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Course of Action Analysis in the Global Information Grid

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Introduction: The Department of Defense (DoD) is investing resources to support the development of the Global Information Grid (GIG)[1] a services-oriented architecture (SOA) based on web services technology (Fig. 6). The GIG will enable interoperability between all levels of military systems, sensors, simulations, operational users, autonomous software agents, etc., in tasks that range from purely administrative through complex Command and Control functions throughout the DoD. This article discusses the participation of NRL in a GIG proof-of-principle prototype that uses web services to provide the connectivity between the Global Command and Control System (GCCS),[2] Joint Warfare Simulation (JWARS),[3] as well as intelligent software agents to support Course of Action Analysis (CoAA). We also describe two of the many challenges that software agents must overcome to realize the full potential of the GIG.

Web Services and the GIG: The World Wide Web Consortium (W3C)[4] is leading the development of web technology, including web services technology such as the Universal Description Discovery Interface (UDDI), Web Service Description Language (WSDL), and Simple Object Access Protocol (SOAP). The UDDI defines web registries to which businesses can upload information about themselves and the services they offer. A WSDL document describes the locations of services and the operations supported by that service. The SOAP is a simple markup language for describing messages between applications. It is used to interact with UDDI registries to locate WSDL documents and to interact with the corresponding service described within the WSDL.

The GIG infrastructure will provide an open environment in which all military systems and users can seamlessly share information, without restrictions and limitations imposed by the current operational DoD architecture, which provides stovepiped interconnectivity between components (e.g., interface points between systems or components are inflexible and nonrobust to change or adaptation). The GIG represents a transformational shift, from stovepiped to a more flexible architecture, providing the opportunity for systems and users to dynamically discover and interact with other systems/users via web services. Figure 6 shows the GIG layers.

GIG Proof-of-Principle Prototype: Simulations are increasingly being used during operations to perform CoAA and develop real-time forecasts of future battlefield conditions. The Defense Modeling and Simulation Office (DMSO) is sponsoring a prototype to demonstrate (1) the utility of web services for providing interconnectivity between GCCS, JWARS, and intelligent agents; (2) the value added in using a standard data model to enable semantic interoperability between each component; and (3) the role of intelligent agents to support meaningful CoAA. NRL is responsible for developing the intelligent software agents; the Naval Warfare Development Command (NWDC) is responsible for web-service interfaces for GCCS and CACI Federal for the overall integration effort as well as the web service enhancements to JWARS.

GCCS is an automated information system designed to support situational awareness and deliberate and crisis planning through the use of an integrated set of analytic tools and flexible data transfer capabilities. The GCCS system correlates and fuses data from multiple sensors and intelligence sources to provide warfighters the situational awareness needed to be able to act and react decisively. JWARS is a campaign-level model of military operations that provides users with a representation of joint warfare to support operational planning and execution, force assessment studies, systems effectiveness, and trade-off analyses, as well as concept/doctrine development. The field of software agents is emerging as an important computing paradigm. Many definitions of software agents exist in the literature, but a general definition of a software agent according to Ref. 5 is "a computer system that is situated in some environment, capable of autonomous action in this environment in order to meet its design objective."

In the proof-of-principle evaluation (Fig. 7), GCCS is initialized with Unit Order of Battle (UOB) data that represent known locations of forces prior to plan execution. JWARS is also initialized with this UOB to ensure consistency with the force representation in GCCS. A tactical system will inject tracks into the GCCS track database as the execution of the plan unfolds, while JWARS will generate the corresponding expected track movements. Both sets of tracks will be made available to software agents that will compare deviations between the actual vs expected

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FIGURE 6
Layers of the Global Information Grid (GIG).

track positions, determine whether certain tracks enter regions of interest (or, alternatively, fail to do so) in a given time period or instant. They will also compare expected vs actual force blue/red ratios in regions of interest. The thresholds or failure conditions associated with these events, as specified by the user, will trigger the agents to send alerts to the JWARS Situation Monitor. The user may then spawn look-ahead excursions in JWARS to evaluate multiple options (i.e., CoAA), selecting the one that maximizes a set of objective functions.

The Command and Control Information Exchange Data Model (C2IEDM)[6] gateway will map the information exchanged between services onto the C2IEDM vocabulary. The C2IEDM is an extensible model representing Information Exchange Require-

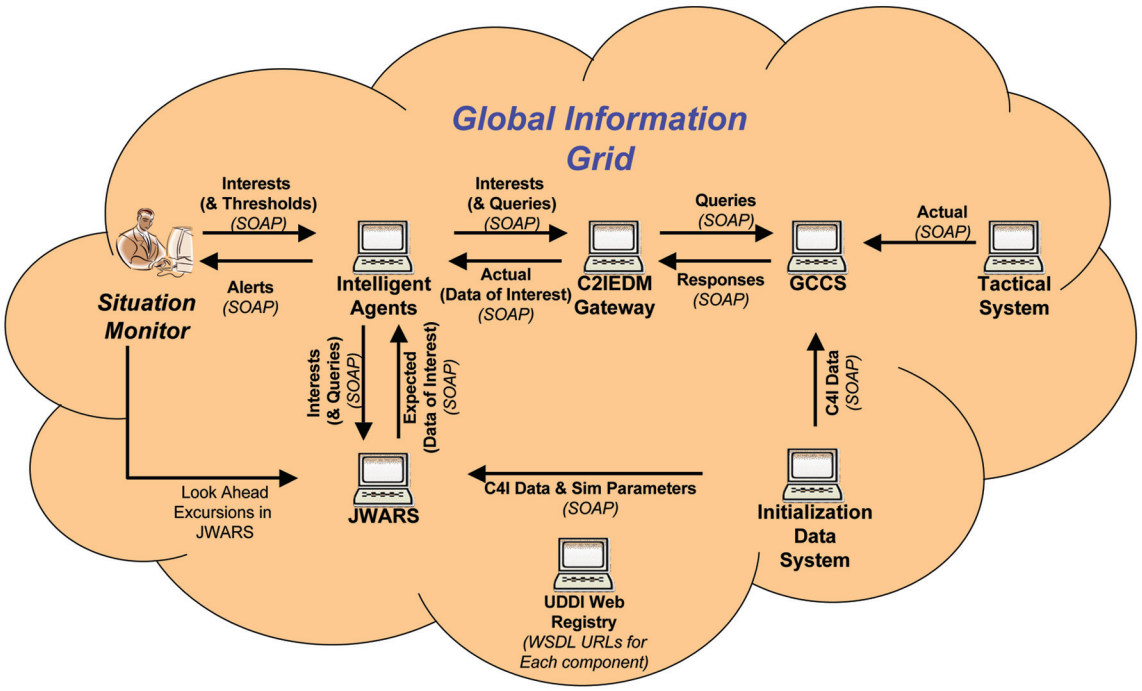

FIGURE 7
The JWA0RS, GCCS, and Intelligent Agent Web Service Federation.

ments for Command and Control that has been developed through the participation of experts from 27 nations.

The technology is currently undergoing experimentation in a laboratory environment and, through feedback from subject matter experts, the capability will be refined to provide these unique CoAA services to the broader GIG community through participation in integrated demonstrations.

Summary: This article has described a GIG proof-of-principle prototype that leverages web services to enable the connectivity between GCCS, JWARS, and intelligent agents to support CoAA. Many challenging issues remain regarding the roles intelligent software agents may play in the GIG, including their use for intelligently discovering services as well as potentially supporting the process of mapping information between the GIG Communities of Interest (COI). The C2IEDM vocabulary may not be persistent throughout the GIG. The proof of principle will enable us to explore the use of semantic web technologies and human-agent cooperation and agent learning techniques to address these problems in the longer term.

[Sponsored by DMSO]

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