

Research
Summaries

Technology Symposium 2009

May 2
Bedford

June 26 & 27
Washington

MITRE

Welcome to MITRE's Ninth Annual Technology Symposium

This book provides summaries of the projects showcased in this year's Technology Symposium. The information included here will also be made available on MITRE's intranet, public server (www.mitre.org/technology/tech02), and compact disc.

The Technology Symposium promotes discovery and discussion within MITRE and its sponsor community. Each year, it provides a forum for visitors and staff members to hear about the innovative work being conducted within the MITRE Technology Program (MTP), including MITRE Independent Research and Development (IR&D) and Mission Oriented Investigation and Experimentation (MOIE), as well as research sponsored by the Defense Advanced Research Projects Agency (DARPA).

The MTP serves as MITRE's primary mechanism for generating, gathering, and disseminating relevant technical knowledge throughout the corporation. The MTP process of exploring technologies that may solve the real-world needs of our sponsors positions us at the cutting edge of technology. The knowledge we gain yields direct benefits to MITRE, our sponsors, our staff, and to industry. By learning to leverage the MTP, MITRE staff can better support the strategic direction of their centers, divisions, and sponsors, and of the corporation itself.

Please visit the exhibits and talk with the principal investigators to learn more about the projects described in this book. I hope that you will find the symposium both informative and enjoyable.

David H. Lehman
Senior Vice President for Information and Technology



Acknowledgments

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MITRE Technology Areas

The research summarized in this booklet is divided into 13 technology areas as well as a grouping of other projects. This is how they are organized at the symposium.

Architectures investigates technologies for designing and integrating complex, COTS-based systems of systems that can adapt and evolve with advances in software and information technologies. This area also seeks to define and measure the attributes of a good architecture. Use and evaluation of tools such as Common Object Request Brokers (CORBA) fall into this area.

Collaboration and Visualization focuses on technologies that support effective use of information systems by individuals and groups. Crucial to the success of such systems are the presentation of information, strategies for organizing its manipulation, and support for geographically and temporally dispersed users interacting with each other and with the information they need and create.

Communications and Networks covers developments in LAN and WAN network protocols, system planning, management, traffic analysis, wireless technologies and high bandwidth networks and the evolution of satellite communications to networks of low earth orbiting satellites.

Computing and Software maintains awareness of developments outside MITRE related to the technologies of computer architecture and engineering, computer science, software engineering and the software profession.

Decision Support focuses on cognitive-centered decision support applications and new methods and tools for developing effective systems that support decision-making. Emphasis is placed on decision-making in dynamically changing real-time environments (occurring in a day or less). Research in human decision-making to enable the development of better support systems for the military or other sponsors is covered in this area. Also covered is the demonstration of decision aids that advance the state of the art.

Electronics investigates electronic component technologies, and their design and fabrication techniques.

Human Language researches computer systems that understand and/or synthesize spoken and written human languages. Included in this area are speech processing (recognition, understanding, and synthesis), information extraction, handwriting recognition, machine translation, text summarization, and language generation.

Information Assurance investigates security vulnerabilities in distributed information systems and develops architectures, systems and techniques for providing protection from attack and exploitation. Existing tools for system protection are tested and evaluated.

Information Management investigates databases, distributed databases, data mining and legacy databases.

Intelligent Information Processing investigates technologies, tools, and processes that support the discovery, processing, exploitation and dissemination of information, tools and knowledge. Intelligent agents are covered in this area.

Investment Strategies is concerned with understanding the benefits and direction of planned and future technology investments by the government. Responsibilities include capturing information on trends in technology investments, understanding the challenges associated with investment decisions, and improving MITRE's abilities to support technology investment studies. The latter includes methods and tools for investment analysis, as well as supporting databases. At present, the technical area team is researching the following broad areas: information technology investments, militarily critical technology investments, and aviation technology investments.

Modeling, Simulation and Training focuses on information technology to support training, and the technology and innovative application of modeling and simulation. The information revolution is fueling changes in the workplace at an unprecedented rate, and these changes are threatening to overwhelm conventional education and training approaches. Fortunately, advanced instructional technologies like embedded training and collaborative learning environments can help warfighters and intelligence analysts adapt to these changes. Advances in simulation infrastructure, interoperability architectures, and modeling paradigms have simplified the application of simulation, demonstrated the feasibility of building simulations from reusable components, and otherwise facilitated a revolution in simulation application.

Sensors and Environment researches technologies employed to detect, monitor, and characterize the environment (terrain, weather, targets, etc.) to determine position within that environment (geoposition), and to manage, exploit and disseminate positional data (geographic information systems). The use of radar, optical, sonic, and multispectral sensors is covered.



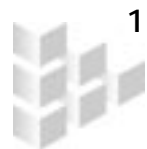
Achieving Predictive Battlespace Awareness

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Pending public release. Research not released by the event dates
will be available in a restricted access area.

Bedford

Architectures



Comparison of SW Agent Based Framework w/J2EE Framework

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Problem

The problem is to determine interoperabilities, conflicts, and synergies (ICS) between software agent frameworks that are compliant with Foundation for Intelligent Physical Agents (FIPA) standards and with J2EE™ specifications. The J2EE is an exemplar of the thin client, high bandwidth, multi-tiered, component-based, backend enterprise information system, Web-centric architecture prevalent today. Software agent systems are decentralized systems whose components are software agents.

Objectives

We will ask focused questions to delve into potential ICS. For example: "Can messaging provide for interoperability even though there is a semantic mismatch between applications in the two frameworks?" "Can a software agent system participate in a transaction, or act as a backend system?" and "How should a software agent system offer or use (from J2EE) a service?" Answers compatible with specifications for both frameworks are sought.

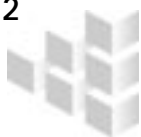
Activities

Initially the project focused on messaging as a pathway to interoperability. This culminated in a MITRE report, a demonstration, and an accepted presentation for JavaOne 2002. We are in final stages of technology transfer of software to FIPA-OS users. The investigation now involves several studies: (1) hybrid system service architecture (using Simple Object Access Protocol (SOAP) and ontologies), (2) data access comparison, (3) FIPA-OS performance, (4) transaction issues, and (5) JXTA (peer-to-peer platform from Sun Microsystems™)-agent integration.

Impacts

We are collaborating with the High Confidence Software Containers project to build an agent-centric container for J2EE. We interact with FIPA-OS users (in the technology transfer process) and the FIPA community via mailing list exchanges. We disseminate our results through MITRE reports, and through peer-reviewed external venues (JavaOne Conference). Additional findings are shared within MITRE (via mailing list and Web site).

Independent Research and Development



Achieving Synergism with Virtual Image Displays

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Problem

The potential for personal empowerment becomes more real as advances in mobile computing, e.g., hand-held and wearable devices, enable the convergence between computing and communication. However, a suitable interaction metaphor for these types of devices has not yet been thoroughly defined, and manufacturers and interaction designers are still trying to determine the types of applications that are appropriate for this technology.

Objectives

Our current understanding of graphics computing and display technology is challenged by the notion of mobile computing and portable information spaces, and we need to consider the task characteristics and information processing mechanisms in order to understand what design features are required. We examine the roles in which computer graphics and “mediated” reality may play and consider the use of multiple modalities for information “display.”

Activities

The project will conduct laboratory experiments to determine the relationship between augmented reality display features (registration accuracy, image fidelity, data reliability) and the attention and trust provided to that data, define new interaction technologies (e.g., finger tracking, eye tracking), and develop and field test a prototype.

Impacts

This work positions MITRE as a government resource for interfacing with portable visual displays for the next generation in computing, i.e., the wearable. As information complexity increases and data portability becomes more critical, the issues examined here will provide MITRE with the ability to define guidelines and develop a seamless natural and usable interface for providing access to visually intensive data.

Independent Research and Development

Collaboration off the Desktop

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Problem

New technologies for user and task mobility are emerging that operate outside the familiar desktop computing environment. Tools like high portability notebooks and PDAs, and wireless networks such as VoIP, CDPD, wireless Ethernet, and Bluetooth provide individual mobility. More shared physical places have better wired networks and display and input technologies designed for group interaction (like projectors and softboards).

Objectives

These technology trends show promise and garner investment because they are designed to allow change in how people and groups work. Yet it is unclear how these technologies integrate, nor is their relationship to existing systems and practice well defined. This project will explore these issues through prototyping and deployment and produce questions and thrusts for technology evaluation and targeted research and development.

Activities

In FY01, we produced a prototype system, called MDAT, that demonstrated simple, direct access to a user's desktop PC from anywhere on the MITRE network. We are researching "sensemaking" as a core C4I activity in Air Operations Centers (AOCs) and crisis rooms. Finally, we are investigating the proposed Instant Messaging extension called SIMPLE that is based on the IETF Session Initiation Protocol (SIP).

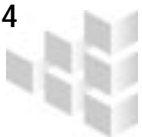
Impacts

The MDAT prototype vividly illustrates serious security research issues in ubiquitous computing, from implementation to doctrine. Our work on "sensemaking" influences the conception of future C4ISR and other sponsor systems. Finally our participation in the IETF SIP/SIMPLE effort helps bring sponsor concerns into the standardization process, as well as providing a base implementation for other integration efforts.

Independent Research and Development

Bedford and Washington

Collaboration and Visualization



Collaboration on Trajectory-Based Future ATM (TBF-ATM)

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Problem

Although worldwide air traffic is expected to grow, communications availability and bandwidth can be expected to grow at a greater rate. Given this scenario, how can the air traffic management system take advantage of the telecommunications revolution to enable more effective and efficient service? Specifically, how can the system take advantage of precise and up-to-the-minute trajectory information generated by the aircraft's FMS and sent potentially to any ATM user?

Objectives

This project has two primary objectives: first, to provide a forecast of future communications issues and technologies and their potential impact on air traffic management, and second, to develop and evaluate strategic and tactical collaborative decision making architectures primarily through the exchange of "6-D" aircraft trajectories (where 6-D trajectories include tailored intent, performance characteristics and priority handling information in addition to the latitude, longitude, level or altitude and time components of a 4-D trajectory.)

Activities

Three activity tracks have been launched. First is to research communications trends up to the 2020 (and beyond) timeframe with a concentration on satellite communications. The second track is the definition of a future ATM operational concept and a flight scenario where a single controller manages an aircraft from origin to destination. Third is the development and evaluation of a plausible systems architecture (communications infrastructure, information processing needs, etc.) supporting the flight scenario.

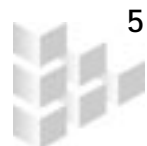
Impacts

Due to the futuristic nature of this work, the inherent inaccuracies of forecasting telecommunications growth, and the large number of political and operational constraints that would need to be overcome, the direct impact of this work will be minimal. The larger impact will be in providing a glimpse into the future and extending the discussion of leveraging commercial technologies into the air traffic management environment.

Independent Research and Development

Washington

Collaboration and Visualization



Command Post of the Future

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Problem

In presenting information to policymakers, the challenge is to make this knowledge accessible to busy senior decision makers who did not participate in its production in a way that will improve their understanding of the situation and potential scenarios. This requires providing an experience that is persuasive, memorable, meaningful, and efficient. Traditional approaches—written reports and point papers and oral briefings (e.g., chart style)—too often fall far short of the mark.

Objectives

Since the dawn of human civilization, storytelling has been used to convey information. Even in the high tech world of today, storytelling could be used together with technology to effectively convey information, solicit information and tacit knowledge, help in making cultural change, and assist in education and providing lessons learned.

Activities

MITRE is engaged in investigating and applying pertinent methods of storytelling in two areas. In the C2 environment, the challenge is to present the multitude of fast information streams bombarding the various echelons in an efficient way. This information needs to be presented in a timely and efficient way. We have shown that storytelling techniques used in narrative (plain words), film, comics and narrative could be effectively used in computer-based visualization and information presentation.

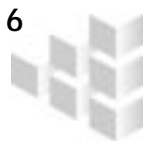
Impacts

Stories seem likely to provide the framework for such an experience, deeply rooted as they are in human communication, understanding, and memory.

Defense Advanced Research Projects Agency

Bedford and Washington

Collaboration and Visualization



Joint Time Critical Targeting (TCT) Experimentation

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Problem

Each military service is independently pursuing unique systems and technologies for TCT, with some of the application development and integration efforts occurring in selected service laboratories. These labs address various components of the TCT process, including sensor tasking and collection, sensor cueing and target development, weapon/target pairing, dynamic mission planning and target data dissemination to weapons. However, these disparate development and integration efforts could present problems to a joint contingency operation in which multiple services may be prosecuting the same time-critical targets.

Objectives

The primary objective of this project will be to demonstrate inter-service technical and operational interoperability in TCT through a series of intra-MITRE laboratory experiments. A collateral objective is to identify and demonstrate technologies that will enhance this interoperability.

Activities

We will determine and resolve service differences related to TCT, such as target definition classification; identify possible technical interoperability problems or shortfalls; determine and apply metrics to judge process improvements; identify/recommend solutions to the problems/shortfalls; and experiment with selected technologies that address/identify shortfalls. We will help evolve/mature an inter-service concept of operations for TCT. A technical report will guide program executive officers and OSD on an acquisition strategy to resolve the technical interoperability issues related to the joint TCT process.

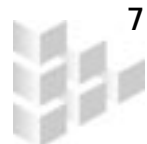
Impacts

The TCT experiments will address specific concerns of OSD and PEOs. In addition, recommendations in the report could influence R&D and acquisition decisions of the various services as well as Air Land Sea Applications documents and joint targeting doctrine. Ideally, this work will result in the services' developing and executing their own program of regular TCT experimentation between their respective labs. Implementation of such a program will highlight MITRE's role as an honest broker between the services and set the stage for inter-service experimentation in other mission areas.

Army-Contract MOIE

Washington

Collaboration and Visualization



Passengers, Information and the Future Travelscape

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Problem

Little research has been done to examine the ways in which current and future information technologies will change the aviation travelscape. Technological trends in computational speed, wireless connectivity, information exchange and intelligent systems could enable a shift in the industry from supplier-driven to buyer- (passenger-) driven and enable more efficient use of existing assets (e.g., planes, gates).

Objectives

The objective of the effort is to create and refine a vision of the future "travelscape" from a passenger perspective. The vision suggests that more efficient utilization of assets may be possible with future technologies. This project seeks to define those categories for future research consideration.

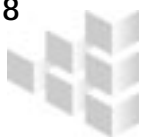
Activities

Major tasks include scanning the information technology environment to hypothesize medium term future capabilities, exploring new business models based on those capabilities, and actively seeking out aviation and travel industry opinions both internally and externally to share this developing vision.

Impacts

This research is intended to lay the groundwork for developing operational concepts and research needs to more completely involve the passenger in the real time collaborative decision making environment of the future.

Independent Research and Development



Strategic Air Traffic Management and Planning in Terminal Airspace

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Problem

Strategic air traffic management and planning tools for en route airspace (e.g., as illustrated by the User Request Evaluation Tool [URET]) have been shown to provide significant benefits to both controllers and to airspace users. However, the usefulness of these strategic tools to the more tactical operations within terminal airspace remains an open question, both for U.S. and European airspace application.

Objectives

This study will address the following questions: What operational and technical differences between the terminal and en route domains impact the application of decision support tools? What are the differences between U.S. and European terminal operations that impact the application of these tools? Is their application to terminal airspace operationally and technically feasible? What are the potential benefits?

Activities

We will assess the functional performance of URET's trajectory modeling and conflict detection when applied to terminal airspace, and compare it to corresponding performance for en route airspace. Using the URET system developed for functional performance assessment, we will examine potential capabilities and benefits with operational personnel, and develop a summary report, including performance assessment and description of potential benefits and capabilities.

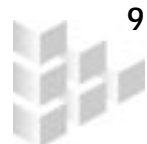
Impacts

This study will directly contribute to the state of the art in the application of decision support tools to U.S. and European terminal operations, and will enhance understanding of a key unsolved problem: strategic air traffic management and planning in terminal airspace. Further research and development in this area has the potential for providing critical improvements in terminal airspace safety, capacity and efficiency.

Independent Research and Development

Washington

Collaboration and Visualization



Adaptive Array Processing for Ad Hoc Networks

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Problem

The adaptive array processing techniques currently being considered for use in military ad hoc networks have serious shortcomings that include inadequate performance gains, excessive computational complexity, and/or insufficient adaptability to the rapidly changing conditions in military wireless ad hoc networks. New, computationally efficient adaptive array processing methods must be developed that provide performance gains without the shortcomings of other methods.

Objectives

The purpose of the project is to develop and apply advanced space-time adaptive signal processing methods to military mobile wireless ad hoc network architectures. The project will concentrate on transmit and receive space-time adaptive processing (STAP) methods that maximize the channel capacity and transmission range while minimizing co-channel interference and probabilities of detection and interception.

Activities

There are three major elements to this project. The first is a system-level analysis to provide reasonable expectations for performance improvements and system requirements. The second is the development of the algorithms themselves. Receive-only algorithms will be developed first, with transmit algorithms being considered later. Finally, the algorithms will be tested and demonstrated using live captured data.

Impacts

This project will advance the state of the art in STAP methods, and will build MITRE's reputation both in the R&D community and with key DOD sponsors. The techniques we develop will mitigate multipath and co-channel interference and offer anti-jamming capabilities that are essential to ensuring the capacity and reliability of future tactical communication networks (e.g., Future Combat System).

Independent Research and Development

Adaptive C4I Node

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Problem

The military needs to replace the hardware-intensive designs of legacy radios with newer software-based designs to accomplish waveform generation and processing, encryption, and other major communication system functions. The Adaptive C4I Node (ACN) hardware architecture is waveform independent, and its reprogrammability permits multiple radio signals to be simultaneously processed in one box.

Objectives

ACN will provide simultaneous in-theater multi-mission capabilities, including communications, signals intelligence, electronic warfare, offensive information warfare, and radar capabilities. The Adaptive C4I Node (ACN) hardware architecture is JTRS waveform as well as JASA compliant. The goal is to have a generic box containing four RF 60 MHz channels in each that are completely tunable from 30 MHz to 3 GHz in the first instantiation. Additional boxes extend the instantaneous frequency coverage.

Activities

The project will review and perform independent evaluation of approaches and technologies proposed by two industry teams and their subcontractors.

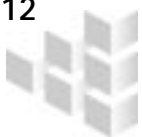
Impacts

ACN can be tailored to fill mission-specific C4I needs. ACN's flexibility also extends to the platform it can be hosted on with the common box implementation. The single-box approach simplifies the repair chain and in-theater logistics. Because ACN is a multi-missioned box, fewer assets/platforms need to be brought into theater.

Defense Advanced Research Projects Agency

Washington

Communications and Networks



Adaptive RF Links

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Problem

Realization of a robust, ubiquitous Global Grid will require future wireless links to automatically adapt to changes in channel propagation conditions and to the delivery needs of a widening variety of user traffic. Specifically, future links will need to manage channel throughput, bit-error rate, and latency to match the carried traffic's volume, urgency, and correctness objectives.

Objectives

Our objective is to demonstrate the benefits of wireless link adaptation through the development of a proof-of-concept prototype. The resultant prototype and demonstration will highlight how link adaptation can more efficiently use radio spectrum by adapting to changes in channel conditions and varying user needs.

Activities

This project is building on a per-packet adaptable framework developed in its first year. Specifically, we are implementing a "Link Manager" that autonomously drives adaptation based on user needs and channel conditions. To accomplish this, the Link Manager must be able to determine user needs, use channel feedback metrics, negotiate link changes over the air, and employ an adaptation policy.

Impacts

Adaptive RF Links takes the next step towards an efficient Global Grid. Our project work has an opportunity to impact several programs. We will highlight how the Advanced EHF/AWS program can use one terminal to meet competing robustness and capacity objectives. We also have an opportunity to show how TACP operations might benefit from increased capacity without sacrificing robustness.

Air Force MOIE

Adaptive Spectrum Utilization with Software Defined Radios

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Problem

More efficient techniques for use and management of the radio frequency spectrum are needed to support the increased demand for wireless applications. Current spectrum assignment methods are highly risk averse and require extensive planning to adapt to new requirements. Wireless applications are limited in their ability to dynamically share spectrum as a result of policy and technology.

Objectives

This project investigates the design and performance tradeoffs associated with wireless systems that sense the RF spectrum and adapt transmit waveforms in real time to the available spectrum. The objective is to develop the adaptive spectrum system concepts and implementations to further their acceptance in the user and spectrum policy communities.

Activities

The project is developing design parameters for control, interference minimization, waveform adaptation, and RF spectrum sensing necessary to implement a software-based adaptive spectrum system. The basic functionality of this system will be demonstrated using digital signal processing platforms in a laboratory environment. Additionally, real spectrum usage data to support the demonstration equipment design process is being collected.

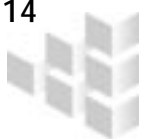
Impacts

The use of real-time adaptive spectrum occupancy waveforms has the potential to significantly increase user connectivity and data capacity for a defined frequency band as compared to current wireless applications. The use of adaptive frequency selection reduces the current spectrum management workload by replacing individual users' channel assignments with frequency band assignments in which the adaptive wireless system operates.

Army-Contract MOIE

Washington

Communications and Networks



Autonomous Network Management

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Problem

The size and complexity of networks have grown tremendously over the last decade. Unfortunately, the growth of networks has not been matched with efforts to reduce the complexity. Today's methods of configuring and maintaining networks are manual, slow, and antiquated. Without a change in the way we build networks, the military's need to rapidly deploy their networks will be unmet.

Objectives

The objective is to develop a collection of protocols and software tools enabling networks to be rapidly configured and maintained by untrained personnel. The military needs the ability to plug routers and hosts together and have the network configure itself. We will also provide a software tool to analyze the network and recommend changes resulting in a more efficient and robust network.

Activities

The project is divided into two phases. The first phase is to enable auto-configuration of networks. The second phase is to create a software program to gather the topology of the network and its traffic flow, then determine possible solutions to increase throughput, add redundant links and suggest other network improvements.

Impacts

We will enable networks to be deployed rapidly and without requiring network administrators. By providing routers capable of auto-configuration we remove the time and skills needed to configure the network. Our software program will help make the best use of available resources and provide advice on where to add new equipment.

Air Force MOIE

Bluetooth™ and Wireless Personal Area Network (WPAN)

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Problem

Intra-team communication is essential to the success of many missions. Communications at low echelons are typically supported by netted push-to-talk (PTT) radios. These radios do not provide the continuous communications needed to monitor health and status and situation awareness on a small scale. Determining the location of team members in buildings is an unsolved problem.

Objectives

This project will use Bluetooth devices as a stepping stone to ultra-wideband (UWB) and other technologies that show promise for intra-team communications. The objective is to assess these wireless personal area network (WPAN) technologies and develop new approaches to enhance intra-team communications.

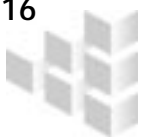
Activities

Activities will be focused on two areas. First, approaches will be developed for location determination among team members. This will involve determining the pair-wise distances between nodes and an algorithm for determining relative location. Absolute location will be provided by GPS-enabled nodes. Second, approaches to enhance communications reliability will be investigated.

Impacts

Improvements in intra-team communications will be beneficial to many types of teams including Army platoons and civil emergency first-responders. Good intra-team communications will allow near-continuous connectivity among team members so that health and status and situation awareness information can be frequently exchanged. Situation awareness information will include team member location as well as other data.

Independent Research and Development



Future Combat Systems (FCS) Communications Modeling and Simulation (M&S)

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Problem

The intent of the DARPA Future Combat System Communications (FCS-C) program is to provide the enabling technology to develop the FCS communications system. In support of this, the FCS-C program will demonstrate the capabilities of the FCS communications components via modeling and simulation (M&S), with a special emphasis on network and communications technology scalability.

Objectives

Our objective is to define and demonstrate an M&S framework that will be used by the technology development contractors and independent analysts to investigate the performance of alternative routing and MAC layer routing schemes in mobile ad-hoc networks.

Activities

Our activities this year include: (1) formulation of the M&S plan, (2) development and implementation of a model and accompanying data to represent foliage- and terrain-induced attenuation, (3) integration of applicable M&S capabilities being developed for the Joint Tactical Radio System program, (4) generation of representative operational FCS scenarios, and (5) exercise of the M&S environment using contractor-provided FCS protocols.

Impacts

Our activities this year will help ensure that the communications and networking technologies being developed under the FCS-C program are meeting performance and scalability objectives. The M&S effort is the only way that scalability can be evaluated. The results of several field demonstrations will be used to help validate the results generated.

Defense Advanced Research Projects Agency

Gateway to the Global Grid

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Problem

The Global Grid concept presumes seamless communications between all allied users. Presently, the military has a plethora of legacy systems, each finely tuned for its specific mission but, all too often, not interoperable with other systems. Certainly, one of the first challenges – and perhaps the single greatest challenge – to achieving the Global Grid vision is providing a migration path for these specialized systems which will enable them to fully participate in a heterogeneous networked environment.

Objectives

This project will begin to develop the tools and technologies necessary to migrate legacy military communications systems to the future Global Grid. More specifically, these tools will be applied to the JTIDS radios to demonstrate a common transport over Link-16 and to demonstrate the utility of a common data format.

Activities

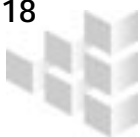
In this phase of the project we will investigate candidate common data formats. A common data format will then be defined and implemented in a prototype gateway between a civilian air traffic management system and Link-16. Our activities will culminate in a demonstration of the utility of this Global Grid compliant gateway.

Impacts

This project will demonstrate enhanced interoperability between a legacy communications system and the evolving Global Grid. Our research will help to define an evolutionary strategy for bringing the Global Grid to the doorstep of the fighter. A prototype gateway will also demonstrate how this enhanced interoperability can mitigate an operational air traffic safety issue.

Air Force MOIE

Bedford



Medium Data Rate SATCOM On the Move for the Battalion-Level Warfighter

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Problem

Current Army digitization architecture lacks a beyond line-of-sight (BLOS) on-the-move (OTM) medium data rate (MDR) capability at battalion tactical operations centers (TOCs). The DOD currently has a requirement to provide long range communications to TOCs OTM. Army doctrine is moving toward lighter, more mobile/agile, and more geographically spread forces, which will culminate as the Objective Force (OF). With the increased coverage area, agility, and mobility demands, the battalion echelon terrestrial network must be augmented by SATCOM OTM.

Objectives

We will design and prototype an affordable SATCOM terminal that can support reduced data rate SATCOM OTM (SOTM) and MDR SATCOM on-the-pause (SOTP). The anticipated data rates required by the battalion-level warfighter are 16 kbps and 256 kbps for SOTM and SOTP operation, respectively. We will develop the associated technology and transition it to the next-generation Army SATCOM and common user communications programs.

Activities

Research is underway in four key challenge areas: development of a low-cost platform stabilization and antenna tracking system; development of a link layer protocol to support shared channel access; analysis of waveform performance; and development of a small aperture low sidelobe antenna. The prototype terminal will represent the successful integration of our research with low-cost COTS products to support SOTM.

Impacts

This effort offers MITRE the opportunity to improve our understanding of SOTM requirements and technology and lead technology transfer to the Army and to industry. Our understanding of SOTM technology has enabled us to develop requirements for Warfighter Information Network-Tactical procurement and to assist the MILSATCOM program manager with Ka-band terminal specification. WIN-T is the Army's OF and will include Unit of Action (UA) and Unit of Employment (UE) components up through theater. In addition, DARPA recently expressed interest in transfer of MITRE's technology to the Future Combat System (FCS) program.

Army-Contract MOIE

Mobile Ad Hoc Networks for the Transformed Army (MANTA)

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Problem

Army transformation simultaneously requires dramatically higher data rates, low probability of detection, and resistance to jamming for highly mobile networks. These requirements strongly suggest the use of highly directional communication mechanisms. Current mobile ad hoc networking techniques neither embrace directionality nor accommodate the qualities of service necessary to support the C4ISR collaborative applications needed.

Objectives

We will determine the following: What channel access mechanisms are most appropriate for ad hoc networks that combine directional and omnidirectional elements (aka directional ad hoc networks)? How should one initiate and maintain a network topology in directional ad hoc network environments? What routing algorithms are necessary to achieve standard (unicast), high-assurance, and multipoint data delivery services in directional ad hoc networks?

Activities

We have recently developed simulation models of the Mobile Mesh protocols and have made them available to the Army's Future Combat System-Communications (FCS-C) program. We are actively developing channel access mechanisms for modestly directional ad hoc networks. We are engaged in simulation efforts that are identifying values for key design parameters of our Synchronous Collision Resolution (SCR) media access protocol. These results are being utilized in our development of a proof-of-concept prototype directional radio system. We will soon be developing protocols to support the use of highly directional components. We will develop various policies for determining where to place highly directional links in the network and will show the effects of these policies through simulation.

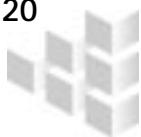
Impacts

The results of this research are directly applicable to programs that rely upon mobile ad hoc networking technology. We have already impacted the FCS-C program by sharing our insights into modestly directional media access techniques and by providing simulation models.

Independent Research and Development

Bedford and Washington

Communications and Networks



Multicast Visualization and Management

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Problem

Based on past military exercises, the need for a tool that provides multicast visualization and management of large networked environments has surfaced. Existing tools are inadequate for understanding the impact that multicast is having on our networks. This lack of understanding and potential pitfalls that multicast enabling can cause are major reasons multicast has not been permitted on most networks.

Objectives

Using the capability developed in FY01 for multicast traffic visualization and analysis as a foundation, the project team will develop tools for proactively managing a multicast-enabled enterprise network under congestion. We will provide a network-based access control mechanism that allows some central authority to control who can subscribe to which multicast group for a given multicast source.

Activities

The task breakout is as follows: continue management information base (MIB) analysis, investigate standards on multicast admission and session announcement, refine FY01 tool developed for retrieving selected MIB information, develop multicast admission control application, develop multicast management application, simulate multicast environment for software test and evaluation, and conduct a series of tests simulating different multicast environments and document the behavior under varying conditions.

Impacts

Although not widely used, multicast traffic tends to be the most efficient manner to disseminate information. Without proactive management, however, it can create serious problems for a network (especially under crisis situations). As we demonstrate how multicast traffic can be managed, organizations will be able to seriously consider becoming multicast aware to allow more efficient utilization of their existing network resources.

Air Force MOIE

Next Generation SATCOM Terminals

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Problem

SATCOM is an increasingly critical component in seamless connectivity of the Global Grid. Many recent military SATCOM programs have suffered technical setbacks and many commercial SATCOM ventures are proving unprofitable. Unless corrective action is taken, the military will be left without critical SATCOM capabilities and capacities. The problem is not a lack of DOD investment, but the want of a flexible architecture and extensible, reusable components.

Objectives

This project will develop, demonstrate, and transition key communications and networking technologies of direct and immediate relevance to network-centric military SATCOM. This project will focus and extend MITRE's prior research to the widening gap between needed and fielded SATCOM capability. Key design objectives for future terminals must include ease of use, cost effectiveness, ease of upgrade, spectral efficiency, and extensibility to new applications.

Activities

The project will work closely with the direct-funded MILSATCOM programs and will research solutions to long-term problems including: implementing differentiated services over SATCOM, extending transport-level protocols for heterogeneous networking, developing flexible, extensible, platform independent antenna APIs, developing a DHCP-like autonomous network management capability, developing algorithms to manage resource allocation in steered-beam satellites, and enabling the use of multicast IP in SATCOM networks.

Impacts

The eroding commercial SATCOM business base and recent foundering of several MILSATCOM programs present a window of opportunity to influence the future of military SATCOM. This project will enable MITRE to effectively and credibly exert that influence on future SATCOM designs. Additionally, much of this work will be directly applicable to other military communications systems and will facilitate the continuing development of the Global Grid.

Air Force MOIE

Bedford



Optimizing Spectrum Use in the 960–1215 MHz Band

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Problem

The FAA and DOD currently have systems operating in the L-band and each has plans to operate future systems there as well. The third civil GPS frequency also resides within the L-band. The L-Band Steering Committee and the Interagency GPS Executive Board have been formed to make difficult decisions impacting spectrum use and system design; however, adequate tools do not exist for them to assess the impact of their decisions—decisions that could have potentially monumental consequences.

Objectives

The purpose of this project is to develop a tool suite for effective L-band spectrum management. The tool suite will be capable of modeling L-band RF environments, emitters, and receivers, and will enable the development of radio frequency interference (RFI) mitigation strategies. The FY2001 effort considered the impact of the DOD's Joint Tactical Information Distribution System on the GPS L5, and the impact of Distance Measuring Equipment/Tactical Air Navigation Systems (DME/TACANs) on GPS L5. The FY2002 work will add a number of items to the tool suite so that other L-band systems, RFI environments, and RFI mitigation strategies can be considered.

Activities

Using Simulink, we will complete a high-fidelity model of the pre-Minimum Operational Performance Standards Universal Access Transceiver, and perform in-laboratory validation of the model. We will explore the use of the MatLab/Stateflow toolbox for creating a model of the LA Basin to simulate the RFI caused by multiple L-band systems upon a victim L-band system receiver. If possible, we will develop a model of a DME receiver.

Impacts

There will exist a tool/capability to impartially resolve with a high degree of fidelity FAA, DOD, and commercial issues regarding system design and spectrum use, and to validate any claims made by the users.

Center for Advanced Aviation System Development MOIE

Quantum Information Science Research Project

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Problem

Quantum information science is a new, interdisciplinary field that holds the promise of providing the means for solving practical problems that would otherwise be impossible. Quantum computers solve certain types of previously intractable computational problems, and quantum cryptography allows cryptographic keys to be distributed in real time in unconditional secrecy, a feat that cannot be performed in any other way.

Objectives

In quantum cryptography our overall objective is to design, build and demonstrate the fastest working quantum cryptography system possible. This will allow unconditionally secret encryption in real time. In quantum computing our objective is to develop new quantum computational algorithms. In each area these objectives include developing the necessary underlying comprehensive physical understanding of quantum information through careful analytical research.

Activities

Our activities in quantum computing include performing comprehensive mathematical analyses leading to the quantification of entanglement in systems composed of many quantum bits. This will allow the construction of new quantum computing algorithms. In quantum cryptography we are performing experiments involving high-speed multiplexed quantum channels, as well as carrying out underlying theoretical studies to determine the optimal system design.

Impacts

Quantum computers can break public key encryption systems, and quantum cryptography allows cryptographic keys to be distributed in real time in unconditional secrecy. Both activities are of extreme importance. As a consequence of the work of the project, MITRE has now assumed a position of leadership in this field, which it is using to help provide security for the nation.

Independent Research and Development



Small Unit Operations Situation Awareness System (SUO SAS)

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Problem

The military needs to develop a robust and reliable ad hoc network that ensures timely arrival of critical data to and from anywhere in the network. The radio network must provide radio connectivity to all network members in hostile and rugged environments and provide Quality of Service guarantees when requested.

Objectives

The radio network must provide high capacity radio links anywhere and anytime to ensure accurate position location information and provide seamless voice communications to all network members. The network must also be scalable to thousands of nodes and use radio resources efficiently to reduce size, weight, and power.

Activities

Activities include (1) providing technical expertise on issues relating to RF, networking, and systems integration to the SUO PM and Army Communications-Electronics Command affiliates; (2) developing and analyzing networking field tests of real hardware/software; (3) conducting protocol evaluations to determine network performance under severe co-location conditions; and (4) conducting evaluations of SUO Opnet models and determining radio performance under various conditions.

Impacts

MITRE supported transition efforts of SUO radios to other platforms and produced plans to interface SUO radios with the current Tactical Internet architecture. We also developed and implemented new processes for modeling and simulation of ad hoc networks to expedite the collection of performance statistics and ensure accurate results.

Defense Advanced Research Projects Agency

High Confidence Software Containers

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Problem

For the majority of HCS systems, development and validation of software is more difficult than for "ordinary" systems. In addition, HCS validation is generally brittle, making it expensive and time consuming to modify and revalidate a system once it has been deployed. To support the increasing reliance on software in critical systems, more cost effective techniques for building HCS need to be developed and HCS must be made more resilient in the presence of evolving requirements or configurations.

Objectives

Our objective is to investigate the augmentation of currently available container technologies to make HCS easier, quicker, and more cost effective to build, maintain, and modify. To that end, we will investigate and incorporate currently available and effective HCS techniques into an open source software container.

Activities

We will investigate how to apply HCS techniques to container technology and we will augment an open source Enterprise Java Bean (EJB) container to support the development and deployment of HCS. Our augmented container will be demonstrated at the MTP Symposium. We will document the results of our investigations in a MITRE report.

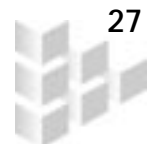
Impacts

We will use our results to influence the direction of software container standards (e.g., J2EE, Openwings) and also influence the way our sponsors (e.g., Defense Information Infrastructure Common Operating Environment (DII COE)) utilize software containers.

Army-Contract MOIE

Washington

Computing and Software



High Confidence Software Research Initiative

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Problem

Across MITRE, a key aspect of our sponsors' systems is an increasing reliance on software. Both the complexity and the consequences of failure of these software-intensive systems are steadily growing. For critical software, our reach exceeds our grasp, yet our reach keeps increasing. For many of the critical systems our nation increasingly depends on, software is the weakest link.

Objectives

This project aims to improve the ability to build, assess, and sustain those complex software systems for which compelling evidence is required that the software delivers a specified set of services in a manner that satisfies specified critical properties. The organizing framework for this research is the collection and analysis of technical evidence from multiple sources to calibrate if the confidence is justified for a given software system.

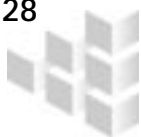
Activities

We are developing a set of canonical problems for evaluating the relevance of various techniques. We have established a Center Liaison Panel with one or more members from each Operating Center, and we are collaborating with the NSF, SEI, and others. We are pursuing focused investigations of aspects of formal methods, testing, model checking, and process guidance, along with increased rigor for calibrating software and for combining sources of evidence. We are concentrating on the challenges introduced by the revalidation or certification of existing systems that are evolving rapidly.

Impacts

The vision for this initiative is a self-sustaining role for MITRE as a national resource for HCS. If this is a vision and not a hallucination, the impacts include reduced risks of unexpected software failures in critical systems, more effective exploitation of software capabilities in modernization and transformation, and a significant contribution to the national interest.

Independent Research and Development



Integrated Services Management for C2

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Problem

The IC2S must be capable of adapting to a dynamically changing environment and dynamically changing mission needs. We have identified critical distributed computing technologies that facilitate constructing such systems. The ISM project will accelerate the commercial availability of these technologies through leadership in Java standardization activities.

Objectives

The objective of this project will be an approved extension to the Java platform enabling real-time distributed applications to be developed using Java. This will extend the scope of real-time Java from single node to distributed applications. The immediate form of this extension (and the desired outcome of this project) will be a complete, approved specification—including a reference implementation and test suite. It is anticipated that commercial vendors will implement products based on the specification and reference implementation, which can then be used for building adaptable, scalable C2 systems.

Activities

As part of this project, we will organize and lead an industry-wide Expert Group under the auspices of the Sun Community Process for Java. This Expert Group will be responsible for reaching consensus on the specification for Distributed Real-time Java. In addition to leading the Expert Group, the project team will participate in the specification process itself, initiate and lead technical investigations, and develop the reference implementation and test suite. During the course of this activity, we anticipate publication of several technical papers and the preparation of several technology demonstrations.

Impacts

This task is unique in that immediate technology transition to industry is an integral and automatic part of the work. MITRE is leading the Expert Group that is creating the Distributed Real-Time Specification for Java (DRTSJ), as part of Sun's Java Community Process. The DRTSJ includes a specification document, a reference implementation, and a conformance test suite. When completed, these all will be freely available on Sun's website, to facilitate the development of COTS distributed real-time Java products.

Air Force MOIE

Polymorphous Computing Architectures (PCA)

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Problem

Current computational architectures in high performance applications require unique digital signal processing and stream processing hardware designs. Development costs, maintenance and system production are driven by the uniqueness of the components and the programming effort to create the system application.

Objectives

PCA developments will enable payload adaptation, optimization, and verification to be reduced from years to days to minutes. The PCA program will replace the current "hardware first and software last" development cycle by moving beyond conventional fixed silicon processing architectures to flexible polymorphous computing systems. Polymorphic is defined as having, taking, or passing through many different forms or stages (i.e., many + form).

Activities

The project will provide identification of opportunities to exploit PCA capabilities in the C4ISR domain, expose PCA system requirements to the research community, explore hardware and software resource management issues using Quality of Service (QoS) metrics, develop a SAR application description and software demonstration, and collaborate with the Morphware forum to facilitate future software libraries in support of PCA.

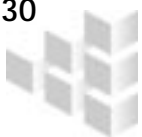
Impacts

The project will lead to improved understanding of PCA systems architecture as it relates to defense applications, and will obtain PCA community feedback of prototype applications lessons learned to evolve the requirements in software and hardware architecture. It will also identify opportunities for future research through improvement in system performance, software development, and architecture issues as they relate to C4ISR target applications.

Defense Advanced Research Projects Agency

Washington

Computing and Software



Understanding Object-Oriented Software

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Problem

While object-oriented approaches to software development promise to provide solutions that are faster, cheaper, and reusable, the software delivered contains enough indirection (via inheritance and polymorphism) to make it more difficult for analysts to understand object-oriented versions compared to strict procedural versions. Through understanding object-oriented code, we can assess qualities such as performance and security, support iterative development, and support reuse.

Objectives

The work of the design pattern software-engineering community provides us with descriptions of best practices, applicability conditions, and consequences of use for specific designs. Hence, we will develop the capability to automatically recognize use of design patterns through static reverse engineering techniques. Moreover, we will develop capabilities to reason about concomitant design rationale and software qualities.

Activities

We are using commercial integrated development environments to extract data on class interactions. First, we will concentrate on structural patterns and validating recognition results by examining software that contains intentional, documented use of patterns. Second, we will broaden this to cover architectural patterns and reasoning about pattern applicability conditions. Third, we will tackle the interplay among multiple pattern types within a single program.

Impacts

Our results will have direct impact on supporting software acquisition. We will be able to document legacy and newly developed software and be able to perform architectural compliance tasks. This work is also a prerequisite for static software vulnerability and malicious code analysis. We will connect with projects where there is an anticipated need for this within the next fiscal year.

Independent Research and Development

Airspace Design Research

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Problem

The ATC system handles increases in traffic by creating more, smaller sectors, splitting workload among more controllers. At some point, further reduction in sector size is not feasible because of insufficient maneuvering space and insufficient flight time in the sector. If further increases in traffic are to be accommodated, a method must be found for increasing the capacity of sectors.

Objectives

The project will develop a concept for managing more traffic in sectors that are too small to split further, or in sectors nearing that limit. Methods may include structuring traffic or changing the roles of controllers in a possibly larger sector team. We will realize the concept in a scenario detailed enough to evaluate with simulation modeling.

Activities

The project will analyze traffic in selected sectors (e.g., choke points) to understand issues besides simple volume that lead to splitting sectors, and use the results in discussions with operational people to refine understanding. We will generate candidate strategies for removing or alleviating constraints on controllers that lead to sector splitting, evaluate strategies, and create one or two integrated concepts described in a scenario suitable for modeling.

Impacts

The work will support user preferences by permitting increased traffic in currently congested areas with minimal rerouting and delays. Achieving this will require the results of this research to be adopted into the FAA work program for evaluation and refinement through fast-time and human-in-the-loop simulation and the development of necessary training and procedures.

Independent Research and Development

Washington

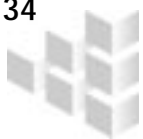
Decision Support



Augmented Cognition

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Pending public release. Research not released by the event dates
will be available in a restricted access area.



Counter-Deception Decision Support

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Problem

Denial and Deception aims to disrupt an adversary's ability to "observe, orient, and decide," and induce inaccurate impressions about friendly capabilities or intentions, causing the adversary to apply intelligence collection assets inappropriately, or fail to employ capabilities to best advantage. While the need for counter-deception (CD) is recognized, proposed solutions make little or no use of the psychology of deception and decision-making.

Objectives

We will develop a decision framework based on existing research on the psychology of deception, and integrate the framework with belief modeling tools to create a counter-deception decision support system for intelligence analysts. Our hypothesis is that the psychology of decision-making and deception can be combined with existing belief management and planning technology to produce a counter-deception decision support system.

Activities

In the Modeling Phase we will construct a psychological framework of deception based on a Deception Taxonomy and Deception Cognitive Model. In the Development Phase we will develop tools for generating deception hypotheses and assessing the evidence of deceptions. The result will be a computational system that helps analysts to recognize potential deception moves, evaluate evidence, identify probable deceptions, and de-bias estimates. The Assessment Phase will test the hypothesis through experiments with intelligence analysts.

Impacts

Research in CD will position MITRE to assist in several intelligence community initiatives. The research will position MITRE to develop systems to address several of our sponsor's identified "hard problems." The research will also augment the Information Operations Planning Tool ACTD with deception planning aids.

Independent Research and Development

Cross-Domain Decision Support

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Problem

When information in one mission area (such as combat support) changes, it may affect information in other mission areas (such as combat operations), but since information is not easily shared across mission area boundaries, except through predefined, hard links, it is difficult to track the impact of changes.

Objectives

This project is exploring ways to propagate notifications of changes to information in one mission area to other mission areas and to flag data that may be affected by those changes. This includes exploration into visual presentation of the change notices.

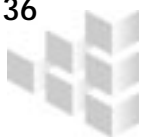
Activities

We are 1) developing a decision aid toolkit to fuse information across mission areas; 2) integrating cross-domain information in simulation-based visual display; and 3) evaluating the effectiveness of presentation mechanisms.

Impacts

This research will help build better decision support systems through aggregation and presentation of information across mission areas. The outcome of this project will provide a basis for determining how to use information aggregation to improve the quality of decisions while decreasing time spent in the decision-coordination cycle.

Air Force MOIE



DEPARTS

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Problem

The ATC system reduces departure delays by assigning departures to runways and by sequencing them to effectively increase runway throughput and reduce user taxi-out times. This is currently done without the use of automated decision support tools. This problem is made difficult to solve by the lack of a timely and reliable prediction of when a flight will be ready to push back. Consequently, at major airports flights can encounter long taxi-out times while waiting in departure queues.

Objectives

The DEPARTS research has previously developed a set of computer algorithms that can be used to recommend optimal departure runway assignments and departure sequences (DEPARTS is not a stand-alone decision-support tool, but rather a set of algorithms that could be embedded in such a tool). We have also previously analyzed the potential benefit of using such algorithms, based on simulated use at Atlanta Hartsfield. The objectives for FY02 include investigating whether we can generalize these algorithms to other locations, performing further benefits analyses, improving computational efficiency, and making recommendations for technology transition.

Activities

During FY2002, DEPARTS is being adapted to function at a wider variety of airports and is being extended to include the explicit modeling of taxi paths from push-back to wheels-off. A number of simulated scenarios are envisioned to show the effect of differing levels of data quality and availability on the benefits of using the DEPARTS algorithms to recommend operational actions (e.g., runway assignments and final departure sequence). Technical interchange meetings are underway with other research organizations, and we plan to present our results at a number of industry conferences in 2002.

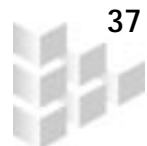
Impacts

The main impact of DEPARTS will be to advance the research being done in the departure planning area, and to impact the design of decision support tools currently being developed. Specific results will demonstrate the benefits of using DEPARTS algorithms for planning departure operations 10–30 minutes prior to push-back, and measure the added benefit of improving data availability and predictability.

Center for Advanced Aviation System Development MOIE

Washington

Decision Support



Development of NAS Operational Concepts for Year 2010 and Beyond

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Problem

Although the NAS Operational Evolution Plan includes enhancements in cockpit and ATC systems until 2010, little change is expected in mode of flight operations. The passengers often spend more time in ingress/egress between home and gate than flight time. What is needed are not only gate-to-gate operational improvements, but also faster access to the airports and real time flight information through a collaborative ATM system permitting users and operators to participate in decision making.

Objectives

The project objective is to develop operational concepts for NAS beyond 2010 incorporating satellite-based communication, navigation and surveillance (CNS), wake vortex avoidance, and enhanced vision technologies. The future ATM system design will not only enhance current hub-and-spoke airport operations but will also provide: 1) direct service between smaller airports; 2) intra-city air taxi operations; and 3) integration of information technologies for real time information exchange with users.

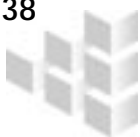
Activities

The activities include: 1) assessment of implications and viability of developing a centralized database for collecting and providing real-time information on flight current positions and trajectory-based flight plans to all users and operators; 2) development of a multi-modal concept of operations for NAS for 2020 by considering use of satellite airports for ferrying passengers from/to the hubs using smaller aircraft, tilt rotors and helicopters; and 3) consideration of electronics for integrating NAS information exchange with individual appliances (e.g., PCs, mobile phones, TVs, etc.).

Impacts

This project will serve as seed corn for setting the direction for the long-range research program for CAASD and the FAA by shifting the paradigm. The findings will help CAASD assume a leadership role in directing the FAA's research for NAS improvements beyond 2010.

Independent Research and Development



Enhanced Planning and Integrated Coordination Capability

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Problem

Operational Supervisors/Controllers-in-Charge (OS/CICs) rely on information from both the Traffic Management Unit (TMU) and sectors to effectively manage area resources and respond to Traffic Flow Management (TFM) initiatives. The existing information flow between the area, TMU and sector is manual, workload-intensive, and often inefficient. The OS/CIC is the focal point for communications between the en route sector and the TMU; however, the current decision support capabilities available in the area do not fully meet their operational needs.

Objective

An operational need exists to provide decision support capabilities that will improve the situational awareness and efficiency of the OS/CIC while facilitating collaborative decision making with TFM-ATC to implement strategic flow initiatives. An operational concept needs to be developed to support the definition and evaluation of decision support capabilities that are designed to improve the efficiency of the OS/CICs as they manage the resources within their area of specialization.

Activities

An operational concept will be developed outlining the definition of decision support capabilities needed to address situational awareness issues and improve the efficiency of the OS/CIC. Evaluations will be conducted with field personnel to refine the operational concept and assess the operational utility and functional impacts and benefits of the capabilities. The proposed research will also define strategies for implementing these capabilities to meet the operational needs of the OS/CIC.

Impacts

Accommodating increasing demand for air traffic services will require improved communication, increased collaborative decision-making, and flexible systems designed to maximize service provider efficiency. Maximum realization of benefits can only be achieved when there are systems in place to support seamless communication and coordination, and when all service providers are adequately equipped with decision support capabilities that best support their roles.

Center for Advanced Aviation System Development MOIE

Exploring Obstacles to Collaborative Weather Rerouting/Congestion Management

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Problem

Within the aviation industry there is a general agreement on the need for collaborative tools and procedures for solving weather-related congestion problems. Through regular meetings and discussions, stakeholders have reached some consensus on high-level concepts, however, current efforts focus on near-term mitigation strategies. Solutions are needed for the longer term, addressing technology gaps and other obstacles.

Objectives

The objectives of this project are to synthesize an FAA/industry collaborative congestion management concept from general philosophical agreements, and to identify issues in congestion management for the future, including essential weaknesses and technology gaps affecting procedures, tools, and data exchange needed to implement that concept.

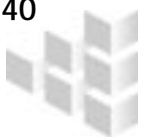
Activities

This project synthesizes a strawman operational concept based on existing FAA/industry philosophical agreements, congestion management strategies used internationally or proposed by other research, and a project-sponsored workshop. It identifies essential weaknesses and technology gaps affecting procedures, tools and data exchange needed to implement the concept. It proposes research needed to investigate promising congestion management approaches.

Impacts

This project can impact two of the NAS Operational Evolution Plan (OEP) solutions: "collaborate to manage congestion" and "respond effectively to hazardous weather." Both can benefit from improved procedures and technology.

Center for Advanced Aviation System Development MOIE



Improving Capacity of Dual and Triple Converging Configurations

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Problem

By combining existing procedures for converging runways with expected final approach speeds and/or flight management system (FMS)-based missed approaches, significant capacity gains can accrue. The key challenges are: a) obtaining good estimates of final approach speeds, which depends on developing a viable option for downlinking relevant information from the cockpit; and b) performance and certification of FMS-based missed approaches.

Objectives

This project will develop an understanding of how accurate the estimates of final approach speed can be 10 to 20 minutes before landing. It will also investigate several architectural alternatives for transmitting this information to the ground automation. The project will also explore the potential for using FMS-based missed approaches.

Activities

Approach speed accuracy will be analyzed through an understanding of cockpit practices and dependence on airframes. A data collection will also be designed with United Airlines. Several data link alternatives will be analyzed and a hazard assessment will be conducted. An operations concept will be developed to reflect a viable approach. FMS-based possibilities will be included as possible.

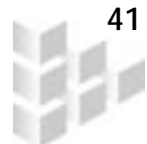
Impacts

Several airports, including Chicago O'Hare, Dallas-Ft. Worth and Washington Dulles, could benefit from a procedure that utilizes these capabilities. In the case of Chicago this could amount to an increase of 15% to 30% in the arrival capacity of the airport in instrument weather conditions.

Center for Advanced Aviation System Development MOIE

Washington

Decision Support



Mental Models in Naturalistic Decision Making

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Problem

In naturalistic decision making, people are faced with uncertain information, dynamic conditions and team collaboration. When do people succeed? How do people fail? Where can computer systems help (or hurt)?

Objectives

Our objective is to develop computational models of how people make decisions in "prototypical" (naturalistic) command and control tasks. The key tasks include risk assessment (with probabilistic information), resource management (on dynamic missions) and rational engagement (in collaboration with teammates and in competition with opponents).

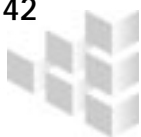
Activities

Our tool for measuring and modeling human decision making is a probabilistic and dynamic card game called TRACS. Our methods include laboratory experiments (to get data), mathematical analyses (to build models) and computer simulations (to test models). Our products are scientific papers that report data, propose models and apply the models to command and control problems.

Impacts

Our research is developing computational models that can explain and predict human decision making. Our results will be used to predict human performance (strengths and bounds), and thereby guide the design of advanced decision support systems. Our results may also be useful in efforts to simulate human behavior for system evaluations (using simulated operators) and operator training (using simulated teammates).

Independent Research and Development



Mixed-Initiative Control of Automa-teams (MICA)

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Problem

Currently, the control of unmanned vehicles requires at least one, and often multiple human operators per vehicle. However, new technologies have stimulated new concepts in military operations. Future visions involve large numbers of unmanned vehicles operating semi-autonomously, with small numbers of human operators supervising. Transforming these visions into reality will entail many challenges in autonomous and human supervisory control.

Objectives

The mission of the MICA program is to enable multi-level planning, assessment, and control of distributed, large-scale teams of semi-autonomous forces with collective objectives. MICA will develop the theory, algorithms, software, modeling and simulation technologies to support this control through the hierarchical application of systems and control theory. The human operator will remain integrated as a critical system component.

Activities

MITRE is supporting MICA program management by providing expertise on human-centered design and supervisory control issues involved in controlling autonomous teams. Towards this goal, MITRE is investigating the roles of humans in mixed-initiative control systems, techniques for modeling and evaluating human performance, and design principles, which assure that humans remain in optimal control of highly automated environments.

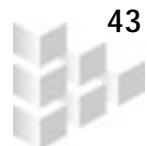
Impacts

Solutions to the MICA problem have the potential to revolutionize future military operations, expanding resources while freeing human personnel from dull, dangerous, and costly tasks. Programs where MICA has direct relevance include Future Combat Systems and Unmanned Combat Aerial Vehicles. Solutions would be applicable across multiple tasks—intelligence, combat, search and rescue—and multiple areas of operation—air, land, water, and space.

Defense Advanced Research Projects Agency

Washington

Decision Support



Operational Complexity Indicators for TFM Decision Support

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Problem

The measure of sector volume currently used for operational decision support in traffic flow management (TFM), peak instantaneous aircraft count, does not reflect the duration for which the peak load is sustained. In addition, the same flight count can represent a vastly different level of controller workload, depending on weather and the complexity of the traffic mix and flows.

Objectives

This project is designed to develop operationally meaningful, sensitive, and predictable measures of the traffic and weather patterns contributing to airspace complexity. A metric for real-time decision support is more useful if it is displayed in an accessible and intuitive fashion; therefore, the project's other goal is to recommend displays for presenting predicted complexity to the traffic management coordinator and other users.

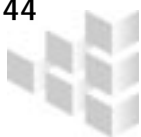
Activities

Operational assessments with field personnel, and quantitative predictability and sensitivity assessment, are the primary tasks. These activities will help adapt, for real-time TFM decision support systems, previous research findings regarding the traffic and weather factors contributing to controller workload, and will inform the design of operationally useful interfaces for displaying appropriate combinations of the factors.

Impacts

Metrics and displays found useful may be further studied for eventual operational implementation to provide decision support beyond what is currently lent by peak count. Traffic metrics may suggest enhancements to the dichotomous NAS resource categorization used in post-analysis tools. Results and literature reviews will increase scientific understanding of how traffic and weather impact controller workload and NAS performance.

Center for Advanced Aviation System Development MOIE



Surface Safety

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Problem

Runway incursions remain one of the FAA Administrator's Top 5 priority items. Multiple analyses related to number and type of incursions, causal factors, and both procedural and technology efforts to mitigate incursions have been undertaken. It is anticipated that if current trends continue, there will be about 65 category A and B events (major runway incursions as categorized by the FAA where there is a high risk of collision) in the next two years. The National Transportation Safety Board has raised concern over the use of three particular ATC procedures, identifying them as high risk for leading to runway incursions.

Objectives

The objective of the effort is to analyze the use of three operational procedures and collaboratively with NASA Ames Future Flight Central identify modifications to the procedures that reduce their runway incursion risk. The three procedures are: Taxi To [also known as 91.129(i)], Taxi into Position and Hold and Multiple Landing Clearance. This project seeks to forge a collaborative framework with NASA Ames as well as provide an unbiased mechanism/perspective to help FAA reach internal consensus on these three contentious issues.

Activities

Major tasks include participating in a cross-FAA panel evaluating data from 1997–2000 runway incursions to establish a baseline of system performance where each of the three procedures was involved. A representative airport where each of the procedures is used frequently will be modeled to analyze capacity and workload implications of potential procedures modifications. After modeling, a core set of procedure modifications will be identified and taken to NASA Ames Future Flight Central for human-in-the-loop experimentation. Experimentation will involve local facility participation as well as workforce representation.

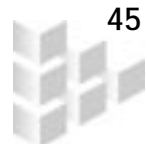
Impacts

The impact will be two-fold. First, this project supports MITRE's mission to serve the public interest by advancing the safety, effectiveness, and efficiency of aviation in the United States and around the world. Second, it also supports our goal to "facilitate good relationships within the community to ensure MITRE has impact."

Center for Advanced Aviation System Development MOIE

Washington

Decision Support



Emerging Technologies for VLSI Applications

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Problem

The military faces an increasingly sophisticated level of threat in the modern battlefield. Warfighters have to rely on advanced electronic equipment to counteract these threats. The use of state-of-the-art microelectronics can provide our armed forces superiority over the enemy.

Objectives

This project will bring critical emerging technologies to the MITRE community. As in previous years, this work will enhance MITRE's microelectronics design capability and enable us to better serve our customer. Our present focus will be on system-on-a-chip technologies that can incorporate diverse forms of processing, including RF, analog, digital, programmable processors, and MEMS sensors.

Activities

We are currently researching the integration of commercially available intellectual property for ICs. Our research has focused on programmable microprocessor cores. We are also researching system-on-a-chip mixed-language circuit simulation and modeling using VHDL, Verilog, and C simultaneously. Finally, we are developing an IC design flow that reduces power by modifying the synthesis cost functions for low-power applications.

Impacts

This project has had a broad influence on other MITRE projects, sponsor-funded work, industry consortia, and academia. We are establishing new system-on-a-chip technologies in the MITRE community. The ability to design multi-million transistor ICs incorporating diverse forms of processing— analog, digital, programmable processors, and MEMS sensors—will enable small, light, and low-power military electronic systems to address the needs on the battlefield.

Independent Research and Development

Radio Frequency Stealth Transmit/Receive Modules

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Problem

Military operations have a demand for wireless systems that are more compact, efficient, reliable, and sophisticated. Such requirements have stimulated the need to successfully merge RF, analog, and digital signal processing functions on a single chip.

Objectives

This project seeks to apply enabling technologies that move MITRE along the roadmap towards realizing a system on a chip (SoC). The objective is to apply embedded microprocessor technology, increase design experience in a mixed-signal IC technology, and to investigate strategic partnerships that foster the state-of-the-art development of SoC.

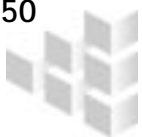
Activities

This project is aligned with the MITRE roadmap for SoC. Specifically, RF, analog, and digital VLSI circuit functions are progressively integrated over a three-year period culminating in an application-specific IC (ASIC)-based digital RF memory (DRFM) tag. Tasks include system analysis, RF integrated circuit (RFIC) design, field programmable gate array (FPGA) design, ASIC design, and DRFM development.

Impacts

MITRE operations will benefit through the experience of applying mixed-signal technology in the microelectronics arena. By taking advantage of a common technology and design tool base, MITRE will leverage its VLSI and RF microelectronic resources and grow its ability to respond to customer problems which call for small, inexpensive, and low-power solutions.

Independent Research and Development



Answer Extraction for Information Retrieval

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Problem

We have developed the QANDA question answering system and have evaluated it in government Q&A competitions. What remains to be done is to determine how the QANDA system performs in real-world applications. To date, no one working on Q&A has put their system in the hands of real users with the goal of determining real-world performance.

Objectives

We will develop example scenarios with our target users and collect performance metrics while test subjects perform the duties specified in these scenarios using both QANDA and a control system such as Key Word Search technology. We will assess parameters such as the quality of the user's performance of the task, the total elapsed time required, the number of questions asked, etc.

Activities

Project activities include defining the evaluation process, adding instrumentation to the system to record evaluation parameters, porting QANDA to two target sponsor environments, conducting internal trials, conducting sponsor trials, and evaluating the results.

Impacts

The knowledge gained in this final phase of the QANDA project will allow us to advise our sponsors intelligently on when, where, and how QANDA or a COTS Q&A system can impact their work. This will also allow us to prioritize our future research agenda in question answering by assessing which initiatives are most likely to translate into benefits for the end user.

Independent Research and Development

Babylon

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Problem

Oral communication between people of different linguistic backgrounds is essential in many areas of modern life, including in many situations involving US government personnel in foreign countries. Since all people prefer to use their native language to communicate, it is essential to provide the technical capability to allow all participants in a conversation to speak their native languages.

Objectives

The primary objective is to develop hand-held speech-to-speech translation systems that can be immediately deployed for use in tactical environments in which English speakers need to communicate with speakers of other languages. Babylon will focus on creating the systems in six to eight target languages (Dari, Farsi, Arabic, Mandarin, Pashto, among others) in three tactical domains (force protection, medical triage, and refugee processing).

Activities

MITRE supports the development of the evaluation protocols for the Babylon systems to assist DARPA in determining the efficacy of the various software systems developed by four Babylon contractors. In addition, MITRE will serve as a liaison to subject matter experts in each of the three domains of interest to assist DARPA in determining the needs of the tactical users.

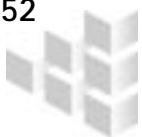
Impacts

As advisors to the Babylon data collection and evaluation process, MITRE brings its extensive expertise to bear on an area of critical national need.

Defense Advanced Research Projects Agency

Bedford and Washington

Human Language



Communicator

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Problem

In a world with more and more information at our fingertips, natural, flexible access via widely available, mobile low-cost devices (such as the telephone) is crucial to providing the most effective distribution of information access at the lowest cost.

Objectives

The mission of the DARPA Communicator program is to extend the state of the art in spoken, mixed-initiative dialogue systems. Success will mean faster and easier methods for information access by military operators. The specific application for Communicator is to enable people to converse with computers in order to create, access, and manage information and to solve problems.

Activities

MITRE's contribution to the DARPA Communicator program includes regular delivery and maintenance of the Galaxy Communicator Software Infrastructure (GCSI), which underlies the dialogue systems built by Communicator participants, as well as related tools. MITRE's contribution also includes publishable research on the contrasts between human-human and human-computer dialogue.

Impacts

MITRE's support of the GCSI helps to build a lasting community of researchers, developers and engineers in mixed-initiative spoken dialogue systems, helps to "lower the bar to entry" for new researchers, and facilitates the emergence of standards and best practice in dialogue system design and construction. MITRE's dialogue research helps to identify requirements for current and future dialogue-oriented tasks.

Defense Advanced Research Projects Agency

Conceptual Browsing

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Problem

Many of our customers are embracing e-commerce applications that depend on effective characterization of information content and efficient access to relevant information. In current Web-based information-access systems, such as Yahoo, the cataloging systems depend upon manual organization and structuring of information into ontologies. However, manual organization is expensive.

Objectives

Our goal is to automatically induce ontologies for information access. We will use a combination of statistical and linguistic methods to identify important terms in document collections and to discover inter-term relationships. We will evaluate the resulting ontologies by asking human subjects to judge relationships inferred by the system, as well as by automatically comparing machine-generated and human-generated ontologies.

Activities

The project has evaluated a domain-independent term discovery method, developed initial knowledge sources for discovering relationships, and integrated them with Veridian's ThemeLink search engine. We also enhanced the algorithms and applied them to a variety of domains. We have completed an initial set of evaluation experiments. We will continue with further evaluation experiments, apply our algorithms to other domains such as bioinformatics and book index generation, and report on transition efforts.

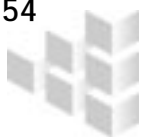
Impacts

This technology can provide for improved browsing capabilities for text collections. It can also enable a variety of Web-enabled e-commerce applications to provide a higher quality of cataloging through the automatic organization of information. This research may also be applicable to the QANDA project. We expect to transition these technologies to the IRS.

Independent Research and Development

Washington

Human Language



Contact Center of the Future Laboratory and Demonstration

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Problem

The IRS is under congressional mandate to improve the quality of its customer communications services, but must do so under severe budget constraints. Current telephony call centers must be modernized to provide accurate, consistent responses to multilingual queries coming in through multiple communication channels. A high degree of automation will be required to contain operational costs.

Objectives

The objective of this project is to build and demonstrate a Contact Center of the Future (CCOF) Laboratory that incorporates emerging contact-center technologies such as VoIP and Voice XML. The laboratory and demonstration will help to establish a partnership between MITRE and the IRS to develop a vision of modernized customer communication services.

Activities

Three activity tracks have been launched to accomplish the CCOF objectives: 1) design and implement a CCOF Laboratory consisting of telephony, networking, and commercial off-the-shelf (COTS) software components; 2) develop IRS-specific call-routing and question-answering advanced applications; and 3) integrate the advanced applications with the CCOF Laboratory for testing and demonstration purposes.

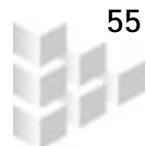
Impacts

The CCOF Laboratory and demonstration will provide an entrée for future MITRE work with the IRS in establishing a clear vision of the next generation of customer communication services. The demonstration will help to establish MITRE's credentials in contact/call center technology, and the CCOF Laboratory will allow testing of new contact-center concepts and products.

Independent Research and Development

Washington

Human Language



Reading Comprehension: Reading, Learning, Teaching

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Problem

This project is addressing a three-stage grand challenge application for human language technology: building a system that can "learn to read," then "read to learn" and finally "teach to learn." This project addresses issues of machine learning, knowledge acquisition and instructional technology.

Objectives

Our first objective is to build a computer-based system that is capable of passing a third grade reading-comprehension test. Second we will build a system that will "read to learn," passing a test on that subject matter after having read the text. Finally we will build a system that can learn through interacting with a person, and at the same time, help to teach the person.

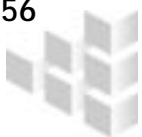
Activities

We have applied prototype systems on reading comprehension tests designed for fourth to eighth graders with a 30%–40% accuracy. We are improving the system to include more components. We will implement a reciprocal teaching demonstration, where the system plays the role of teacher (grading student answers) or the role of peer learner (answering questions posed by a real student).

Impacts

This research will open new areas of research, addressing issues of machine learning, breaking the knowledge acquisition bottleneck, developing new evaluation measures for understanding and learning, and creating new instructional technologies via learning companions and interactive teaching environments.

Independent Research and Development



Reference Resolution in Multimodal User Interface to Map-Based Applications

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Problem

Advanced human-computer interface systems that interpret graphical, gestural, and language-based input are of growing interest to MITRE sponsors. One problem faced by these systems is resolving references across modalities. For example, users may refer to an element on a map using natural language or by pointing and clicking. A problem for multimodal understanding is that information across modalities must be fused.

Objectives

The purpose of this project is to investigate and develop a framework for the interpretation of graphical, gestural, and language-based input for semantic understanding. The research domain will be map-based interaction.

Activities

Our research plan consists of two major thrusts: (1) a corpus study of multimodal interaction and (2) a prototype research system utilizing gesture and speech input for conversing with an artificial agent in map-based interaction. In our third year, we will develop an integrated discourse understanding module demonstrating multimodal fusion in a robot control task.

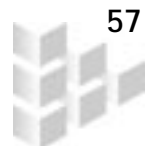
Impacts

MITRE is a leader in natural language and multimedia processing. We will leverage these strengths to create a leadership role in the new field of multimodal understanding. The potential applicability for our sponsors is great. Areas that multimodal reference resolution would benefit include such diverse domains as simulations, command/control, geospatial systems, computer-based learning and text analysis.

Independent Research and Development

Washington

Human Language



Speech in Noisy Environments (SPINE)

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Problem

Voice-driven tactical human computer interface and intelligent information access applications are characterized by harsh environmental conditions such as high background noise, vibration, stress, task loading and interference. Robust, reliable, automatic speech recognition (ASR) technology is critical to the successful deployment of voice-driven systems for military use.

Objectives

The primary objective of the DARPA SPINE program is to improve the utility of ASR in multi-speaker, high noise environments encountered in tactical applications. To achieve its primary objective, the SPINE program will seek fundamental advances in ASR technology areas including sensor/transducer systems, speech signal processing, robust feature extraction, and robust acoustic, language, and discourse modeling.

Activities

MITRE will develop corpora to promote fundamental scientific and engineering advances in robust ASR for tactical applications, conduct formal evaluation of SPINE R&D results and technologies, and develop a flexible, open software infrastructure for robust ASR to assist SPINE researchers and to promote wider and more consistent use of robust ASR technology in a broad range of computing applications.

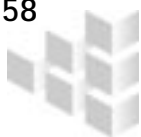
Impacts

MITRE's role in data development and evaluations will help define the course of robust ASR research in the SPINE program and beyond. We expect the open ASR infrastructure to promote collaborative research and development in robust ASR, and to promote the emergence of best practices and standards in robust ASR system design and implementation.

Defense Advanced Research Projects Agency

Washington

Human Language



TIDES (Translingual Information Detection Extraction Summarization)

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Problem

Over the years, expanded trade and travel have increased the potential economic and political impacts of major disease outbreaks. More recently, the potential of biological terrorism has become a very real threat. Appropriate response to disease outbreaks and emerging threats depends on obtaining reliable and up-to-date information, which often means monitoring many news sources, particularly local news sources, in many languages worldwide.

Objectives

The goal of the TIDES program is to provide information on demand, independent of language or medium. Under TIDES, MITRE has developed the MITAP (MITRE Text and Audio Processing) system, which captures and processes global on-line information (including news and email) to provide situation awareness for monitoring biological and other threats.

Activities

MITAP captures over 90 sources (newswire, email, broadcast news) in eight languages and automatically filters, translates, summarizes, and categorizes messages into searchable newsgroups based on disease, region, information source, person, and organization. Critical information is automatically extracted and tagged to facilitate browsing and sorting. A general search engine supports key word search and ordering of results by date or relevance.

Impacts

MITAP is an operational prototype created for tracking infectious disease outbreaks and other global threats. MITAP focuses on providing timely multi-lingual, global information access to analysts, medical experts, government users, and humanitarian organizations. A MITAP product, the World Press Update, is distributed to over 120 readers, including decision-makers in the government and military.

Defense Advanced Research Projects Agency

Understanding Words You've Never Heard

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Problem

Current state-of-the-art techniques in automatic speech recognition (ASR) explicitly model all words in a pre-defined vocabulary list. The ASR system processes the acoustic speech waveform and identifies the vocabulary word that most closely matches the acoustics. Out-of-vocabulary (OOV) words, spoken words that are not explicitly modeled in the ASR vocabulary, are guaranteed to result in output errors.

Objectives

In this project we are developing new techniques for addressing the OOV problem in speech recognition. Our research focuses on identifying post-processing methods for OOV error correction that do not require direct modification of the ASR system itself. We are developing probabilistic models of natural language information content, ASR error patterns, and the phonetic characteristics of speech recognition errors.

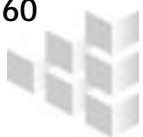
Activities

Our research addresses three major tasks: information extraction, error detection, and error correction. Information extraction involves identifying regions of the ASR output that are likely to contain significant information, such as proper names. Error detection involves identifying which words within the name phrases are ASR errors. Error correction involves using phonetic distance calculations to correct the ASR errors within name phrases.

Impacts

Currently there is no technique available for addressing the OOV word problem in ASR systems other than to add OOV words to the system vocabulary. However, adding words to the vocabulary can actually hurt system performance. Our approach is the first research focusing on post-processing of ASR errors, a technique that can be applied to any ASR system with any vocabulary size.

Independent Research and Development



Collaboration Techniques for Coalition Teams (CT2)

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Problem

The success of many military operations today depends on collaboration and cooperation among non-traditional partners. Strategic use of collaborative tools in these environments could greatly improve team decision-making and ensure synchronized situational awareness. Cross-domain collaboration has not been possible because of a lack of technology and procedures to support the unique security constraints imposed by these teaming arrangements.

Objectives

Objectives for the CT2 project include validating our prototype Instant Messaging (IM) Guard via experimentation. Additionally, we will examine the security and policy constraints unique to collaborative group communications in coalition environments and plan extensions to our initial guard prototype. Finally, we will participate more heavily in standards bodies to further the development of standards and interoperability among collaborative tools.

Activities

The CT2 project team deployed our IM Guard prototype in the NATO Strong Resolve 02 (SR02) exercise in March. Additionally, we have ported our IM Guard application to a trusted operating system (Trusted Solaris) and are beginning work on extensions to the IM Guard to support group chat.

Impacts

Through our participation in SR02, we expect to demonstrate the value of cross-domain collaboration, collect lessons learned pertaining to the use of security guard technology for collaboration, and illustrate the benefits of machine language translation in multinational operations. We also hope to have a positive impact on the ongoing efforts to define standards for collaboration and interoperability within the IETF.

Army-Contract MOIE

DARPA Cyber Panel

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Problem

Computer network defense systems (e.g., technologies being developed under DARPA's Cyber Panel program) aggregate sensitive information about the status of networks in a theatre and provide capabilities to control network elements. These systems present an attractive target for attackers who wish to hide their tracks, access sensitive data, or use the systems' response capabilities to attack networks.

Objectives

The DARPA Cyber Panel program objective is to develop technologies that monitor the state of critical systems, recognize large composite cyber attacks, and determine and execute effective defensive responses. Our objective is to develop a set of principles and requirements that enhance the survivability of defensive capabilities when subjected to stresses such as information attacks, failures, and abnormal loads.

Activities

We have developed a framework that extends the "Defense-in-Depth" principle of security to survivability. We are documenting this framework and are developing a catalog of survivability goals and mechanisms for achieving those goals. We will apply these to a notional Cyber Panel architecture and will identify new capabilities for enhancing the survivability of a Cyber Panel system.

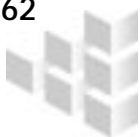
Impacts

Our survivability framework and catalog will provide a systematic foundation for developing survivability requirements and survivability architectures for real-world systems. We will also identify new technologies that must be developed to make computer network defense systems survivable.

Defense Advanced Research Projects Agency

Bedford and Washington

Information Assurance



Decision Support for Computer Network Defense

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Problem

Information assurance vendors have developed independent capabilities: intrusion detection systems, firewalls, etc. When conditions warrant, operators must interact with each component to collect data, perform mental data correlation, consider possible options, then determine and implement a course of action (COA). Because this is a slow, intellectually challenging process, it often is performed perfunctorily, with the COAs being correspondingly crude and inappropriate.

Objectives

This problem is suited to automation. Existing systems support data collection (e.g., Lighthouse, AFED), but analysis and COA portions are missing. Due to the immaturity of the field, this project will pursue a bottom-up technology development approach. This project will leverage off the Outpost data collection and integration system, and develop a rule-based approach to analysis and COA recommendation.

Activities

Operational concerns will drive research. Operators will be interviewed to determine existing processes for security management. A representative scenario will then be selected. The scenario will be decomposed to observables that will be extracted from Outpost data using a rule-based diagnosis system. A mapping from observables to COA recommendations will be performed. Generalizations to other scenarios will parallel prototype development.

Impacts

State-of-the-art information assurance tools provide excellent point solutions, but the training, time, and technical knowledge required to wield these capabilities effectively exceed the domain expertise typical of operators. By undertaking this research and producing solutions to be transitioned to the field, this project will develop technology that will improve the USAF's ability to defend our critical computer assets.

Air Force MOIE

Engineering Issues for Adaptive Defense Network

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Problem

The combination of distributed intrusion detection with adaptive firewalls and other protection mechanisms requires that basic engineering issues about the interaction of these systems be examined before deployment decisions are made. Under attack conditions, algorithms, policies and protocols cause local failures leading to network failures in the organization and beyond. In particular, on-the-fly changes of firewall policies in a specific node may cause problems that introduce new vulnerabilities. If multiple intrusion detection systems can all "command" adaptive firewalls, engineering issues of precedence and conflict arise.

Objectives

We will investigate techniques and methods in creating adaptive behavior for firewall and router policies, and evaluate commercial and research approaches with respect to DOD networks and threats. We will also develop new measurement techniques and tools to evaluate the behavior of products and applications under attack.

Activities

We will develop automated attack tool controls. This important capability is needed as we share our attack testbed with other projects. We will create techniques and instrumentation to monitor network behavior during attacks, including the use of software configurable routers, and conduct out-of-band adaptive control experiments for Cisco routers. We will provide support to the MITRE DMZ network with a prototype sensor for session collection and produce a compendium of the state of the art in Distributed Denial of Service defense.

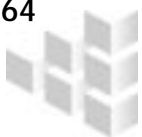
Impacts

This research will enable MITRE to extend its knowledge in a complex and needed capability for future critical networked information systems. Many of our sponsors are developing distributed (WAN) information systems and enterprise solutions that will need autonomous response mechanisms to thwart security threats and activities. Understanding the engineering issues and constraints of system capabilities to create an adaptive defense network will support a secure information infrastructure.

Army-Contract MOIE

Washington

Information Assurance



Information Assurance for Enterprise Engineering (IAFEE)

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Problem

Systems engineers have no immediate effective means of integrating information assurance (IA) into Enterprise Frameworks and Architectures in a manner that is both adequate and complete. Specification of IA at a higher level of abstraction must be adequate for more detailed instantiations at lower levels of abstraction. To address completeness, the IA perspective must fully address the common IA solutions across the enterprise views.

Objectives

This project is capturing and developing IA solutions from the policy level to the implementation level in an architect's representation (i.e., patterns) and will provide an IA Enterprise Engineering Handbook to guide engineering practitioners.

Activities

IA is being integrated into the Zachman Framework, addressing the IA via a separate architecture element integrated across the entire framework as well. To develop the IA element, activities include: IA taxonomy development, pattern template development, Zachman Framework overlay plane development, and identification and authentication details captured with draft patterns. Future activities will include additional pattern development for other IA areas of the taxonomy, case studies, and development of an IA Engineering Handbook.

Impacts

All MITRE customers are building or using architecture frameworks, for example, the Federal Enterprise Architecture Framework (FEAF) and DOD C4ISR Architecture Framework. Many MITRE customers need to address the requirements of OMB Circular A-130, which requires federal agencies to develop enterprise architectures that address specific topics, including IA. This project also enables better leveraging of skilled personnel in the IA area.

Independent Research and Development

Mobile Policy Based Guard (MoP-Guard)

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Problem

Today, guards are used to support release of sensitive information in multi-level security (MLS) environments. As such each project that needs a guard typically develops its own. This has resulted in many different guards being deployed, each of which is difficult to maintain.

Objectives

The objective of this project is to prototype a new approach to implementing guards in information systems. Guards built using mobile policy will be more manageable than current guards but will be able to provide the same level of protection with enhanced accountability for release decisions.

Activities

The project will design and implement a prototype information dissemination server. The prototype will demonstrate the idea of separating data-specific policy from its enforcement and will explore how such an approach to guards can provide security equivalent to today's guards while increasing flexibility, maintainability and accountability.

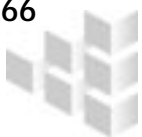
Impacts

The DISA C2 Guard (C2G) currently utilizes the MITRE-developed FELT system to scan documents before releasing them. Mobile policy can make C2 guards easier to certify and manage by decoupling guard certification from policy certification. Since a mobile policy-enabled C2G acts as a generic policy enforcement environment, it can be certified separately. Each mobile policy module can subsequently be certified as it is developed.

Army-Contract MOIE

Washington

Information Assurance



Next-Generation Information Attack Strategies

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Problem

Current understanding of the threat of distributed, coordinated computer-network attacks is limited. Defensive measures are currently developed under pessimistic assumptions about the threat. Without a clearer understanding of the nature of the threat, our defensive models will be incomplete and our defensive mechanisms insufficient. A model of coordinated mobile attack tools is needed to help identify effective defensive countermeasures and postures.

Objectives

This project will research the class of mobile, coordinated attack tools and provide effective defensive mechanisms or postures for defending against this threat. An attack potency relation will be developed that will help predict the impact of a particular class of attacks. The potency relation will also be used to identify defenses against next-generation information attacks through a systems-level approach.

Activities

In a design phase we will generate an architectural model of mobile, coordinated attacks; develop a predictive potency relation that captures the potency of the attack tool; and develop defensive measures and postures that are effective against the threat. In an implementation phase we will implement a prototype attack tool and defensive mechanisms to validate the defenses and predictive potency relation.

Impacts

This project will provide the information assurance community with a model of a specific class of threats: distributed, coordinated information attacks. A predictive potency relation will provide the ability to evaluate the potency of hypothetical attacks. Defensive mechanisms will be designed and validated and provided to the community. The prototype will be useful for developing and validating information operations tactics.

Independent Research and Development

Organically Assured and Survivable Information Systems (OASIS) Program

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Problem

The problem is to develop survivable systems, i.e., systems that are survivable against cyber attacks. A survivable system is one that can continue to provide the specified services, possibly in degraded mode, to the users in the face of a cyber attack or intrusion.

Objectives

The project will support DARPA in the development and assessment of survivable systems.

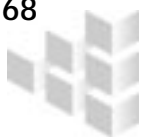
Activities

There are two main activities. First, we will assess DARPA OASIS projects providing survivability technologies and determine the overall coverage of the projects. Second, we will assist DARPA in developing a program to build a survivable system based on a current DOD system and to test that system.

Impacts

This work will result in creation of DOD systems that can better withstand cyber attacks and will be survivable.

Defense Advanced Research Projects Agency



Secure Distributed Computing

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Problem

How can critical security services be made highly available and secure, while individual service components may be faulty?

Objectives

We have two objectives: to design a method for maintaining reliable critical security services under conditions of arbitrary component failures, and to test the method in a prototype. We will extend our current authentication prototype to handle arbitrary failures without breaking security guarantees of the system. This involves combining existing mechanisms for distributed security (threshold cryptography) with robust communication methods between components (consensus algorithms) in an innovative way.

Activities

The combination of past and ongoing research from many different sources in the areas of threshold cryptography and consensus algorithms will support our approach. We will first capture the design of this system in a paper describing our solution. Thereafter, our prior authentication service prototype will give us an established environment in which to implement these additional capabilities for fault-tolerant, secure authentication.

Impacts

This research will provide insight into how reliable systems can be built from imperfect and unreliable components. By combining two previously separate approaches, we will distribute trust throughout a collection of authentication servers, placing total trust in no single server. We believe that this will lead to a method that is both theoretically sound and practically feasible, and that our design will increase the availability and security of distributed systems.

NSA Secure Systems Research Office

Trust Management for Mobile Devices

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Problem

Access rights are often context-sensitive and transient. For instance, two soldier-carried devices that share data when in close physical proximity may no longer trust each other when they move apart, due to potential device capture by the enemy. Today, access rights don't change as a user's context changes, e.g., as a soldier moves. Can we build security mechanisms that adapt to a user's current environment? Can we simplify the task of application developers who must use these enhanced mechanisms?

Objectives

Our primary objective is to develop techniques for building secure applications that function seamlessly even as trust relationships change due to device mobility. A second objective is to simplify the development of security-aware applications by separating the specification of security and functionality aspects of the applications.

Activities

We are developing techniques that establish spatial and temporal attributes of mobile devices in the presence of malicious adversaries. We are using these contextual attributes within a generalized access control (trust management) framework. Finally, we are developing a secure peer-to-peer instant messaging application for mobile devices that uses our new mechanisms to enforce context-sensitive access control policies.

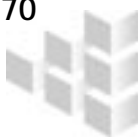
Impacts

This project will advance the state of the art of information assurance by addressing two novel concepts: transient trust relationships and separation of concerns. Our theory and language publications will impact the academic and R&D communities. Our prototypes will enable us to demonstrate these concepts to sponsors and develop a work program that focuses on sophisticated access control capabilities for next-generation mobile systems.

Independent Research and Development

Bedford and Washington

Information Assurance



Building the Semantic Web

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Problem

As the amount of information on the World Wide Web continues to grow, the value of automated tools capable of finding, filtering, and combining information in response to specific user requirements greatly increases. The largest barrier preventing more automated use of Web resources is that the semantics (meaning) of these resources is generally unavailable to automated agents.

Objectives

The objective of this project is to develop technical foundations for a "Semantic Web," in which programs such as agents, search engines, or service brokers can identify and use World Wide Web resources (including both information and services) based on machine-readable representations of their semantics.

Activities

We are investigating language concepts for representing and processing semantic information that scale to the Web environment, and application areas that include eBusiness and disaster relief. We are participating in the World Wide Web Consortium's Semantic Web Activity, engaging in joint research with MIT's Context Interchange (COIN) project, and cooperating with researchers in DARPA's DAML (DARPA Agent Markup Language) program.

Impacts

This research addresses a key area of current Web technology development, impacting numerous MITRE programs dependent on Web technologies such as XML, as well as wider eBusiness and other communities addressing issues of large-scale interoperability. The research also provides technology transfer opportunities with a wide range of academic and industry R&D activities and standards groups.

Independent Research and Development

CEM Design and Project Support Laboratory

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Problem

The evaluation of proposed approaches and technologies that will be used in the IRS information and data management research project requires access to development tools used in the modernization effort. For example, tools are needed to support research on the impact of XML on data processing, and research on a metadata repository.

Objectives

CEM will develop an internal facility of resources and technologies to support the research on key topics identified in the IRS information and data management research project. This facility would allow CEM staff to have access to development tools used in modernization efforts as well as alternative tool sets for the evaluation of proposed technical approaches.

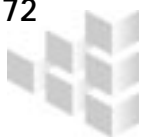
Activities

The CEM Design and Project Support Laboratory will host a set of tools for research and evaluation of key topics. The initial set of tools includes the Rational Enterprise Suite and System Architect Modeling Tool for the initial evaluation of metadata repository approaches, and IBM DB2 and Extend Business Process Modeling Tool for the impact analysis of XML in data processing.

Impacts

The facility will enable CEM staff to conduct independent research on topics that are directly relevant to the IRS modernization program. Results of this research should provide the basis for MITRE to make proactive recommendations on related technical work by contractors.

Independent Research and Development



Data and Information Management Research at the IRS

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Problem

Currently, the IRS has limited ability to capture information and data from multiple inputs such as tax returns and information returns and to analyze and provide timely reports from multiple data source systems. Changing regulations have altered business rules that affect the processing of more than 40 terabytes of taxpayer data.

Objectives

The project will define a research agenda that will guide information innovation grant studies addressing information and data management (IM/DM) topics relevant to the IRS. These studies will assist in determining approaches for dealing with IRS challenges in managing the increasing information demand and volume of data for the current and future systems.

Activities

Current IRS information and data management challenges will be identified and will guide the identification of research topics. Investigators will further define each topic and a proposed approach for addressing it. The initial set of topics will include determining the impact of XML on business processing, defining approaches for metadata repositories, and implementing and managing business rules.

Impacts

As new components of the IRS modernization program are defined and developed, MITRE will be able to directly relate and apply its research results regarding the topics defined in this project. This work should assist the IRS in implementing information systems that support the goal of providing timely information to stakeholders.

Independent Research and Development

Data Integration as an Industrial Process

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Problem

Data integration requires too much human time and skill. We need to industrialize, to create narrow-skill steps, each of which produces reusable knowledge rather than opaque code. To move from (easily evaded) mandates to natural incentives, we will explore "describe and generate" tools to make even the first connection easier. The approach should be incremental, driven by real interoperability needs, not special initiatives.

Objectives

Our goals are to refine the industrial approach and to move industry, the research community, and sponsors toward that vision. Specifically, we will extend (very scalable) profile-driven integration techniques to be compatible with commercial multidatabase query tools, develop metrics to help project planners compare data integration techniques and judge tools' utility, and evaluate emerging describe-and-generate data integration research prototypes in real projects.

Activities

In the first year we performed a modular breakdown of integration steps and compared profile-driven against federated techniques. We also began constructing an experimental framework and metrics for comparing integration techniques. In the second year we will conduct experiments using research prototypes (e.g., IBM Research's Clio) with aviation, brain mapping, and tax administration data; conduct a survey of data integration practitioners to determine where the costs are the greatest; and adapt metrics to improve project planning. In the third year we will refine the metrics and perform further experimentation. Throughout, we will publish results and transition them to MITRE and sponsor projects.

Impacts

We will reframe a critical technology to reflect rarely addressed organizational realities. We will influence emerging industrial tools and researchers' agendas, and provide metrics where none previously existed. MITRE's sponsors will be aided in moving from giant doomed data integration initiatives to incremental progress.

Independent Research and Development

Washington

Information Management



Database Curation and Access for Bioinformatics

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Problem

Biological databases store information on proteins, genes, and their functions. The biomedical literature describes the experiments behind the database entries. Many databases lag behind the literature because they require biologists to transfer the information from articles to database entries. Biologists need interactive tools to help in the timely and consistent transfer of information from the literature into the databases (the "curation" process).

Objectives

This project will develop interactive techniques for the curation of biological databases. These techniques will allow curators of databases to maintain currency and consistency of these databases in the face of exponential growth of research in genomics and proteomics. To provide the curation tools, we will develop information mining methods for free text and structured data, specifically geared to the biology domain.

Activities

In the first year we will determine requirements for biological database curation and mine existing databases for training and test data. We will also develop an initial curation system prototype and conduct initial technology and user-centered evaluations. In the second year we will refine our interactive curation system and further evaluate it. Finally, we will explore a Question & Answer front-end.

Impacts

This work will have impact on the biology community by defining methods and evaluations for automating database curation. We estimate that hundreds to thousands of biology databases exist, and the number is growing rapidly. Investment in this area leverages MITRE's expertise in text data mining and databases, allowing MITRE to become a significant player in bioinformatics.

Independent Research and Development

Distributed Metadata Service

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Problem

DOD and commercial practice are moving towards dynamic composition of Web-based systems using publish/subscribe paradigms and metadata (e.g., XML). The Joint Battlespace Infosphere (JBI), Universal Description, Discovery, and Integration (UDDI), and peer-to-peer systems are examples of this. For these "infospheres" to succeed, they must be scalable, flexible, and evolvable, and support component reuse both in applications and in the infosphere services themselves.

Objectives

We are "pushing the edge" of the architecture envelope for Web-based infospheres with respect to distribution and participant stewardship of metadata (for scalability), uniformity (for simplicity and reuse), and dynamic integration of components (for flexibility). As these architectural principles are validated, we transition them into DOD initiatives, programs, and commercial use.

Activities

We will define a metadata-based architecture to improve scalability, uniformity, and flexibility, and a profiling language for advertising Web service / information "haves" and "needs." We will develop components and a software development kit (SDK) for architecture evaluation, technology transition, and demonstrations. As architectural principles are validated, we will transition them via consultation, delivery of components, and training and provide inputs to industry consortia, conferences, and discussion groups.

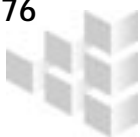
Impacts

Our profiling language, which expresses both "haves" and "needs," is used for the JBI. Our brokers, profile editors, and SDK will be transitioned to the 3Q2002 JBI release. We support projects in becoming "JBI enabled." We consulted with a MITRE project developing an information service and XML schema that allows "advertising" of UAV intelligence products, as well as "publishing needs" for UAV intelligence products.

Independent Research and Development

Bedford and Washington

Information Management



ISR Information Service (ISRIS)

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Problem

Legacy intelligence, surveillance, and reconnaissance (ISR) systems connect through stove-piped interfaces to command and control (C2) systems. This limits the ability to form a common operational picture to support missions such as time-critical targeting. A variety of "battlespace intranets" are emerging to address this problem, but the challenge remains: how will ISR assets connect to these information management initiatives?

Objectives

This project is experimenting with the integration of advanced Internet technologies into the ISR sensor ground station. The objective is to enable access for all C2 users to the real-time services and data of an ISR platform from within a user's standard Web browser, and ultimately show the way ahead to the next generation of DOD ISR and C2 Web services.

Activities

The FY01 ISR Information Service (ISRIS) prototype supports the Air Force Global Hawk UAV. We plan to experiment with ISRIS during live flights in FY02 using servers on the MITRE MII and on SIPRNET. We will extend the ISRIS concept to the Predator UAV and U2. The subscription and profiling technology of the Air Force Joint Battlespace Infosphere (JBI) will be integrated with ISRIS.

Impacts

ISRIS research is helping the DOD develop the concepts and technology for next generation Web services on battlespace internets. These services will enable an unprecedented level of access to real-time situational awareness information and raw sensor data. Doing this within the user's generic browser will streamline deployment and enable a browser-based common operational picture.

Air Force MOIE

Managing Data Quality with Shared Views

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Problem

Data quality, defined as fitness for use, is increasingly seen as a serious problem in government and private sector databases. Sometimes the data is of low quality; in other cases users cannot easily determine whether the data is satisfactory. Consequences range from user mistrust, lack of use, and creation of redundant stores to mission failures.

Objectives

We have developed technology to manage data quality annotations: to store them using a defined model, to capture them with minimal impact on users by modifying existing production tools, and to use them by extending existing applications. We will show how this technology can be applied to two systems by extending database view technology to include quality annotations and to propagate data quality annotations between systems.

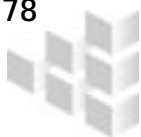
Activities

We will make recommendations on improving data quality within two key government databases. These recommendations will include use of views and quality annotations for improved propagation of data between the systems. We will also develop a data quality assessment tool and demonstrate it for one of the systems.

Impacts

Data quality annotations help a user employ data appropriately and can inform organizational efforts at data quality improvement. We will enable end-to-end management of data quality via creation of better (and more easily maintained) data quality views for various communities of interest (COIs). Our work will make it easier for COIs to form and interact with government databases.

Army-Contract MOIE



Neuroinformatics

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Problem

The neuroscience community is accumulating a vast amount of human brain mapping data using techniques that operate over many spatial scales. Currently data use is generally limited to the lab of origin; the data is not readily available to other investigators for subsequent studies. Data may exist that a researcher could use to explore a particular hypothesis, but that investigator is not aware of its existence or does not have ready access to it.

Objectives

The overall goal of this research is to design, prototype, and evaluate an information infrastructure for human brain mapping data which will help realize the full potential of this growing store of mapping data. In this initial undertaking, we focus on a system that enables the analysis, exploration, and dissemination of structural magnetic resonance imaging (MRI) data from multiple labs.

Activities

The project will develop and deploy a digital library for structural MRI data; design a warehouse of structural MRI data; design a content-based system that will allow users to retrieve images with features similar to those in a submitted example; develop techniques that enable users to aggregate warehouse information into a probabilistic brain atlas; and develop a prototype system that will ground architecture and query language development in a real-world setting.

Impacts

The problems encountered by the human brain mapping community are isomorphic to those encountered by many of MITRE's traditional sponsors. We expect research conducted under the auspices of this project to be readily transitioned to our Treasury Department, IRS, DOD, and USGC sponsors. In addition, this project provides an important public service to the neuroscience research and clinical communities.

Independent Research and Development

Next Generation Joint Battlespace Infosphere (JBI) Core Services

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Problem

Digital information rapidly is becoming integrated into all aspects of military activities. Operations are becoming increasingly fast-paced and diverse. To provide commanders with the knowledge required to make decisions in this environment, a greatly enhanced command and control (C2) concept for intelligence gathering, dissemination and visualization is needed, based on revolutionary new information-age concepts and technologies.

Objectives

Our primary objective is to evaluate and integrate the first versions of the best existing research and commercial technologies into the core services of the C2 Enterprise Integration/Common Integrated Infrastructure (C2EI/CII) platform in a manner consistent with the overall JBI vision. This initial integrated set of services is expected to be used by early adopter SPO prototyping efforts.

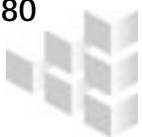
Activities

The modeling of user information needs and decision goals will be the focus for FY02 research. In addition, investigation of deployable commercial products consistent with major C2 SPO selections and the JBI vision must be continued. Finally, continued improvement to existing JBI functional services will continue. These core services will be evaluated and prototyped for integration into C2EI/CII enterprise services.

Impacts

This project should provide better insight and a working relationship among major S&T community members and form a bridge between technology and information management research. The integration of "best of breed" implementations for each of the C2EI/JBI platform components can form the basis for C2 SPOs and other DOD related programs to adopt an adaptable Web services-based architecture.

Air Force MOIE



Using Domain Knowledge in Data Mining

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Problem

Domain knowledge is not being fully exploited by current data mining methods. As a result of this deficiency, data mining tools generate a large number of patterns that are not "interesting," i.e., overly complex, already known or unnecessarily low in predictive power.

Objectives

Directly incorporating domain knowledge into data mining algorithms should improve the quality of the output and therefore reduce the amount of manual filtering and interpretation of the discovered rules (required to be done by humans) and improve the overall efficiency of the process.

Activities

We plan to research the proposed method by accomplishing the following: acquiring domain knowledge and preferences and representing them in a suitable format; modifying Association Rules and Decision Trees algorithms to allow direct use of domain knowledge and preferences within the mining process; evaluating the effect of our techniques; and summarizing our research activities in a conference paper.

Impacts

Because of the popularity of the selected algorithms and the generality of our approach, this work can have a positive impact on any of the ongoing data mining projects within MITRE and on the broader data mining community and tool vendors who support this work.

Independent Research and Development

Analyze, Share, Know (ASK)

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Problem

Analysts must form a correct view of the world from very large quantities of data that are not necessarily structured to help them answer their questions. Every analyst must potentially be able to leverage the insights gained by the work of others in the organization. The analyst should be able to know what the rest of the organization knows about the target subject and that information's relevancy to the current analysis task.

Objectives

Using a mix of COTS, GOTS, and research components, the ASK program seeks to demonstrate novel analytic tools to support efficient inference against large data collections, analysis coordinated through structured argumentation, and an integrated, collaborative knowledge management environment for the analytical enterprise.

Activities

Leveraging previous work through judicious systems integration, the ASK team is creating prototypes of several advanced capabilities, including: automatic generation of timelines with event extraction; spatio-temporal fusion of imagery, signal processing, and linguistic sources; structured argumentation to organize all-source analysis; dialogue agent analytic tool interfaces mediated by an instant messaging system; reinforcement learning in the analytic environment; and analytic enterprise integration strategies.

Impacts

On-going interaction between members of the ASK team and specific government communities informs our choice of tasks. Capabilities demonstrated here are being fed back into the real-world work of intelligence systems engineering.

Corporate

Audio Hot Spotting

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Problem

Large volumes of recordings require rapid retrieval of segments potentially relevant to a given query (audio hot spotting). Spoken document retrieval systems that simply combine automatic speech recognition (ASR) with information retrieval (IR) do not meet this need in real applications. This is because of high ASR word error rates and the loss of important audio information in the speech transcription.

Objectives

We propose to research and develop audio-specific retrieval algorithms in critical domains by 1) exploiting multiple types of acoustic information from the audio signals; 2) exploring several adaptive techniques to improve existing ASR performance; and 3) fusing component technologies such as ASR, language/speaker identification, audio feature extraction, and information retrieval.

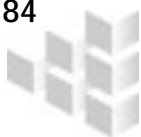
Activities

We will research algorithms and techniques to extend and improve ASR and audio feature extraction and to develop audio-based query algorithms making use of the multiple types of audio information. We will research and develop fusion algorithms to build an audio hot spotting system based on the extended ASR, audio feature extraction, language/speaker identification, and the new audio query language.

Impacts

Our research in audio hot spotting algorithms and prototype development will address the needs of MITRE's sponsors with warehouses of recordings waiting for efficient retrieval. It will extend MITRE's information retrieval capability from text to include audio. The expertise gained through the research will equip MITRE to better advise industry developers and our sponsors on audio information retrieval topics and evaluation standards.

Independent Research and Development



Automated Discovery of Structural Patterns in Link Analysis

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Problem

The threat from terrorist actions is perceived to be immediate and growing. However, it is believed that clues to the capabilities, intentions and organization of terrorist and other criminal groups can be found in already available data. Identification of suspect behavior is made difficult through the intentional concealment of relationships, and thus the efficient discovery of patterns from large databases is a very difficult problem.

Objectives

We will explore promising, although unproven and technically risky, new approaches for automating the discovery of patterns of suspicious behavior and associations. We will attempt to train a classifier that can identify criminals or terrorists based on descriptions of the types of associations or relationships that they have in common.

Activities

We will develop a demonstration prototype for a large-scale repository supporting link discovery and analysis. Initial emphasis will be on techniques for transforming multiple, large databases into an integrated, searchable link representation. We will test approaches for storage and traversal of the links and mechanisms for inserting additional links. A series of three prototypes will demonstrate increasingly sophisticated techniques. The link repository will grow with each demonstration.

Impacts

The proposed research can contribute to the national effort by bringing new methodologies to bear in discovering terrorists, terrorist organizations, fraud, and other criminal behavior. There are challenges in attempting to scale current practices in link analysis to large-scale databases and to find suspects based upon data that is intentionally being manipulated. The methodology could be transferred into the counterterrorism and law enforcement domains if it proves effective.

Army-Contract MOIE

Automated Information Discovery and Retrieval from Asian Language Sources

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Problem

While several commercial capabilities exist to address particular facets of machine translation (MT) needs, emphasis has been placed on European-based languages. Furthermore, none of the existing COTS products is particularly well suited to the military environment. English translation of the Asian languages is a much more difficult problem than for European and has presented the MT community with significant challenges.

Objectives

This project will develop a capability to perform Chinese and Korean cross-language information retrieval, information discovery (ID), data mining (DM), and knowledge management (KM) in support of open source intelligence analysis. The project will develop a prototype capability that can support in-field experimentation with a broad spectrum of users.

Activities

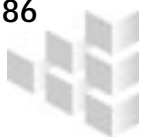
The project will provide an automated capability to translate electronic textual information between Chinese and English, and between Korean and English. We will characterize and subsequently retrieve information, based on user-specified profiles, from Chinese and Korean language sources by means of a prototype analytic tool. A dictionary management capability will allow users to build, import/export, and aggregate custom dictionaries.

Impacts

This project has the potential for improving the efficiency and effectiveness of intelligence organizations currently impacted by foreign language translation issues. It is expected to provide the beneficiaries with needed interim capabilities and validation of the most fertile areas for the future application of government funds.

Army-Contract MOIE

Washington



Foundations for Next Generation Information Access

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Problem

Computerized support for information gathering is fragmented across multiple research communities and integration is difficult due to a lack of an underlying formalism that cuts across the different technologies. Statistical techniques developed for individual components have been developed in isolation and without a common theoretical foundation. As a result we are left with a number of reasonably effective, semi-principled, incompatible techniques.

Objectives

The principal objective is the development of statistical foundations for information access. A successful foundation will comprise rigorous characterizations of the issues of modeling and estimation, together with principled methodologies for adapting to new languages, genres, information domains, auxiliary knowledge sources and tasks.

Activities

We will develop simulations that model the stochastic generation of latent document features, observable document features, the determination of document relevance, and the distribution of query characteristics. We will perform exploratory data analysis on available research corpora to verify our models. A central focus will be research into the importance of variance reduction and the potential benefit of various bias-variance strategies.

Impacts

This research is of direct relevance to existing MITRE projects. The results will allow MITRE to develop information access systems incorporating new sources of evidence and to tailor information systems to meet specific military and intelligence needs. MITRE will then be strategically positioned to set the direction of research into, and development of, next generation information access technology.

Independent Research and Development

Graph Based Data Mining

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Problem

The threat from terrorist actions is perceived to be immediate and growing. However, it is believed that clues to the capabilities, intentions and organization of terrorist and other criminal groups can be found in already available data. Identification of suspect behavior is made difficult through the intentional concealment of relationships, and thus the efficient discovery of patterns from large databases is a very difficult problem.

Objectives

We will explore promising, although unproven and technically risky, new approaches for automating the discovery of patterns of suspicious behavior and associations. We will attempt to train a classifier that can identify criminals or terrorists based on descriptions of the types of associations or relationships that they have in common.

Activities

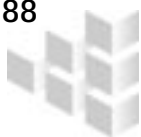
We will develop a demonstration prototype for a large-scale repository supporting link discovery and analysis, emphasizing techniques for transforming multiple, large databases into an integrated, searchable link representation. Three prototypes will demonstrate increasingly sophisticated techniques for storage and traversal of the links and mechanisms for inserting additional links. Sensitive but unclassified databases from the USCS will form the basis for the second and third demonstrations.

Impacts

The research can contribute to the national effort by applying new methodologies to discover terrorists, terrorist organizations, fraud, and other criminal behavior. Feasibility of these techniques in the USCS environment will be demonstrated in the areas of counterdrugs and counterterrorism. The methodology could be transferred into the counterterrorism and law enforcement domains if it proves effective.

Independent Research and Development

Washington



Robot Platoon Command and Control

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Problem

Reliable autonomous soldier robot teams will not be possible for many years. However, an intermediate level of autonomy, where a commander gives high-level commands (e.g., go to the top of Hill 203), is achievable in the near future. This supervisory control requires only occasional intervention by a commander during a mission.

Objectives

This proposal asserts that one human is adequate for directing a small team of robots. We will use reconnaissance tasks in urban terrain as our test bed. Validating the assertion will require us to demonstrate a working team system where robots exhibit some automated reasoning (route planning, navigation) and cooperative behavior, while attending to human guidance.

Activities

We will extend behavior-based robotics approaches to include the memory and communication required for human participation in the team. Our principal demonstration task will be to produce a team entry for the RoboCup-Rescue annual competition. We will also investigate the utility of platform mobility for reconnaissance-directed sensor networks.

Impacts

MITRE's capability in robotics will be of considerable importance to our customers in the near future. This proposal builds on MITRE's current expertise in command and control and artificial intelligence. Robot platoon command and control defines a niche that is a natural extension of this expertise.

Independent Research and Development

Social Information Retrieval

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Problem

Our research is focused on developing new technology for tracking internet-based networked organizations, and using those results to identify potential vulnerabilities and threats. Current information retrieval technology does not directly address the problem of detecting activist networks, assessing behavior, and tracking their evolution; new technology is needed to detect networks based on their structure and context.

Objectives

The main objective is to develop technology for a worldwide monitoring system used to detect the emergence of new groups (e.g., activists) and track the evolution of existing organizations based on their online activity. The focus will be on assessing an organization's behavior and its vulnerabilities.

Activities

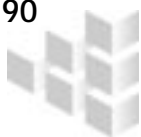
We are exploring the confluence of information retrieval for collecting distributed information, social network analysis for determining network structure and characteristics, and dynamical systems modeling for determining network function or behavior. Work includes the development of advanced smart crawler collection tools that will use adaptive and cooperative searching techniques to provide efficient and high-coverage collection from the Web or other network search environments.

Impacts

This research will provide new tools for detecting emergent networked organizations in the open Web and enterprise environments, and will provide a basis for modeling their behavior, identifying critical nodes for assessing vulnerabilities and network robustness. Our initial work has already had impact on several sponsor mission areas.

Independent Research and Development

Washington



Adapting Private Sector Virtualization Strategies to Federal Agencies

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Problem

Our goal is to offer MITRE's government clients an approach for understanding and analyzing investment choices that "virtualize" government business.

Objectives

The project seeks to produce a guide for managers considering virtualization. At the very least, the guide will contain a set of heuristics which managers should consider before acting and some way to measure project risk.

Activities

A major task of this phase has been simply to draw a boundary around a very nebulous concept and then develop a methodology for clients to measure the risk and return on investments in virtualization. We also developed a process model for virtualization projects. We developed a set of contacts in government with experience or interest in virtualization.

Impacts

We will present our clients with a balanced view of virtualization and tools for assessing it. These resources will help government organizations achieve cost reduction and better service (quality, quantity, time), and will provide new capabilities and the ability to reallocate money to fulfill unmet needs.

Independent Research and Development

Applying ROI Analysis to the Full Investment Management Process

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Problem

The absence of concrete, standard definitions, processes, and other methods for performing and applying return on investment (ROI) analysis throughout the investment management lifecycle creates considerable confusion for government.

Objectives

Key objectives include differentiating between ROI calculation/analysis regulations and other required investment analyses. An approach for quantifying investment value creation and intangible costs/benefits within the ROI analysis will be recommended. An ROI calculation/analysis will be recommended that most effectively manages investments over the entire lifecycle. The ROI guideline developed in FY01 will also be validated via case study.

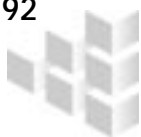
Activities

Investment selection/evaluation regulations will be compared and overlaps will be identified. Key attributes for selecting methods to measure investment benefit will be identified. The applicability of decision analysis methods for typical government ROI needs will be evaluated. A case study will be conducted to validate the extensibility of the ROI analysis guideline. An ROI maintenance program will be developed.

Impacts

This research will increase MITRE's knowledge of the latest strategic, financial, and investment theory and of best practices in commercial industry and government investment decision-making. Continued investigation of multi-criteria decision analysis methods will supplement MITRE's extensive knowledge in this area. Development of ROI calculation and analysis recommendations will be communicated to standards bodies.

Army-Contract MOIE



Aviation Demand and Performance Analysis

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Problem

With the increasing tension between capacity and demand, the economics of air transportation is increasingly important to understanding the likely operational impacts of changes in the National Airspace System (NAS).

Objective

We will expand our understanding of the economic factors that impact NAS operations. We are focused on three items: passenger demand for air transportation, changes in demand management, and economic trends that affect air transportation.

Activities

We are performing an assessment of current literature and building a database of regional economic and passenger ticket information. We are constructing an econometric model of passenger demand by origin-destination pair and a model to estimate the likely impacts of changes to current demand management procedures. Finally, we are developing processes to collect and synthesize data on economic trends affecting air transportation.

Impacts

By expanding our economic analysis capabilities, we expect to produce better estimates of the operational impacts of possible changes in NAS policies and procedures. This is increasingly important as the persistent imbalance between capacity and demand in the NAS pressures policy makers to examine a wider range of possible changes.

Independent Research and Development

Contract Investment Strategies

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Problem

Recent federal agency modernization efforts are conducted within a complex environment of rapidly changing commercial technology and resulting drives for organizational change. Civil agencies have had to resort to traditional contractual approaches, but such techniques, which have evolved from the defense and aerospace program environment, are not always appropriate for civil agency modernization. Furthermore, civilian agencies usually do not have staff who are highly trained in large-scale acquisitions.

Objectives

This research project will examine and compare different federal agency modernization programs and identify the risks and challenges in developing effective contracting strategies. Factors such as maintaining competition as a performance incentive and the effectiveness of contract types (e.g., firm-fixed price, cost reimbursable incentive fees and award fees, performance-based incentives, etc.) will be examined in the context of the complex enterprise modernization environment.

Activities

MITRE will conduct research and compile lessons learned from the IRS, Customs, and other modernization programs. The Economic and Decision Analysis Center, MITRE research library and government Web resources will be consulted. Attendance at seminars will enhance current issue awareness. The final products are expected to be (1) an article published in *Contract Management Magazine*, and (2) a white paper and briefing for sponsors and potential customers.

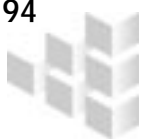
Impacts

This research seeks to establish a new framework for assessing optimal effectiveness of contract strategies for large federal agency modernization programs. It will identify risks and challenges, lessons learned and best practices from both government and civilian contracting practices. The output from the research effort could be applied to current agency sponsors as well as potential sponsors contemplating major modernization programs.

Independent Research and Development

Washington

Investment Strategies



Enterprise Modernization Best Practices

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Problem

U.S. government agencies are launching major enterprise modernization programs to improve service efficiency and effectiveness, and to reduce the cost of operating and maintaining complex legacy systems. The interrelated dynamics of governance processes associated with enterprise modernization are not yet understood, and best practices are yet to be developed, leading to high failure rates and excessive cost.

Objectives

We plan to develop a better understanding of the dynamics associated with enterprise modernization, including integrated engineering of systems, processes, organizations, and personnel. We will determine how internal and external drivers impact enterprise modernization, identify and characterize the multiple interacting change processes that comprise the enterprise life cycle, and define a research agenda for analyzing current enterprise governance practices and defining better practices.

Activities

We will describe the enterprise life cycle processes associated with enterprise modernization, or, more accurately, ongoing enterprise evolution. We will compare and contrast these processes in U.S. government agencies, commercial companies, and DOD. We will also identify areas for further investigation, such as differences in enterprise and system life cycles, development and use of enterprise modernization roadmaps and architectures, investment strategies based on performance measures, an enterprise modernization capability maturity model, etc. In addition, we will generate proposals for research in enterprise evolution governance.

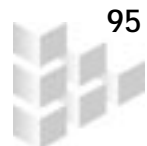
Impacts

A better understanding of the complex interrelated dynamics of the enterprise life cycle should guide simplification and management of these processes so they can be executed in a repeatable, predictable fashion. Such improvements would allow enterprises to evolve continuously in response to change drivers and new technologies. MITRE could take a lead role in developing best practices that are tailored to an agency's mission and strategic goals, rather than being based on immature vendor solutions.

Independent Research and Development

Washington

Investment Strategies



Information Technology Investment Management

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Problem

Information technology accounts for a significant segment of the federal budget. Historically, much of the money spent has resulted in failed or under-performing projects. Investment management is a significant component of the overall management process. While current practices and techniques are improving, the "state of the art" is still not mature enough to help prevent monetary waste.

Objectives

MITRE will engage with the federal IT investment communities to identify and/or develop IT investment management practices and techniques (for application at an enterprise level) that will deliver better mission-oriented results with more efficient and effective use of government resources.

Activities

MITRE will work with the GAO to complete their ITIM framework with emphasis on stage 5 of the associated maturity model. Future activities will support investigating IT management factors and contributing to the Federal CIO Council's new "First Practices in Portfolio Management" guide. Additional activities will include disseminating the results of the previous two activities throughout the MITRE community working on related issues.

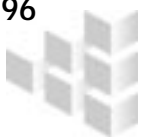
Impacts

MITRE will provide credible and cutting edge support to our sponsors, helping them become more efficient and effective in managing IT investment resources. We will assist our sponsors in meeting and exceeding standards being imposed by federal oversight entities in our effort to deliver greater mission success.

Independent Research and Development

Washington

Investment Strategies



Jet:Wise

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Problem

Airlines react to changes in their environment (such as increased delay or reduced passenger demand) by varying certain elements of their business (such as modifying fares, adjusting schedules, etc.). Those decisions take into account the reactions of their competitors to these same factors. With over 50,000 flights in the U.S. daily, modeling the number of possible interactions is not feasible using traditional methods.

Objectives

Using agent-based modeling, Jet:Wise seeks to model these interactions using individual agents that seek to fulfill a specific objective function. In doing so, Jet:Wise should simulate the complex interactions of the real world.

Activities

The major focus of the research this year is to examine the output of Jet:Wise and characterize its usefulness in analysis by comparison to real-world data. This will be done by comparing both the individual components and the behavior of the overall model against known data. Major milestones are the design-build-test phase through the end of May 2002 and code freeze and final test in June.

Impacts

This work will yield better estimation of likely airline uses for capacity increases, and the capability to estimate likely effects of these changes on passengers in the form of possible changes in fares, trip length, and service patterns.

Center for Advanced Aviation System Development MOIE

Research Topics in Enterprise Modernization Technologies

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Problem

Excessive vendor hype and "consultant speak" cloud implementation and integration issues associated with new and emerging technologies for enterprise modernization and lead to high risk of program failures. In addition, there is a strong need for some technologies not yet developed or adapted to CEM client needs, such as enterprise architecture metamodels and repositories for all our clients, and detection/tracking tools for Customs.

Objectives

We plan to develop a better understanding of new and emerging technologies that enable legacy system modernization, e-government, and specific Customs functions, gain experience in successful technology insertion strategies, and define a research agenda for investigating specific new and emerging technologies that are relevant to our clients' enterprise modernization programs.

Activities

We will identify new and emerging IT technologies for further investigation in areas of e-business, enterprise application integration, enterprise architecture, knowledge management, etc. We will also identify and investigate detection and tracking technologies that could be adapted to support Customs, define needs for an integrated CEM lab that could support evaluation of enterprise modernization technologies, and generate proposals for research on enterprise modernization technologies.

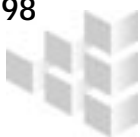
Impacts

A better understanding of new and emerging technologies associated with enterprise modernization and specific Customs missions would enable MITRE to provide objective advice to clients on their legacy system modernization and ongoing enterprise evolution programs. Resolving the technology gap in transitioning from architecture frameworks to useful architecture representations would benefit all MITRE customers.

Independent Research and Development

Washington

Investment Strategies



Automated Discovery of Innovative Tactics and Behaviors

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Problem

Modeling and simulation play a key role in the design, analysis, and implementation of new military concepts and systems. Effective modeling in this context requires the capability to quickly generate innovative twists on operational concepts, tactics, and possible threat responses. Currently, the only possibilities examined are those few that happen to come to mind for the human designers and analysts.

Objectives

Any technique that enables the human to systematically examine a broader range of options, or suggests alternatives the human may not have considered, would greatly increase the effectiveness of these simulation-based activities. We will develop new machine learning techniques to address this need. Our hypothesis is that innovative tactics and behaviors can be learned automatically from experience in a simulation.

Activities

The research will first develop techniques that can learn rule-based reactive behaviors given feedback about outcomes. That approach will be extended to learn more structured, distributed behaviors (e.g., requiring teamwork). The final improvement will address behaviors requiring primitive problem-solving capabilities. The techniques will be tested on benchmark machine learning problems, then applied to discover tactics in some combat simulation.

Impacts

This research will develop new capabilities that will enhance the effectiveness of simulation technology in critical applications like Simulation Based Acquisition and Joint Experimentation. If successful, these developments will also advance the state of the art in machine learning and produce several refereed publications.

Independent Research and Development

Capturing Behavioral Influences in Synthetic C2

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Problem

According to a recent National Research Council (NRC) study, "...an enormous gap exists between the current state of the art in human and organizational modeling technology on the one hand and the military needs on the other." A key area that needs further effort is the application of this technology to time-critical command and control decision-making processes.

Objectives

This project will investigate the potential for emerging human behavioral representation (HBR) technologies to deliver better C2 by strengthening analysis, decision aids, training, and experimentation. We will evaluate HBR modeling frameworks for their applicability to C2, then develop and experiment with a behavioral model of a Joint Surveillance Target Attack Radar System (JSTARS) operator.

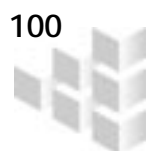
Activities

The project will configure a testbed facility and install/evaluate battle simulations and HBR tools in the testbed facility. We will develop a JSTARS Surrogate Human (JOSH); perform cognitive task analysis of a representative human operator; select HBR tool(s) and "draft" JOSH; perform iterative experimentation in which we compare JOSH's behavior to that of a human operator and adjust JOSH accordingly; and assess the strengths/limitations of JOSH.

Impacts

This effort improves the representation of human behavior in simulated C2. This facilitates more effective C2 analyses and decision-aid applications. Projects of this sort also build a better understanding of operator decision performance and strengths/limitations. The development of software surrogates that can perform C2 operator tasks extends/enhances man-in-the-loop experimentation efforts and eases staffing requirements for large-scale battlestaff training exercises.

Air Force MOIE



Computational Embedded Training Strategies

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Problem

Today's military and intelligence organizations depend on complex software applications to support all aspects of their operations. Training a cadre of software operators and maintaining their readiness in the face of frequently changing assignments, rapid deployments, and personnel turnover continues to be a critical task. Effective training requires periodic hands-on practice sessions focused on relevant mission functions.

Objectives

The general objective of this research is to apply artificial intelligence methods to the development of embedded tutors. Our specific objective is to develop a dialogue-oriented instructional agent that pursues explicit instructional strategies aimed at teaching individual users how to operate a complex software application in support of mission objectives.

Activities

We will initially implement a training agent that can assign an exercise and provide simple within-exercise coaching guided by an overarching instructional strategy. The agent will be enhanced to include planning a small curriculum, modeling and adapting to student behavior, and exhibiting a range of strategy-driven coaching and feedback. We will evaluate the agent's instructional effectiveness in a realistic training context.

Impacts

Our embedded training agent will be able to provide intelligent instruction driven by explicit instructional strategies. Through the design process, we are learning how to construct intelligent software applications to support education and training. Our evaluation studies should indicate whether such computer-assisted learning technologies represent a promising advance over conventional methods.

Independent Research and Development

Diagnostic and Analysis Tools for Agent-based Combat Simulation Models

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Problem

An emerging area of interest is agent-based simulation, where the process unfolds in a highly unpredictable manner, i.e., small changes in one part of the battle space produce profound effects in another. It is extremely difficult to quantitatively evaluate the outcomes or, for that matter, to determine the relevance or novelty of what we see in simulation. Stated more simplistically, where do we look for interesting behavior that can be exploited to understand the process of warfare?

Objectives

The intent of this project is to focus on developing complexity-based analysis tools that address three key problems in agent-based simulation: data interpretation, "novelty" filtering, and statistical characterization of outcomes.

Activities

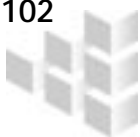
The first phase addresses the development of novelty detectors using multifractal techniques and a GUI-based complexity toolbox for the rapid analysis and editing of combat simulations. The second phase examines the statistical characterization of the combat surface using multifractal methods.

Impacts

The major impact of this work would be to assist the Marine Corps officer in developing realistic and useful warfighting principles and doctrine. Much of the technical development effort involves creating ways to test various hypotheses, as well as interpreting the prodigious amount of data generated through simulation. Moreover, it is often difficult to determine where to look for interesting behavior and how to diagnose what to do in a particular situation. Our project would have an important impact in these areas. It would also impact issues related to the statistical distillation of data suitable as input to more traditional simulation-based models.

Independent Research and Development

Washington



Distance Learning with Intelligent Agents

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Problem

Classroom learning improves significantly when students participate in learning activities in small groups of peers. As the U.S. military moves from schoolhouse instruction to Web-based distance learning, students risk losing this important opportunity to collaborate with other students. Adding conventional groupware tools, such as chat and email, is a start, but these tools do not necessarily remove the deficiencies.

Objectives

This project will develop and insert a learning agent into a collaborative distance-learning environment to promote interaction amongst students and help warriors become better thinkers. Collaboration tools allow multiple students to participate together from a distance, but they cannot guarantee quality interaction. We will develop a learning agent capable of acting as a peer with the students to enhance learning.

Activities

A learning agent will be developed that plays different instructional roles. The agent will observe and manipulate the environment, as well as communicate directly with students. Research in multi-agent planning and studies on paradigms for instructional support in collaborative learning groups will be conducted to determine the proper roles of learning agents. Finally, empirical evaluations of the learning agent will be performed.

Impacts

The proposed research will provide a new and more effective foundation for the Web-based distance learning programs underway in the military. Our intelligent system and collaborative learning research has already spawned a new Army program in companion-based learning and has been applied to a number of research prototypes.

Independent Research and Development

En Route Airspace Modeling

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Problem

Present models of en route airspace used in MITRE and other simulation models do not accurately reflect the operation of airspace in the real world. Also, they are not sensitive to many of the changes brought about by new technologies and procedures under consideration. This severely limits the utility of existing models, and the accuracy, precision and completeness of simulation studies.

Objectives

This project will develop a more complete, accurate and comprehensive method of representing en route airspace in simulation models. The new model will more accurately represent the functions of real airspace, and will be sensitive to changes in factors influenced by new technologies and procedures under study now and in the future.

Activities

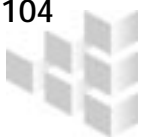
We will research existing en route models in MITRE and elsewhere in the industry, develop new en route models with the desired properties, and experiment with and demonstrate these models in prototypes created in a fast prototyping language. Individual sectors and areas of about six sectors will be prototyped. We will select and demonstrate the preferred model to the MITRE modeling community.

Impacts

The new en route airspace model will enable simulation of the impacts of new technologies and procedures much more comprehensively than existing models permit. It may permit enhancement of existing models, or support the creation of new models. The prototype models created this year may themselves be useful for certain types of analysis.

Independent Research and Development

Washington



Realistic Schedules for Future Air Traffic Scenarios

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Problem

MITRE does not have a tool that creates future aircraft schedules that account for new kinds of demand and new air travel paradigms, such as those that would exploit small low-priced jets to give better service to passengers. In addition, the current tool for generating future traffic does not give aviation analysts the flexibility they need to examine the sensitivity of their results to different assumptions about how air traffic will grow in the future.

Objectives

This project will develop algorithms that create several schedules that represent a reasonable range of characteristics of future demand.

Activities

The activities will concentrate on variations of determining flight times, origin-destination pairs, and flight-leg linking strategies. The final product will create schedules with ranges of demand scenarios for the NAS Operational Evolution Plan studies and scenarios that represent changes in fleet mix and origin-destination strategies.

Impacts

MITRE will be better able to model a variety of air traffic demand scenarios to help assess a broader range of future scenarios. These scenarios would include changes to the current distribution of demand by time of day, new air transportation hubs, and more realistic itineraries linking successive flight of each aircraft. In addition, it would help MITRE to model new types of air travel paradigms, such as more flexible service to passengers facilitated by small, low-priced jets.

Independent Research and Development

TFM Post-Event Analysis

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Problem

At present, decision-making by the FAA at the Air Traffic Control System Command Center (ATCSCC) does not adequately account for information uncertainty, especially regarding weather impact predictions. Often, decisions are based on what seemed to work or did not work in recent operational experience, rather than a probabilistic understanding of weather predictions. Of particular concern are relatively low-probability severe weather events that are predicted hours in the future.

Objectives

The initial objective is to develop a model to aid TFM post-event analysis with uncertain weather forecasts, based heavily upon actual experience with weather events in the past. The perspective of decision analysis will be taken to account for uncertain information, although formal decision analysis (which includes utility assessment) will not be undertaken. The final objective is to change decision-making policies to reflect information uncertainty.

Activities

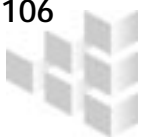
The project will define the decision analysis perspective and apply it to past TFM decision-making events. We will develop a conceptual model accounting for information uncertainty in TFM decision making for the selected scenario type, populate a prototype model for post-event analysis with data from actual TFM events, complete an initial prototype model with expert opinion, and define requirements, if any, for simulation modeling of TFM events for post-event analysis for the selected scenario type. We will test the prototype model against an initial set of TFM events, and generate a set of requirements for the post-event analysis tool based on experience with the prototype tool.

Impacts

If successful, the tool has the potential to fundamentally change decision-making strategy at the ATCSCC, and to benefit the flying public during aviation schedule disruptions. We also expect to present an early application of the decision analysis approach to TFM at a major Air Traffic Management R&D symposium.

Independent Research and Development

Washington



Advanced Coding Techniques for Complex Sensor Systems

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Problem

There is a need to demonstrate high fidelity compression and high resolution spectral analysis of acoustic data.

Objectives

The project seeks to achieve faster and more reliable acoustic data transmission and enhanced acoustic intelligence extraction.

Activities

For the compression research, lossy and lossless coders will be obtained and used to compress real sonar data. Fidelity versus compression ratio is the main tradeoff of interest. For the spectral analysis, a variety of subband structures will be implemented and tested with real and synthetic sonar data. Resolving tonals better than conventional spectral analysis is the main goal.

Impacts

This work will lead to faster and more reliable acoustic data transmission and enhanced acoustic intelligence extraction.

Army-Contract MOIE

Affordable Moving Surface Target Engagement (AMSTE)

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Problem

As the US military has become adept at engaging fixed targets, our opponents have increasingly sought the sanctuary of movement. At the same time, our options for engaging such moving targets are either expensive, applicable only against specific targets and in specific conditions, risky (collateral or own-force damage), or a combination of the above.

Objectives

The Affordable Moving Surface Target Engagement (AMSTE) objective is to demonstrate affordable all-weather precision engagement of moving targets with minimal collateral damage and own-force risk. This will be accomplished through fusion of standoff ground moving target indicator (GMTI) assets providing precision track updates to a GPS-guided weapon.

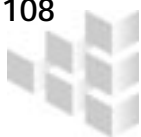
Activities

FY02 activities are to demonstrate actual AMSTE-type engagements in a series of four live experiments involving multiple GMTI platforms and three different types of weapons engaging a mix of ground and maritime targets. There will also be a live experiment to demonstrate long-term continuous tracking against multiple targets in a challenging (hilly, wooded) environment.

Impacts

The impact of AMSTE will be to provide a flexible architecture to deny our foes the sanctuary of maneuver, as well as a significant increase in our general surface situation awareness capability through the development of continuous-tracking technology.

Defense Advanced Research Projects Agency



Autonomous Negotiation Teams and Network Embedded Software Technologies (ANTS/NEST)

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Problem

With increasing use of large numbers of sensors in the battlefield, how to manage and use them effectively becomes an important problem. The sensors are distributed in the field with limited computation and communication resources. The ANTS and NEST programs are investigating the technology of bottom-up coordination and control in closed-loop interactions of sensors, subject to resource and environmental constraints.

Objectives

The objective of the ANTS/NEST program is to develop technologies for fusion of physical and information processes. NEST plans to build dependable, real-time, distributed, embedded applications comprising 102-105 computing nodes with sensors and actuators. The nodes are networked, and their operations are coordinated and dynamically reconfigured as a response to changing physical conditions and modes of operation in a closed loop interaction. MITRE defines and supports the Challenge Problem Experiments for both programs.

Activities

MITRE conducts experiments on the ANTS and NEST sensors to develop calibration procedures and understand their physical constraints. We also work with government contracting agencies to define the challenge problem scenarios, coordinate the experiments, collect the data and define metrics to evaluate the experiment results. MITRE also leads the technology transition effort, helps packaging the technology in a readily transferable form.

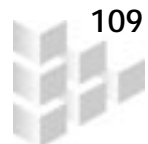
Impacts

MITRE provides independent evaluation of the DARPA research teams to the PM. To evaluate competing approaches, MITRE advocates the use of a common Challenge Problem to put every ANTS and NEST team on par, define the common metrics and study the performance of each technical approach based on the experiment data. This methodology has proven to provide concrete insight to the PM to make critical decisions. MITRE leads the technology transfer effort for the programs.

Defense Advanced Research Projects Agency

Washington

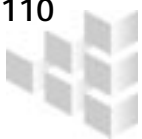
Sensors and Environment



Integrated Tasking, Collection, Processing, Exploitation, and Dissemination for Emerging Sensors

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Pending public release. Research not released by the event dates
will be available in a restricted access area.



Joint Time Critical Targeting (TCT) Experimentation

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Problem

The JEFX 02 goal is to consistently attack time-critical targets within 30 minutes of detection, which is an intermediate step towards the desired end state of attack within 10 minutes of detection. Even the intermediate goal requires a dramatic reduction in the time needed to execute the find, fix, track, target, and engage components of the "Kill Chain"(F2T2EA). Unfortunately, current methods for F2T2EA often require hours to complete, and thus are ineffective, and no single task appears to be the "long-pole."

Objectives

The objective is to develop and test time critical targeting (TCT)/time critical strike concepts and technology while leveraging the existing infrastructure at MITRE, focusing on integrating technologies critical to speeding up the F2T2EA process. The technical approach will be to integrate joint target development and execution methodologies as well as multi-sensor fusion algorithms and integrating and tuning those capabilities in the ESC Software Interoperability Facility for Time Critical Targeting (SWIFT) lab.

Activities

Current activities are integrating an MTI eXploitation (MTIX) workstation into the other TCT applications to improve ground situation awareness, integrating a collaborative tool for distributed target development, and installing sensor simulation and scenario generation tools. This will culminate in joint experiments carried out with the Navy Strike Cell in Reston and the Army Intelligence and Information Warfare Directorate (I2WD) lab in May and July.

Impacts

The enhanced capabilities in the SWIFT lab will be well suited for transition to ESC's 707 testbed and programs, and will address specific interoperability concerns of OSD and PEOs. Recommendations could influence technology R&D and acquisition decisions of the various services as well as joint targeting doctrine. Further, successful experimentation will set the stage for funding from the PEOs or OSD for additional inter-service missions.

Air Force MOIE

Bedford and Washington

Sensors and Environment



Multi-Sensor and Multi-Platform Sensor Exploitation for Combat ID

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Problem

An unresolved issue with most operational multi-sensor and multi-platform surveillance systems is an analytically tractable approach to target ID or automated target recognition (ATR). Historically, target ID/ATR systems have been developed through empirical approaches, leaving little means for understanding observed system performance or predicting the extent to which system performance could be improved by including data from new sensing modalities. Theoretical approaches to target ID/ATR can provide the ability to analyze and predict performance and therefore allow sensor systems developed for one application to be readily assessed in other problem domains.

Objectives

The primary objective of this project is to develop, implement, and evaluate optimal fusion approaches for target ID. These fusion approaches will be developed within a unified analytic framework that will allow them to be readily employed in multiple problem domains. These diverse domains range from ground combat situations, where both non-cooperative and cooperative targets are present, to space-based and airborne multi-platform sensor systems.

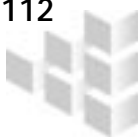
Activities

The following case studies will produce and evaluate multi-platform combat ID (CID) algorithms and/or adaptive sensor tasking algorithms. 1) A multi-sensor automatic track verification algorithm will be developed and evaluated using data from the DARPA Moving Target Feature Phenomenology program. 2) A multi-phenomenology CID algorithm will be developed. 3) Space-based radar ground moving target indicator track association and sensor tasking algorithms will be developed and evaluated.

Impacts

The approaches developed in this project will improve time-critical targeting (TCT) performance and will assist the automation of intelligence, surveillance, and reconnaissance (ISR) tasks towards the goals of information superiority and global awareness that are the Joint Vision 2020 Integrated Command and Control target end states.

Air Force MOIE



Netted RF Sensors

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Problem

Netted sensor concepts are based on the supposition that modestly performing distributed sensors, netted together using ubiquitous communication and advanced processing, provide an output significantly greater than both the performance of any single sensor and the sum of individual contributors. However, there is no general theory to validate this supposition; simulations and experiments would be needed to support it.

Objectives

This project seeks to develop a set of principles to guide the application of netted sensors for measurable performance and cost. This will be done by using simulation and experimentation to study the tradeoffs among the number of sensors, their deployment, and sensor complexity.

Activities

The project will address the specific problem of using RF sensors to detect and track vehicles in a battlefield environment. Modeling and simulation tools are being developed to simulate multiple RF sensors observing moving entities on a battlefield. Experiments will be conducted with COTS hardware to validate and complement the simulation effort. The results from this specific problem will then be extended to more general ones.

Impacts

The results and "lessons learned" from this program will have a significant impact on a number of our sponsor's programs that are currently making use of, or planning to make use of, netted sensors. Several important problems requiring the integration of sensors include combat identification, time critical targeting, electronic attack/electronic protection, underground facility characterization, and nuclear-chemical-biological agent detection.

Independent Research and Development

Resource Management for Netted Sensors

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Problem

A critical enabling element of the Army's Future Combat Systems (FCS) and other network-centric warfare concepts is exquisite situational awareness, which many of MITRE's sponsors assume will be developed through broadly distributed networks of heterogeneous sensors. The lack of algorithms for effective management of networks of distributed, resource-constrained sensors may hinder fielding this "sine qua non" capability.

Objectives

Our hypothesis is that a distributed resource management (RM) approach is required to successfully implement netted sensing and that RM can be, and should be, pursued in a sensor-independent way. The objective of this research is to develop algorithmic guidelines and principles for managing resources for netted sensors, including the control and management of sensor elements, ad hoc networks of sensor elements, and the network in general.

Activities

We will formulate distributed RM for netted sensors as a distributed constraint satisfaction problem (DCSP). The constraint variables will be a set of local resource parameters, such as power consumption or communications and network bandwidth, and the ranges of feasible values, as well as higher-level system constraints. This project will apply a DCSP approach to managing resources of distributed sensors and investigate netted air acoustics sensors for US Customs Service (USCS) applications.

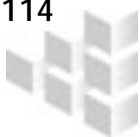
Impacts

Sensor-independent RM algorithms are directly applicable to (1) the Army's FCS and Advanced Hornet/Raptor Wide Area Munitions, (2) the Navy's Expeditionary Sensor Grid; (3) MITRE's proposed SeaBot effort; (4) DARPA's Network Embedded Software Technologies, Multi-function EW System, SenseIT, and Smart Sensor Web; (5) Special Operations Command's Multi-Intelligence Reporting and Signal Sensor; and (6) USCS Netted Surveillance.

Independent Research and Development

Bedford and Washington

Sensors and Environment



Simulation of Passive and Active Radar for Coherent Location and Exploitation (SPARCLE)

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Problem

The technology for passive coherent location (PCL) is not new, but is receiving renewed interest from the National Intelligence Council (NIC) and other sponsors as a possible adjunct to an Integrated Air Defense System (IADS). Fearing that current radars have been well characterized by potential adversaries from an ECCM perspective, there is an increased interest in further investigating PCL capabilities for improving native air defense.

Objectives

We will provide an analysis toolset that will lead to understanding that will guide potential new development in PCL technologies to support both DOD and Intelligence Community applications. The study will consider the value added that a PCL system provides to an overall air and missile defense system and investigate the logical role for PCL to provide value to an IADS.

Activities

Previous work has already developed the basic scenario generation architecture and monostatic and bistatic radar models for theater ballistic missile threat analysis. This legacy tool is being modified to include more precise multistatic radar modeling for rapid development of a theoretical error analysis model to estimate the minimal achievable track accuracy for an optimal tracking filter against air-breathing, low-altitude threats.

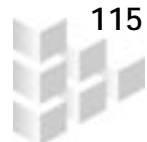
Impacts

MITRE can establish a lead role in the assessment and quantification of the inherent limitations of PCL. The analysis tool will provide extremely valuable scenario-dependent estimates and a better understanding of the value added of a PCL system to an overall air defense network. The Ballistic Missile Defense Organization, NIC, and the IADS communities will all benefit from having MITRE conduct systems engineering trade studies.

Army-Contract MOIE

Washington

Sensors and Environment



State Predicted Interference Cancellation and Equalization (SPICE)

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Problem

The demand for more data in less time via wireless links has resulted in an increasingly crowded RF spectrum. As a result, in many cases, co-channel interference, instead of noise, has become the primary factor limiting the performance of communication, navigation, and sensor systems. To achieve optimum performance, new interference cancellation methods are needed to remove the co-channel interference.

Objectives

The objective of this project is to develop and assess the performance of advanced nonlinear interference cancellation and equalization methods for next-generation communication and sensor systems.

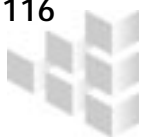
Activities

Research areas include the development and refinement of multi-user detection (MUD) algorithms for CDMA systems. Activities include the assessment of current methods and development of new, computationally efficient MUD algorithms tailored to military environments.

Impacts

The technology being developed in this project is critical to next-generation communication, navigation, and sensor systems. These systems will not be able to achieve the needed capacity, detection sensitivity, and navigational accuracy without the performance improvement provided by the new interference cancellation algorithms. Already, the products of this project are being integrated into customer-sponsored sensor development projects.

Independent Research and Development



Vegetation Forensics

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Problem

Nefarious activities are often extremely difficult to detect directly with today's sensor technology, due to the clandestine and transient nature of activities as well as active denial and deception techniques employed. Indirect sensing techniques may provide the most benefit in some cases.

Objectives

Research shows that environmental pollutants, as well as oil, salt, and metals, affect plants in ways that can be measured both in the laboratory and with remote sensing. The stress to plants can be measured after single events or after long-term exposure. This research will demonstrate the application of indirect sensing of vegetation stress stemming from activities of national security interest.

Activities

We will conduct plant biology experiments on healthy and stressed vegetation to characterize the effects of stress agents on vegetation under varying conditions. We will collect laboratory and field signatures of the vegetation being studied and conduct remote sensing experiments using this ground truth data. Laboratory, field, and remote spectral data will be analyzed to determine the detection limits and the ability to distinguish between types of stresses caused by natural, nefarious, and benign activities.

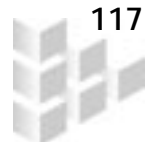
Impacts

Indirect sensing of indicators, such as vegetation stress, has the potential to have a large impact on difficult problems susceptible to denial and deception. Counter-drug applications and other national security concerns where direct sensing of activities range from difficult to extremely difficult are prime candidates. Transition opportunities of this vegetation stress research will be pursued with national and military intelligence organizations.

Army-Contract MOIE

Washington

Sensors and Environment



Advanced Computing and Information Solutions

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The Advanced Computing and Information Solutions (ACIS) division will be presenting the following demonstrations at this year's MITRE Technology Symposium. More information on the ACIS work program is available on the MII at FastJump ACIS or <http://info.mitre.org/infrastructure/acis/>.

Voice Enabled Services (ConnectMe)

Voice access to corporate information is a key enabler for ubiquitous computing. ConnectMe is a voice service that will allow speaker-independent voice recognition of over 9,000 names in MITRE's Lightweight Directory Access Protocol (LDAP). The service will enable a user to be connected to a MITRE employee or tenant just by speaking the person's name. Callers can use a single phone number to access this service while in their office, on a cell phone, or while traveling. We were able to build ConnectMe using the data available in LDAP and have acceptable recognition. We have added a Web interface to allow people to change the pronunciation of their name. This has a secondary benefit of making the correct pronunciation of colleagues' names accessible from the MII.

Wireless LAN Pilot

Wireless LANs provide easy deployment and accessibility for mobile users. However, wireless LAN technology has not been designed to provide the security required for deployment at MITRE. MITRE is conducting a pilot test of wireless LANs that has widespread coverage and provides an excellent experimental network for evaluating wireless services and testing several security designs that are easy to use. We also are evaluating how to use VoIP over the wireless LAN on laptops and on xPDAs.

My MII on the Internet

MyMII on the Internet enables employees to access MII services from outside MITRE's firewall using SecureID authentication. The services currently available include the Time Reporting System, MII PhoneBook, MII Banners, and the Administrative menu. This system will be available as a limited pilot test early in the third quarter of this fiscal year.

My MII Portal

The MyMII Portal, the next phase in the evolution of the MII, is currently conducting a limited pilot test. Building on the personalization that was released with the previous version of the MII, MyMII offers MITRE employees a customizable view of the content and services that they choose, as well as the ability to add or remove services and organize services the way they would like to see them displayed on their home page. New services are currently being developed and will be phased in as the pilot continues, eventually expanding to all of MITRE.

MII Integrated Instant Messaging

An extension of the MII phonebook is being tested to provide quick access to two different instant messaging tools, AOL Instant Messenger and Jabber, with the goal of providing a collaboration tool that keeps MITRE traffic inside the firewall. Ultimately, this project will settle on a set of standard clients, providing a supportable client for each supported operating system. A beta pilot of the AIM interface was available beginning in the second quarter of this fiscal year.

Audio Indexing/Hotspotting

In collaboration with the Audio Hot Spotting Project, ACIS will capture and index the video and audio of the keynote speaker in real time and make it available at the Symposium. Users will be able to search both the presentation and selected components of MITRE's multimedia catalog by keyword.

Independent Research and Development

Bedford and Washington

Other Projects

BioComputation

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Problem

A large and expanding repertoire of available physiological, biochemical, and molecular approaches has resulted in dramatic growth in the biological sciences. Unfortunately, these advances in biotechnology also lower the barrier to developing novel biological weapons for use in asymmetric warfare or terrorist activities. In addition, the biomechanisms within cells are working molecular-scale devices that have vast potential for applied use.

Objectives

DARPA's BioComputation Program will develop a computational framework, BioSPICE, that facilitates the rapid construction of sophisticated simulations of intracellular processes. This system will enable researchers to rapidly explore the effects of a novel pathogen and to quickly identify possible intervention strategies. Another goal is to develop novel and useful computational architectures, sensor devices, and physical structures using biomolecules.

Activities

Biologists, mathematicians, and computer scientists are developing the BioSPICE architecture. Experimental researchers are using BioSPICE to explore the logical implications of alternative competing hypotheses and to simulate the behavior of cells. DNA and RNA nucleotides are being used to perform massively parallel, NP-hard computations, and being programmed to self-assemble into physical structures. MITRE is identifying additional high-impact research opportunities.

Impacts

BioSPICE will speed response to a novel biological threat by allowing researchers to rapidly simulate cellular processes and refine hypotheses before conducting costly wet-lab experiments. In addition, advances in engineering and information technology will derive from demonstrations of using cellular machinery to compute, sense the environment, and self-assemble. Finally, this program will cultivate a cadre of interdisciplinary researchers.

Defense Advanced Research Projects Agency

Bedford and Washington

Other Projects

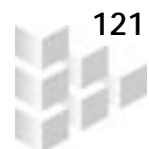
FCS Technical Support

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Pending public release. Research not released by the event dates
will be available in a restricted access area.

Bedford and Washington

Other Projects



Section 508 and Accessibility Standards

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Problem

Section 508 requires federal agencies to provide disabled employees and members of the public access to electronic and information technology that is comparable to those who are not disabled. Within the next decade, accessible E&IT will become part of the IT landscape, just as wheelchair ramps required by the Americans with Disabilities Act are now part of the architectural landscape.

Objectives

We will monitor and influence government and commercial trends through participation in the National Committee for Information Technology Standards (NCITS) IT Access Standards Committee and selected related activities. We will provide corporate reach-back in the area of Section 508 and universal access in the form of a mini-TEM on the subject.

Activities

Continuing activities begun in FY01, we will participate in NCITS accessibility standards activities, as well as other government-sponsored activities, e.g., GSA sponsored Accessibility Forum. We will continue to provide corporate reach-back to sponsors. In FY01 we established a "virtual team" of individuals with interest in accessibility. We will organize a mini-TEM on Section 508 and universal usability in FY02.

Impacts

Section 508 will change the IT landscape over the next 5–10 years. Larger issues of universal usability will also be positively impacted by the stimulus of this federal legislation. Under FY01 funding, MITRE actively participated in accessibility community activities. We will continue this participation in standards work as well as providing reach-back to sponsors.

Independent Research and Development



Technology Transfer Office

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Technology transfer can highlight MITRE's achievements and innovations while making our technology affordable, supportable, and available to our government sponsors, academia, and industry. It can be accomplished through a variety of means, such as licensing, cooperative research and development agreements (CRADAs), open source publishing, consortia, and industry standards. MITRE's Technology Transfer Office (TTO) can help employees develop transfer strategies, plan and execute transfers, negotiate licenses, assess risk, evaluate patent applications, and develop business plans for corporate business investments.

At the symposium, the TTO will be joined by its partners, the Open Channel Software Foundation and LaunchFuel, who will be available to discuss ways they can help us facilitate the technology transfer process.

Independent Research and Development

Bedford and Washington

Other Projects



The Research Computing Facility (RCF)

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The Research Computing Facility (RCF) provides a distributed computing environment to the MITRE technical community. Our mission is to help MITRE researchers focus more on their research efforts, and less on their computing assets. Our solution is a highly scalable environment, largely based on the Andrew File System (AFS), that ensures users a common view of their home directory, project spaces, and application suite regardless of geographic location or supported UNIX platform (currently Solaris, Irix and Linux). We also do our own research into the state of the art in various information technologies to ensure that we are able to provide our customers with up-to-date capabilities and expertise in the management of their resources. Worthwhile learnings are passed on to MITRE's customers. We also provide system administration services to non-RCF managed machines on a consulting basis. This year's research is looking into how to manage high capacity storage technology and how to centralize system management across a Wide Area Network (WAN).

Corporate

Bedford and Washington

Other Projects



