objective statement

The goal of the Fast Connectivity for Coalitions and Agents Project (FastC²AP) is to extend agent-based technologies to accommodate secure web services and user-level implementations.

vision statement

FastC²AP will enable the secure connection of traditional agent technology to web services and provide this capability to military end users (not just system administrators). Additional benefits will include reduced development time (time to construct, integrate, and make interoperability relevant), reduced execution time (time saved by off-loading tasks from humans), increased Situational Awareness, and reduced maintenance costs (time and effort to change or enhance a fielded system).

fast connectivity for COALITIONS AND AGENTS PROJECT

2005

FASTC²AP

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ABSTRACT

Changing circumstances have created a barrier to effective deployment of agent-based technologies. FastC²AP will attempt to remove that barrier by applying agent-based technologies to two principal developments in software user requirements. The first development to be addressed is the use of web services. The second development is the increased popularity of collaboration tools. Ultimately, by demonstrating the successful application of agent-based technologies to these two developments, FastC²AP may be able to facilitate the widespread adoption of agent-based technologies by the military services.

FastC²AP is doing this by leveraging DARPA's $55 Million investment in the Control of Agent Based Systems (CoABS) program, which developed a breakthrough, disruptive technology with dynamic discovery and connection of military systems in heterogeneous environments. By establishing a framework for integrating diverse legacy systems, the technology developed under CoABS provided a capability to enhance operations.

The goal of FastC²AP is to establish a Common Maritime Operational Picture so a single watchstander can manage more than 100 High Interest Vessels and Vessels of Interest, as demonstrated in the Theater Maritime Fusion Center (TMFC) in Naples, Italy, with less than one percent false alarms in real time identifications of anomalous behavior.

To achieve this goal, Phase 1 of FastC²AP focused on proof of concept demonstrations and establishing a transition path. Phase 2 of the program is focusing on hardening, expanding, and implementing the concepts from Phase 1 as well as other required improvements.

THRUSTS

The FastC²AP program consists of three interconnected thrusts summarized below.

THRUST 1

Agent-Based Computing for Maritime Common Operational Picture (ABC-MCOP)

This thrust represents a spiral development effort led by Mr. Ranjeev Mittu that will prove that the FastC²AP technology really works in US C2 environments. The goal of ABC-MCOP is to demonstrate the utility and effectiveness of agent-based computing for providing an improved MCOP to watch-standers at the US Sixth Fleet TMFC.

THRUST 2

Human Systems Integration

The Human Systems Integration Thrust, led by Dr. Jeffrey Morrison, will work to make agents readily accessible to warfighters. This will be achieved by allowing agents to be dynamically adaptable to access different operational information. Work under this thrust will also make user-created applications available across enclaves as they are created.

THRUST 3

Coalitions and Agents Experiment 2

CoAX2 will prove that the technology really works in coalition C2 environments by enabling coalition interoperability at a fractional cost and schedule. It will deliver agent-based capabilities that fundamentally simplify the effort to interconnect coalition C4ISR systems to enhance planning, command, execution, combat support, and response to changing coalitions. Specifically, this thrust will deliver tailored software grid and agent software; experimentation with a suitable limited objective experiment; and hardened software and transition to a naval supporting program of record.

THE STORY FastC²APf

The Fast Connectivity for Coalitions and Agents Project (FastC²AP) and its driving technology may seem intimidating to individuals new to the underlying technology. As is the case with many programs on the cutting edge of technology, the story of the program and its applicability in certain domains can get clouded while trying to wade through the relevant terminologies and acronyms tied to technological advancements. *The Story of FastC²AP* acts as an introduction to those new to the program, and serves as a refresher to those familiar with the supporting technologies and the actual program.

Agents

Imagine a software application such as Microsoft Word. Now imagine if this program acted if it had a "mind of its own" without waiting for user input. That is, the hypothetical program may proactively seek data from other programs and begin populating a Word document without a single keyboard operation on the part of the user. This hypothetical, autonomous program serving as an assistant to individuals or other programs is referred to as an "agent."

Agents are at the root of the story of FastC²AP and its predecessor program CoABS (Control of Agent Based Systems). The CoABS program created a framework for software agents to interact and the FastC²AP program has built upon that framework by introducing new advancements to agent-based systems. You'll find many contradictory definitions of agents, because they are a hot, new area of research. Therefore, we must define what we mean by FastC²AP agents.

For the purpose of *the Story of FastC²AP*, we will define agents as autonomous software programs that have specific functionality. Furthermore, these autonomous software programs, or agents, must register themselves to a look up service that maintains a record of the currently available agents. While this definition is basic, it serves as a starting point for our continuing discussion of agents. More specifics about agents for the FastC²AP domain are discussed in later sections, including more detailed descriptions of the terms addressed in the above definition.

FastC²AP Infrastructure

We will use a running analogy to illustrate the story of how FastC²AP agents form and interact. The analogy is that of a small business in which our autonomous agents serve as employees. We'll affectionately name our business FC, Inc. For now, let's disregard the nature of FC, Inc.'s business and develop our analogy further as we delve into the features of FastC²AP.

First, let's discuss our agents (employees). The first thing to consider with employees of a business is that each one is hired to do a specific task. The same holds true for agents. The agents in FastC²AP are either created from scratch for a specific task, or are "agentized" from an existing legacy system. This simply means that for certain legacy (pre-existing) programs, it is possible to run a wizard (similar to many you'll see in commercial off-the-shelf programs), to wrap a communication shell around the pre-existing agent, allowing it to communicate with other agents. This is a powerful feature because instead of developing software from scratch to satisfy a purpose, you can use pre-existing programs with minimal effort.

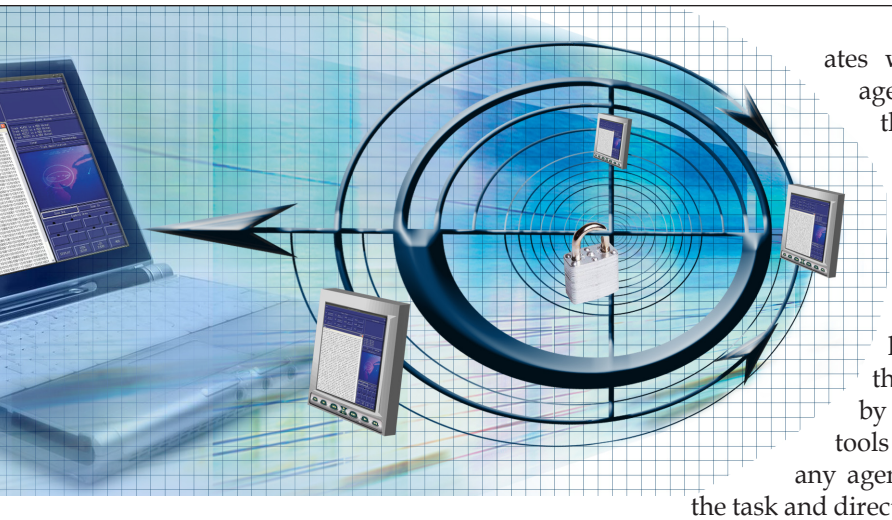
The way that these agents are created essential to the FastC²AP program, however the question exists about how these agents announce to the world that they are available for communication. To answer this question, we'll revisit our analogy about FC, Inc. Our company uses badges as a security measure to record when employees enter or leave the office. Employers may then reference this record to determine when an employee is on the premises. Similarly, because FastC²AP agents must register with a look-up service (LUS), the LUS is always aware of what agents are present within a local area network (LAN) at any given time.

The idea of a LUS and agent registration is made possible by the FastC²AP Grid. The Grid serves as a means (i.e., middleware) for the integration of heterogeneous FastC²AP agents. Thus, the Grid includes software for the LUS, agent registration, agent communication, and security. The Grid is often used to describe the combination of the FastC²AP infrastructure including all of the agents and web services connected on it, but for clarity purposes all references to the Grid in this article refer strictly to the software involved for these agent based systems.

Security

The idea that there are various autonomous agents sending messages back and forth between each other could raise the question of data security. However, unlike many software projects finding themselves plugging holes as serious security breeches occur, from the start the FastC²AP program has made security a top priority and continually prides itself on taking a proactive approach to security.

There are various features of FastC²AP that make agent based computing very secure. One security feature provides the capability for encryption of data as it is passed from one agent to another. A second security feature dictates that the receiving agent is only allowed to decrypt the data if the agent passing the data "trusts" the receiving agent. The technical way to describe this process is that communication between agents uses Secure Sockets Layer (SSL) where a peer has to present a trusted PKI certificate to establish communications. A third security feature in FastC²AP, is that there are two types of agents, public and private. Private agents are not exposed



ates workflows of agents, enabling them to communicate with each other to accomplish a larger task. FastC²AP has addressed this problem by introducing tools that enlist any agent relevant to the task and direct that agent to interact with other agents within the system to accomplish the task at hand.

externally, limiting communication to only a limited subclass of agents.

Usability

At this point in our story we have an infrastructure for our agents to thrive in, and we have means for them to securely communicate with each other, but what is their purpose or intent? In terms of our business analogy, we now have a company full of employees without a manager. Without a manager directing employees to utilize their skills and collaborate to complete tasks, nothing would ever get accomplished. The same is true in the agent world. The human operator seeking information is our FastC2AP manager. This individual must configure agents to retrieve the information of interest. The proper configuration of single agents and the creation of workflows for a series of agents (i.e., the management plan using our analogy) can be a daunting task. FastC²AP has established state-of-the-art tools to maximize the utilization of agents.

There are two main subclasses of problems that face a user wanting to manipulate an agent based system. One problem arises during the configuration of a preexisting agent for a particular task. An agent may have a usable capability requiring certain types of input. FastC²AP has simplified the process of defining that input, allowing agents to configure in less than a minute! A more complicated problem arises when the user cre-

Web Services

One of the most exciting new developments to come out of FastC²AP is interoperability with web services. Web services are defined as applications that register themselves to a sort of "Yellow Pages," called UDDI, using Web Services Description Language (WSDL) and then exchange data using Extensible Markup Language (XML), usually with SOAP – a protocol for exchanging messages between web services. Let's take a deep breath and analyze what all of those acronyms mean. XML is a format for representing data. Almost anything that deals with web services involves XML in some way. WSDL is a description (XML-based) of the web service that describes how to communicate with the web service. And as mentioned earlier, web services register to UDDI, which serves as the "Yellow Pages" for web services.

Web services are essential to FastC²AP because many of these services appear in both industry and the Department of Defense, so interoperability is important. FastC²AP achieves interoperability by creating an agent that utilizes other FastC²AP agents and then creates WSDL entries in UDDI servers for them. It is also capable of taking in a WSDL entry as input and creating an equivalent agent that is then registered to the LUS. The result is that a FastC²AP agent appears as a web service and a traditional web service appears as an agent.

FastC²AP Users

It is time to reveal the type of business that FC, Inc. performs. The nature of the business is … whatever you need it to be. A common misconception experienced on the FastC²AP program is pigeonholing it and the technologies it has introduced to one particular instantiation. FastC²AP technologies have been instrumental in various military applications such as a maritime awareness system in C6F. However, the C6F transition is just one of many possible instances of FastC²AP technologies being used. This doesn't mean that if you are not in the business of tracking ships that you can't use FastC²AP. This is analogous to hearing that your friend wrote a novel using Microsoft Word and deciding that you shouldn't use Word because you aren't a novelist. The power of agent based computing is its freedom to be used in various domains and the technologies introduced by FastC²AP make applying agents that much more efficient.

The Future of FastC²AP

The contributors to FastC²AP are not the types to rest on their laurels. Instead, everyone involved in the program continually pushes the envelope for what agent based computing can accomplish. Although usability has come a long way for agent based computing through this program, further HCI research and wizards are being examined to make agent use even more efficient. Security will continue to be updated to coincide with industry standards. The technology introduced to create seamless integration between agents and web services is being extended to include service-based software in the military that may not be WSDL-based. The story of FastC²AP has a beginning, but because of the contributions to the field of agent based computing and the research ideas it has inspired, the end does not appear to be anywhere in sight.

theater maritime FUSION CENTER

John Mittleman

The Theater Maritime Fusion Center (TMFC) in Naples, Italy, was stood up on 23 January, 2004, with the vision of an all-source track and Command and Control (C2) systems management center. In particular, the TMFC manages the Global Command and Control System (GCCS) Common Operational Picture (COP), and tactical data links to produce a Common Maritime Theater Picture for dissemination to operational units and command elements throughout the European Command area of responsibility.

The TMFC is also responsible for future C2 and track management operations, which will include data feeds from our NATO allies and emerging partners, as well as data related to navigational safety for merchant vessels. By including these feeds in the data to be managed by the TMFC we will, this year, experience an order of magnitude increase the volume of data to be assimilated, analyzed, filtered and displayed. To meet this enormous challenge, the TMFC is reaching out for cutting-edge technologies – among them intelligent agents, web-based services, and multilevel security guards – that will help the watchstanders understand normal and anomalous behaviors, and generate actionable alerts when questionable events or behaviors are noted.

The TMFC also prepares data for exchange with NATO and coalition partners, and works hand-in-hand with the Military Sealift Command to include USNS and charter vessels supporting theater operations. The TMFC operates 24/7, communicating continuously with units afloat and ashore to produce the most accurate Common Maritime Theater Picture possible.

darpa's mission TO SUPPORT CUSTOMERS

The Defense Advanced Research Projects Agency (DARPA) is the central research and development organization for the Department of Defense (DoD). It manages and directs selected basic and applied research and development projects for DoD, and pursues research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions.

DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.

DARPA's mission implies one imperative for the Agency: radical innovation for national security. DARPA's management philosophy reflects this in a straightforward way: bring in expert, entrepreneurial program managers; empower them; protect them from red tape; and quickly make decisions about starting, continuing, or stopping research projects.

onr's mission TO SUPPORT CUSTOMERS

The Office of Naval Research (ONR) coordinates, executes, and promotes the science and technology (S&T) programs of the United States Navy and Marine Corps through schools, universities, government laboratories, and nonprofit and for-profit organizations. It provides technical advice to the Chief of Naval Operations and the Secretary of the Navy and works with industry to improve technology manufacturing processes.

ONR's mission is *"To plan, foster and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, forced entry capability, and the preservation of national security."*

DESCRIPTIONS Organizations performing on FastC²AP

Global InfoTek, Inc. (GITI) is an innovator in the development and application of intelligent systems and software agents. GITI has conducted research with software agents for DARPA and applied its research towards nationally important problems in the defense and intelligence communities. Under the FastC²AP effort, GITI developed the Composable Heterogeneous Agents for Intelligent Notification (CHAIN) technology. This technology allows thousands of autonomous agents to seamlessly and semantically interoperate in order to monitor and fuse massive amounts of information into actionable intelligence for shared situation awareness, effective decision-making and critical event notification.

Lockheed Martin Advanced Technology Laboratories (ATL) is the Corporation's advanced computing, applied research and development asset. Lockheed Martin employs about 130,000 people worldwide and is principally engaged in research, design, development, manufacture, and integrations of advanced technology systems, products, and services. Lockheed Martin ATL serves as a prime contractor on the FastC²AP program working with University of Maryland's MindLAB. For this effort, ATL is developing a suite of software tools that will provide: rapid agent tasking from user-level requirements, smart discovery and orchestration of services through semantic reasoning, seamless linkage of services across DoD frameworks, and verifiable compliance with disparate security architectures. These software tools will allow operational end-users to effectively compose agents that are adaptable to new situations and emergent operational demands.

Pacific Science & Engineering Group, Inc. (PSE) is a small business, headquartered in San Diego, California, specializing in human factors, cognitive science, and organizational processes for solving challenging problems in complex systems. The senior staff at PSE are board certified in Human Factors and Ergonomics; most of their technical staff of 34 professionals hold advanced degrees and several are affiliated with universities and colleges. PSE's work has appeared in scientific journals, been presented at professional conferences, and is in operational use in U.S. military command and control systems worldwide. PSE is providing design support to the HSI thrust of FastC²AP as well as performing supporting research.

The Georgia Tech Research Institute (GTRI) is the nonprofit, applied research arm of the Georgia Institute of Technology. GTRI conducts groundbreaking research, educational programs, and economic development initiatives that advance the global competitiveness and security of Georgia, the region, and the nation. GTRI's approximately 1,200 employees perform or support more than $130 million in research yearly for clients in government agencies, industrial firms, academic institutions, and private organizations. Under the FastC²AP effort, GTRI serves as the lead of the HSI team with the mission to provide technical expertise to Lockheed Martin and DARPA on the topic of human interface design within the overall human systems interface.

The Naval Undersea Warfare Center (NUWC) is the Navy's full-spectrum research, development, test and evaluation, engineering and fleet support center for submarines, autonomous underwater systems, and offensive and defensive weapons systems associated with undersea warfare. One of the corporate laboratories of the Naval Sea Systems Command, NUWC is headquartered in Rhode Island, and has two major subordinate activities -- Division Newport (also in RI) and Division Keyport (in Washington State). For FastC²AP, a team from NUWC is focused on architecture design, development of data gathering agents, and project coordination in cooperation with NWDC, DARPA, SSC-SD, GITI, and Lockheed Martin ATL.

The Naval Research Laboratory (NRL) in Washington, DC is the corporate research laboratory for the Navy and Marine Corps and conducts a broadly-based multidisciplinary program of scientific research and advanced technology development. The research areas encompass materials, techniques, equipment, systems, ocean, atmospheric, space sciences and related technologies which are directed toward maritime applications. NRL is leading the ABC-MCOP thrust area and serving as the technical liaison between Global InfoTek, Inc. (GITI) and the Naval Undersea Warfare Center (NUWC) to ensure the associated software addresses operational requirements at the TMFC.

Space and Naval Warfare Systems Center San Diego (SSC San Diego) is the Navy's lead command and control research, development and engineering center. Although it reports to Space and Naval Warfare Systems Command (SPAWAR), SSC San Diego also performs technical program work for a wide variety of other Navy and joint command sponsors. The Center conducts a wide range of R&D, test and evaluation, engineering and fleet support tasks related to command & control and human factors. SSC San Diego is providing Human Systems Integration (HSI) and systems engineering support to FastC2AP. They are facilitating the certification and accreditation of the tools being developed as well as facilitating their transition into Navy programs of record.

SPAWAR Systems Center San Diego

The University of Maryland Information- and Network- Dynamics Laboratory (MIND Lab) is a unique off-campus laboratory, associated with the UM Institute for Advanced Computer Studies, which focuses on the transition of technology from academic research to practical applications. MIND Lab projects include work in Semantic Web technologies, advanced computer networking, and location-aware services. Co-Directed by Jim Hendler and Ashok Agrawala, the MIND Lab works closely with industrial and government partners to develop technology demonstrations and early prototypes showing how cutting edge research can be used to solve real-world problems. The MIND Lab is the world's research leader in the application of semantic technologies to the issues of composition and integration of service-based software and also a participant in a number of key Web Service specification activities at the World Wide Web Consortium.

MINDSWAP

Maritime Domain AWARENESS

Bruce Stevens

Maritime Domain Awareness (MDA) can mean many things to many people. To a watchstander involved in maritime theater operations, it may mean taking advantage of as many available information sources to determine what is going on around his or her area of responsibility for the underway "zoo." One particularly important aspect of this concept is the ability to recognize peculiar or anomalous behavior that may suggest the eminent occurrence of a terrorist event.

The task of providing MDA can be viewed as an information flow process. The end-to-end information flow process can be decomposed into three steps. The first step, data gathering, includes the collection of data elements from multiple diverse data sources that do not share a common data model, representation, or ontology. In this step, we must aggregate and align only as much data as is needed and store it into a normalized data store being careful to maintain the links and pedigree to the original data sources. These links can be utilized by the watchstander when verifying conclusions drawn by follow-on processes.

The second step, information synthesis, takes on the challenge of analyzing the data in various ways to potentially identify significant peculiar or anomalous facts based on theater specific criteria. It is necessary to capture the theater specific criteria in some fashion through some standard mechanism such as a rule base or hypothesis base. It would be desirable to separate the criteria from the implementation in this way so that ultimately, the watchstander can change the behavior of the system without necessitating a redesign or reimplementation of the system. The ability to change the criteria is also needed to remap the needs of MDA to the ever changing theater environment. It is expected that this step would generate higher level information and alerts to be delivered to watchstanders as well as other responsible personnel.

The third and final step, display, provides the knowledge map of the results generated from the first two steps. This would include the ability to display alerts and information in various ways to complete the picture and analysis. Information displayed in innovative ways can enable a watchstander to recognize a peculiarity or anomaly in seconds where thousands of lines of analysis software code could not match in capability. This step can also provide the necessary collaborative environment needed to conduct theater operations in a global environment.

This end-to-end information flow process represents just one way of viewing a solution to providing an MDA capability. Steps are presently being taken by government and industry partners to provide solutions through collaborative development of experimental prototypes and delivery of these prototypes to theater for operation by real theater personnel for evaluation by all.

principals BACKGROUNDS

Dylan Schmorrow, Ph.D. CDR, MSC, USN.

DARPA Program Manager

CDR Schmorrow is a Naval Aerospace Experimental Psychologist and has served as a Program Manager at DARPA. He manages the FastC²AP and the Improving Warfighter Information Intake Under Stress programs. He also works with ONR to transform promising technologies into Naval operational capabilities.

Jeffrey Morrison, Ph.D.

ONR Program Officer

Dr. Morrison has been a scientist with the U.S Navy since 1990, where he works in the fields of cognition, decision support, advanced automation, and human factors. He is currently employed by the Space and Naval Warfare Systems Center, San Diego (SSC-SD), and is detailed to the Office of Naval Research (ONR), where he is executing FastC²AP on behalf of DARPA. He serves as the primary point of contact for the program.

John Mittleman, Ph.D.

Science Advisor

Dr. Mittleman serves as the Science Advisor for Commander, U.S. Naval Forces Europe and Commander, U.S. SIXTH Fleet in Naples, Italy. He is the principal liaison for the combined CNE/C6F staff with ONR, the Naval Research Enterprise, and more generally, the global community of technology producers. Dr. Mittleman has a wide variety of responsibilities and is instrumental in providing operational guidance for the FastC²AP team.

Ranjeev Mittu

Technical Advisor

Mr. Mittu is the Head of the Intelligent Decision Support Section at the NRL. He has been involved in numerous DARPA, DMSO and ONR research efforts involving the development and application of intelligent multi-agent systems for Command and Control. His research interests are in the areas of artificial intelligence, multi-agent systems, web services, and modeling and simulation.

Bruce Stevens

Technical Advisor

Mr. Stevens has been employed by the Naval Undersea Warfare Center Newport Detachment, Newport, Rhode Island for the past 26 years. He is a member of the Submarine Combat Systems Directorate, Combat Systems Department, Combat Systems Technology and Architecture Division, Warfare Interoperability Branch.

Wayne Perras

Senior Advisor

Mr. Perras is the Deputy Commander & Technical Director of the Navy Warfare Development Command (NWDC), Newport, Rhode Island.

Robert Simpson, Ph.D.

Senior Consultant

Dr. Simpson has 36 total years of Industry and Government experience and his primary research interested is in applied artificial intelligence.

Kendra Moore, Ph.D.

DARPA Program Manager

Dr. Moore joined DARPA as a Program Manager in April 2005. She is developing a new initiative called Predictive Analysis for Naval Deployment Activities (PANDA). In addition, Dr. Moore will assume leadership for FastC²AP in late 2005 upon CDR Schmorrow's departure from DARPA for his next assignment.

Leland Kollmorgen RADM (Ret.) USN

Senior Advisor

As a career Naval Officer, RADM Lee Kollmorgen (ret.) focused on technical programs and resource management after completing nearly 20 years in naval attack squadrons with four command tours and over 200 combat missions. RADM Kollmorgen is a former Chief of Naval Research, Chief of Naval Development, and Chief of Naval Material for Technology.

Martin Hofmann, Ph.D.

Principal Investigator

Dr. Hofmann is a manager in the Artificial Intelligence Laboratory at Lockheed Martin Advanced Technology Laboratories, leading a research group focused on software technologies for network centric operations. His research interests include intelligent agents, agent-based systems, agent collaboration frameworks, semantic web technologies, fuzzy qualitative reasoning, heuristic search methodology, and systems research.

Ray Emami, Ph.D.

Principal Investigator

Dr. Emami is the CEO and Chief Scientist of Global InfoTek, Inc. (GITI). Dr. Emami has been the Principal Investigator for several DARPA's research projects such as Control of Agent Based Systems (CoABS), Command Post of the Future (CPOF), Active Templates, and Project Genoa. Dr. Emami received DARPA's "Significant Technical Achievement Award" in FY04.

Ronald Moore

Principal Investigator

Mr. Moore serves as Director of the Knowledge Management and Decision Support Systems division of PSE and as Program Manager for a variety of decision making / decision support research efforts. Mr. Moore has nearly twenty years experience in data, operations, and systems analyses; human factors engineering; and concept and system design and development.

James Hendler, Ph.D.

Senior Consultant

Dr. Hendler is a Professor at the University of Maryland and the Director of Semantic Web and Agent Technology at the Maryland Information and Network Dynamics Laboratory (MIND Lab). He has authored close to 200 technical papers in the areas of artificial intelligence, Semantic Web, agent-based computing and high performance processing and is one of the inventors of the "Semantic Web."