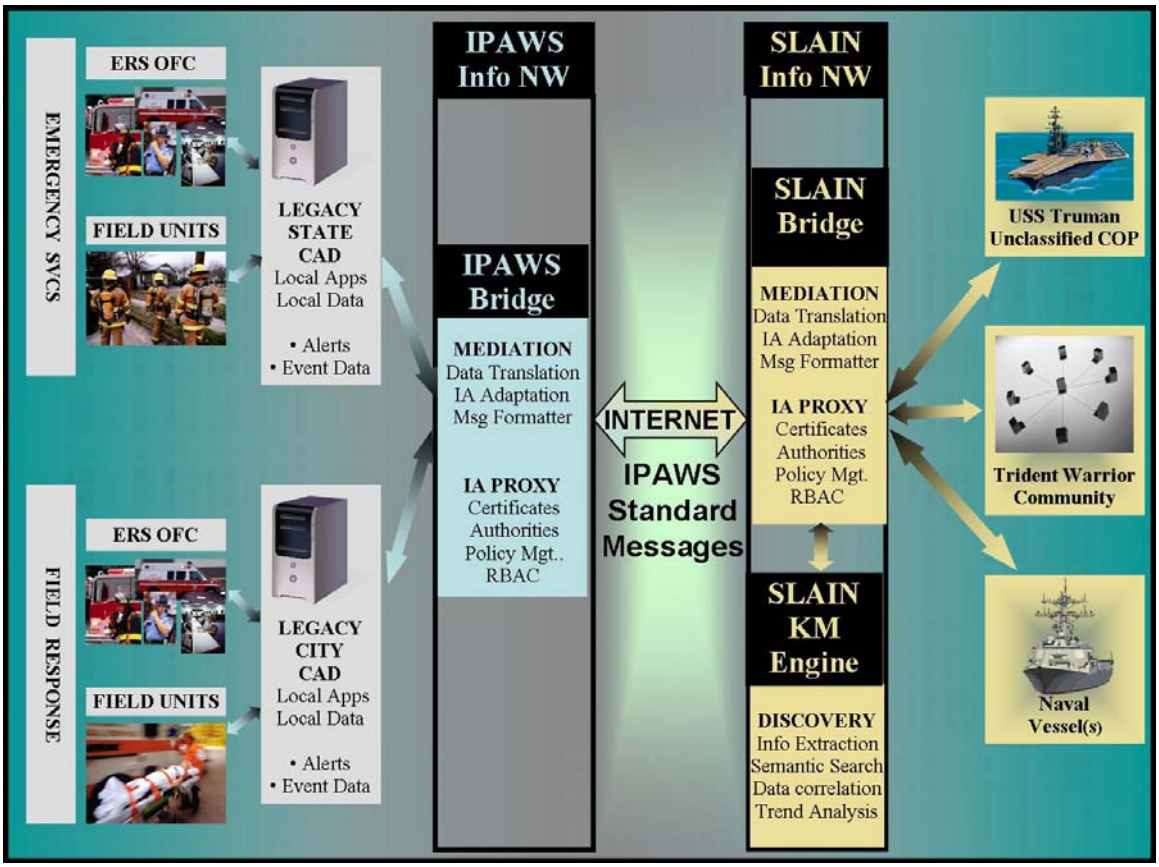

Figure One – Part of the Maritime Domain Awareness (MDA) COI experiment in the Trident Warrior'07 Exercise using the FEMA IPAWS (Integrated Public Alert & Warning System) functionality for the thirteen-state hurricane risk area of the US.

Summary

The SOA network environment can act as a strong catalyst for development of effective and agile C2 structures. The vision of an effective C2 system becomes a network of formally defined, locally clustered cells with longer range links (shortcuts over the internet) between them: a Small World network. In summary, "both Informal Networks and the Formal Organizational Structure are required to work well together in order to deliver the Agile Organization" for effective C2. The secure object routing framework described earlier promises to provide the "shortcuts" essential to C2 network evolution.

However, significant challenges remain to develop the SOA networks required. The overhead associated with maintaining the message stream and the higher levels of abstraction required in web service communication make this promise difficult in systems of even moderate complexity. This is particularly pronounced when using an integration architecture that follows traditional, centralized orchestration patterns. The challenge is maintaining security, performance, and reliability across disparate systems while minimizing the impact on service levels and the need for significant additional

infrastructure investment. As a result of our Navy work, we will be addressing several fundamental issues that need to be solved for deployment of C2 over the GIG with full situational (and cultural) awareness to support integrated Military and Civilian operations.

References

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