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## THESIS ABSTRACTS

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### NETWORK CONFIGURATION USING XML

Mohammad Ababneh-First Lieutenant, Royal Jordanian Air Force  
B.S., Mu'tah University, 1994

Master of Science in Information Technology Management-September 2000

Master of Science in Computer Science-September 2000

Advisors: Geoffrey G. Xie, Department of Computer Science  
Daniel R. Dolk, Information Systems Academic Group

The primary goal of this thesis is to investigate the use of the Extensible Markup Language (XML) as a network configuration language. Network configuration is a difficult and time-consuming task. Current network configuration solutions are based on proprietary configuration languages and parsers. XML is a platform-neutral data representation language and worldwide standard. It potentially advantageous to use XML to configure networks. However, XML was not developed for network configuration. A new XML based configuration solution for the Server and Agent Active Network Management System (SAAM) is provided to marshal evidence that XML can be used effectively as a network configuration language.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** XML, Quality of Service, Network Configuration, Next Generation Internet, Networks

### EXTENSIBLE INTEREST MANAGEMENT FOR SCALABLE PERSISTENT DISTRIBUTED VIRTUAL ENVIRONMENTS

Howard A. Abrams, DoD Civilian

B.S., Embry-Riddle Aeronautical University, 1996

Doctor of Philosophy in Computer Science-December 1999

Dissertation Supervisors: Michael J. Zyda, Department of Computer Science

Donald Brutzman, Undersea Warfare Academic Group

Rudolph P. Darken, Department of Computer Science

Theodore G. Lewis, Department of Computer Science

Sandeep Singhal, IBM Corporation

Eventually there will exist virtual environments inhabited by millions, but as virtual environments grow in size and number of entities, many problems emerge. Because of these problems, increasing attention is being brought to the issue of filtering data that is not of interest to a given client. Such filtering is known as *interest management*.

This dissertation outlines a three-tiered approach to interest management. The first tier breaks the world into manageable pieces. The second tier uses the data from the first to create a protocol independent perfect match between a client's interests and the environment. The third tier, building on the second, adds protocol dependence allowing the client to receive only the data from the protocol it needs. At the same time, separating out the protocol from the core interest management can allow multiple protocols to simultaneously exist within the same environment, while using the same underlying filtering mechanism. Results from this work have shown that it is possible to create an interest management software architecture that allows bandwidth, packets per second, and CPU time to scale dependent only on the number of entities a given client is interested in at any one time.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Simulation, Multicast, Interest Management, Distributed Virtual Environments, Bamboo

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## THESIS ABSTRACTS

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### **ANALYSIS OF MECHANISMS FOR TCBE CONTROL OF OBJECT REUSE IN CLIENTS**

**Cihan Agacayak-Lieutenant Junior Grade, Turkish Navy**

**B.S.E.E., Turkish Naval Academy, Tuzla Istanbul, 1994**

**Master of Science in Electrical Engineering-March 2000**

**Advisor: Cynthia E. Irvine, Department of Computer Science**

**William A. Arbaugh, WAA Associates, LLC**

This study contributes to the realization of a high assurance Multilevel Secure Local Area Network. The system consists of a Trusted Computing Base (TCB) that acts as a server base. Clients are Commercial-off-the-Shelf (COTS) workstations and software, augmented with a hardware-based TCB Extension (TCBE). This work concentrates on object reuse control on the client, which is one of the security services to be provided by the TCBE.

Object reuse mechanisms are designed to assure that sensitive information does not persist across sessions of session level changes. Twenty-nine chips on the PC motherboard were analyzed. Possible solutions were proposed and evaluated for object reuse control of four storage areas: main memory, AGP memory, cache and Real Time Clock (RTC) memory. The feasibility of one proposed solution was demonstrated.

It was found that main memory can be cleared by slowing its refresh rate. It was determined that AGP memory cannot be read out by devices on the PCI and ISA bus. The Intel INVD command can be used to clear cache. RTC memory can be accessed and its integrity checked by TCBE software.

This study establishes a foundation for object reuse control efforts targeting COTS PC products manufactured by various vendors.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Electronics, Other (Information Security)

**KEYWORDS:** Multi-level Secure Local Area Network (MLS-LAN), Trusted Computing Base (TCB), TCB Extension (TCBE), Object Reuse, Secure Systems, Object, Subject, Computers, Networking, Information Security

### **A PRO-ACTIVE ROUTING PROTOCOL FOR CONFIGURATION OF SIGNALING CHANNELS IN SERVER AND AGENT BASED ACTIVE NETWORK MANAGEMENT (SAAM)**

**Hasan Akkoc-First Lieutenant, Turkish Army**

**B.S., Middle East Technical University, 1994**

**Master of Science in Computer Science-June 2000**

**Advisor: Geoffrey G. Xie, Department of Computer Science**

**Second Reader: CDR Deborah R. Kern, USN, Department of Computer Science**

As networks are upgraded to provide services for streaming applications, the current way of routing is not satisfactory. Server and Agent based Active network Management (SAAM) introduces a novel network architecture that provides guaranteed quality of services to real-time traffic. In SAAM, the server and routers need to establish two-way, robust, and efficient signaling channels for exchange of control and management information. Any change in network topology must be determined and handled as they occur in order to support guaranteed services. Local detection of topological changes and hop-by-hop dissemination of knowledge of these changes is not optimal for SAAM architecture. A reactive method of updating routing tables takes longer time than tolerable for real-time traffic. Therefore, a pro-active approach that re-configures the signaling channels in real time and without degrading services to user traffic is mandatory. This thesis presents such a pro-active routing protocol for configuring the signaling channels of a SAAM region.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Computing and Software

**KEYWORDS:** Routing Protocol, Signaling Channel Configuration, Soft-State Approach, Pro-Active Approach, Networks

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## THESIS ABSTRACTS

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### **SERVER PROBING FOR SERVER AND AGENT BASED ACTIVE NETWORK MANAGEMENT**

**Mustafa Altinkaya-Lieutenant Junior Grade, Turkish Navy**

**B.S. Turkish Naval Academy, 1994**

**Master of Science in Computer Science-March 2000**

**Advisor: Geoffrey G. Xie, Department of Computer Science**

In Server and Agent Based Active Network Management (SAAM) architecture, a server will make routing and other important decisions on behalf of the routers in its region. In order to make the right decisions and to support QoS (e.g., IntServ and DiffServ), the SAAM server needs to maintain an accurate region-wide view of network performance. This will be achieved as routers periodically send Link State Advertisement (LSA) messages to the SAAM server. Currently, the LSA messages report two key Link Performance Statistics, the average delay and the loss rate experienced by packets. Moreover, the server needs to perform sanity checks of these statistics by probing specific links. This thesis describes a server probing solution in which the SAAM server probes a router by dynamically injecting customized probing programs into the adjacent routers. In other words, the probing will be done with the active networking approach. An important feature of the server probing solution is that the probing activities cannot be detected by the router being probed.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Active Networking, Quality of Service, Networks

### **AN INTELLIGENT AGENT SIMULATION OF SHIPBOARD DAMAGE CONTROL**

**Sylvio F. Andrade-Lieutenant Commander, Brazilian Navy**

**B.S., Brazilian Naval Academy, 1987**

**Master of Science in Operations Research-June 2000**

**Advisors: Neil C. Rowe, Department of Computer Science**

**Donald P. Gaver, Jr., Department of Operations Research**

**Second Reader: Patricia A. Jacobs, Department of Operations Research**

A fire on board a ship presents special challenges. It requires not only special anti-fire devices but well-trained teams of firefighters. Since crews rotate periodically, there is a need for ongoing personnel training and not all crew members have the same amount of training. A significant problem is how to assess the effectiveness of a team of firefighters with different skills in a real situation. A team should work together efficiently and follow standard procedures correctly if it is to successfully extinguish the fire within a reasonable period of time and with minimum damage. The question is: What skills are of most importance to a successful team of firefighters? It is difficult to carry out physical experiments without risking human lives and material losses. This thesis uses a reactive agent-based simulation to study the importance of different firefighting skills and anti-fire devices to the prosecution of fire on board a ship.

**DoD KEY TECHNOLOGY AREAS:** Modeling and Simulation, Human Systems Interface

**KEYWORDS:** Artificial Intelligence, Fire, Firefighters, Firefighting Skills, Anti-Fire Devices, Stochastic Modeling

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### TESTING AND EVALUATION OF THE SMALL AUTONOMOUS UNDERWATER VEHICLE (AUV) NAVIGATION SYSTEM (SANS)

Suat Arslan-Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 1993

Master of Science in Electrical Engineering-March 2000

Advisors: Xiaoping Yun, Department of Electrical and Computer Engineering  
Eric R. Bachmann, Department of Computer Science

At the Naval Postgraduate School (NPS), a Small AUV Navigation System (SANS) was developed for research in support of shallow-water mine countermeasures and coastal environmental monitoring. The objective of this thesis is to test and evaluate the sans performance after tuning the filter gains through a series of testing procedures.

The new version of SANS (SANS III) used new hardware components which were smaller, cheaper, and more reliable. A PC/104 computer provided more computing power and, increased the reliability and compatibility of the system.

Implementing an asynchronous Kalman filter in the position and velocity estimation part of the navigation subsystem improved the navigation accuracy significantly. To determine and evaluate the overall system performance, ground vehicle testing was conducted. Test results showed that the SANS III was able to navigate within  $\pm 15$  feet of global positioning track with no global positioning update for three minutes.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Surface/Under Surface Vehicles - Ships and Watercraft

**KEYWORDS:** INS, GPS, AUV, SANS, Navigation, Kalman Filter

### NAVAL ARCHITECTURE ENVIRONMENT: FACILITATING JV2010

Thomas Henry Augustine-DoD Civilian  
B.S.E.E., University of California, 1983

Master of Science in Software Engineering-December 1999

Advisor: Luqi, Department of Computer Science

Second Reader: Barbara McBride, Space and Naval Warfare Systems Command

This thesis demonstrates that the Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Framework Version 2.0 requirements can be satisfied with one modern object oriented CASE tool. It provides an alternative scenario-centric approach to architecture development. The combination of scenarios and Unified Modeling Language (UML) semantics is referred to as the Naval Architecture Environment (NAE). Specifically, it recommended the acquisition of Rational Rose.

The NAE combines the best practices of software development with the domain-specific insight contained in the Framework to create an efficient process, supported by a commercial tool and robust semantics, to allow the analysis and design of interoperable C4ISR systems. These are systems that will support Joint Vision 2010's call for Information Superiority.

**DoD KEY TECHNOLOGY AREA:** Command, Control, and Communications

**KEYWORDS:** C4ISR, Architecture, Unified Modeling Language (UML)

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### **IMPLEMENTING AN INTRANET-BASED PERSONNEL DATA SYSTEM IN COMBAT ARM SCHOOLS**

**Muammer Aygar-First Lieutenant, Turkish Army  
B.S., Turkish Military Academy, 1992**

**Master of Science in Information Technology Management-March 2000**

**Advisors: William J. Haga, Department of Systems Management  
Chris Eagle, Department of Computer Science**

This thesis presents a model of intranet implementation for a military organization. The model includes the design and implementation of a relational database for a personnel department which is connected to the intranet. The database connectivity from back-end to front-end constructed by Active Server Pages (ASP), enables the users to manipulate the database via their web browsers.

From the technical aspect, in order to achieve a successful and secure intranet implementation, several software and hardware components are reviewed and some are recommended. The intranet pages are built with Microsoft Front Page 98. This prototype will be a first and big step for this organization to initiate a transformation from the traditional manual world to a digitized world. Therefore, it is highly expected that there will be a change problem in the organization. From the management aspect, specific change strategies are suggested to manage change.

**DoD KEY TECHNOLOGY AREA:** Other (Internet, Intranet, Database and Security)

**KEYWORDS:** Intranet, Internet Technology, Information Technology, Database, and Web-Database Connectivity

### **WEB SERVER CONFIGURATION FOR AN ACADEMIC INTRANET**

**Stamatios Baltzis-Lieutenant Colonel, Hellenic Army  
B.S., Hellenic Army Academy, 1982**

**Master of Science in Information Technology Management-September 2000**

**Advisors: Norman Schneidewind, Information Systems Academic Group  
LCDR Chris Eagle, USN, Department of Computer Science**

The Internet has undergone a tremendous growth in the past decade. After the evolution of personal computers and the radical decrease of their prices, people have the ability to access all the massive information that only the Internet and the World Wide Web can provide. One of the factors that boosted this ability was the evolution of the Web Servers. Using the Web Server technology man can be connected and exchange information with the most remote places all over the world. So, the web can be thought as a mass medium. This study will provide the necessary information required to configure a Web Server within the boundaries of an academic Intranet. It will also serve as an example for both Greek and US DoDs or other organizations seeking to implement a Web Server as an improvement to their existing Servers.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Web Server, Web Browsers, Intranet

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### COMMAND AND CONTROL DATA DISSEMINATION USING IP MULTICAST

Raymond C. Barrera-DoD Civilian

B.S., California State Polytechnic University, 1989

Master of Science in Software Engineering-December 1999

Advisor: Gilbert M. Lundy, Department of Computer Science

Second Reader: John Iaia, Space and Naval Warfare Systems Center-San Diego

Tools have been developed which allow tactical data to be exchanged over Internet Protocol networks, but the quality of service necessary to operate these tools is not available for most Naval vessels at this time. The objective of this thesis is to show that using Multicast IP, distributing data in layers using an efficient protocol, and sending data with no inherent mechanism to ensure that packets arrive at their destinations will allow data to be exchanged over IP networks at much lower bandwidths than is required today while still maintaining a common tactical picture. Software was developed which interfaces to GCCS-M and exchanges data over a multicast network. This software was tested in a laboratory which simulated a Naval environment. The results of testing demonstrate the potential of using the characteristics of the track data being exchanged in a true multicast architecture to develop a efficient tactical data distribution system for users operating in the Naval environment.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Computing and Software

**KEYWORDS:** Multicast, Command, Control, Communications, Common Operational Picture

### SUPPORTING A TRUSTED PATH FOR THE LINUX OPERATING SYSTEM

Scott A. Bartram-Ensign, United States Navy

B.S., Oregon State University, 1999

Master of Science in Computer Science-June 2000

Advisors: Cynthia E. Irvine, Department of Computer Science

Paul C. Clark, Department of Computer Science

The existence of Trojan horses, viruses, and other malicious software has motivated the computer security industry to invent mechanisms that protect against malicious software. One such mechanism is called the Trusted Path. The Trusted Path provides a way for the system to authenticate itself to the user. Once invoked, the Trusted Path provides an environment in which the user can perform trusted operations such as login, logout, and change password.

This thesis provides a high level design for a Trusted Path and an in depth analysis of how a Trusted Path can be implemented in the Linux operating system. Research of process family creation and keyboard handling has led to the implementation of a Secure Attention Key that can be used to invoke a Trusted Path in Linux.

This research is meant to be used in combination with other efforts to enhance the Linux operating system as an inexpensive platform for instruction on computer security policies.

**DoD KEY TECHNOLOGY AREAS:** Other (Secure Computer Systems, Computer Security, Information Assurance)

**KEYWORDS:** Trusted Path, Secure Attention Key, Computer Security, Linux, Policy Enhanced Linux

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### DISTRIBUTED RELATIONAL DATABASE SYSTEM OF OCCASIONALLY CONNECTED DATABASES

**Pavel Bielecki-DoD Civilian**

**B.S., Technical University in Brno, Czech Republic, 1976**

**Master of Science in Computer Science-March 2000**

**Advisor: C. Thomas Wu, Department of Computer Science**

**Second Reader: Chris Eagle, Department of Computer Science**

The Troop Command at the Presidio of Monterey requires an information system that will provide timely and accurate data about all serviced troop activities with students and permanent party stationed at the Defense Language Institute Foreign Language Center. Data sources that could provide required information already exist, but are physically spread over the Presidio, are maintained in diverse formats, and are not interconnected. Some data sources, maintained by other activities located at the Presidio, are available on the Campus Area Network. As new technologies emerged, it became possible to integrate all available data sources into a heterogeneous distributed information system, in which some information will be shared, while other information will be under some degree of local control. This thesis studies the feasibility of such an information system, and proposes one possible implementation.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Distributed Database, Heterogeneous Database System, PowerBuilder 7, SQL Server 7

### DISTANCE PERCEPTION AND VISUALIZATION USING VIRTUAL ENVIRONMENTS

**Dale D. Bigham-Lieutenant, United States Navy**

**B.S., Jacksonville University, 1993**

**Master of Science in Modeling, Virtual Environments and Simulation-September 2000**

**Advisor: Rudolph P. Darken, Department of Computer Science**

**Second Reader: Barry Peterson, Department of Computer Science**

The studies in this thesis include experiments in training transfer, metric and visual feedback, field of view within the visual display, and cognitive relationships with distance perception. Participants were tested to show positive training transfer, retention of training, and organizational skills. Participants were trained to judge the distance perception in the in-depth plane, given a distance in a frontoparallel plane and also trained to judge perceived distances from themselves to an object. Experiment one shows that a positive training transfer exists from the virtual to the real world and visa versa. Experiments two and three show that perceptual feedback gives more information than metric feedback. Experiment four shows that between 30 – 60 degree geometric field of view setting should be used for optimal performance on distance estimation tasks using an HMD with 60-degree optical FOV. Experiment five shows that there is no correlation between how well participants organize symbols and how well they can be trained to judge distances. Experiments also confirm that as distances increased so did the amount of error.

**DoD KEY TECHNOLOGY AREAS:** Human Systems Interface, Manpower, Personnel, and Training, Modeling and Simulation

**KEYWORDS:** Distance Perception, Feedback, Human Factors, Human Error, Modeling, Manpower, Personnel and Training, Simulation, Training Transfer, Virtual Reality

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### A COMPUTER SIMULATION APPROACH TO THE STUDY OF EFFECTS OF DECK SURFACE COMPLIANCE ON INITIAL IMPACT IMPULSE FORCES IN HUMAN GAIT

David A. Bretz-Lieutenant, United States Navy  
B.S., United States Naval Academy, 1993

Master of Science in Mechanical Engineering-March 2000

Advisors: Young W. Kwon, Department of Mechanical Engineering

Robert B. McGhee, Department of Computer Science

The Navy's leadership is looking at improving quality of life and reducing long term health problems through the reduction of knee disorders. One proposal for reducing knee disorders is to install more compliant decking. The goal of this thesis is to develop a computer model of the human gait that estimates the transarticulation forces in the knee during walking on various surfaces. This model can be used to evaluate the reduction of the heel strike forces during walking when deck surface modifications are made. Previous analytical and computer models of the human gait are reviewed. The major contribution of this thesis is a detailed dynamic model of foot-ground interaction during the initial phase of load bearing in human gait.

**DoD KEY TECHNOLOGY AREAS:** Biomedical, Computing and Software, Manpower, Personnel, and Training, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

**KEYWORDS:** Human Gait, Computer Model, Simulation, Deck Surface Compliance, Ground Reaction Forces, Dynamics

### FACILITATING SECURE MAIL IN A HIGH ASSURANCE LOCAL AREA NETWORK

Emma J. M. Brown-Lieutenant, United States Navy  
B.S., Savannah State College, 1993

Master of Science in Systems Engineering-September 2000

Advisor: Cynthia Irvine, Department of Computer Science

Second Reader: James P. Anderson, James P. Anderson, Inc.

Currently, almost all DoD systems are operated at a single level, classified or unclassified. The problems encountered on these single level systems with mail exchange, its storage, and manipulation are the multiple networks and workstations required to handle different security levels of data as well as the high cost of maintaining them. The Naval Postgraduate School Multilevel Secure Local Area Network (MLS LAN) project supports a high assurance server. This LAN is COTS-driven (commercial-off-the-shelf) and enforces a mandatory security policy while permitting users to employ standard office productivity tools on standard workstations. Initially, there was no means for multilevel mail exchange between clients of the system.

This research was to implement the simple mail transfer protocol (SMTP) server, Sendmail, on the Wang Federal XTS 300 as a multilevel server. A port of a UNIX version of Sendmail 8.9.3 was made to the XTS 300. Modifications to Sendmail were required so that it could be supported by the UNIX-like XTS 300 STOP 4.4.2 operating system. Sendmail proved to be a successful mail server for exchange of mail between system clients. Tests demonstrated successful transmission of simple mail and mail with attachments.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Multilevel Security (MLS), MLS Local Area Network (LAN), High Assurance, Sendmail, Commercial-off-the-Shelf (COTS), Platform, Server, Client, Trusted Path, Trusted Computing Base (TCB), Wang Federal XTS 300

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### A NEW PARADIGM FOR MIGRATING TO CONVERGED INTEROPERABLE NETWORKS

Dag-Anders Brunstad-Captain, Royal Norwegian Air Force  
B.S., University of South-Troendelag, Norway, 1995

Master of Science in Computer Science-September 2000

Master of Science in Information Technology Management-September 2000

Advisors: J. Bret Michael, Department of Computer Science

Rex A. Buddenberg, Information Systems Academic Group

In both the military and the commercial sector, requirements for interoperability between systems have grown. The fact that requirements change rapidly in the information age and that customer needs are unknown and often impossible to correctly predict has created the need for an architecture for communication systems that affords flexibility and interoperability. As an alternative to solving the interoperability problem for individual systems, the thesis introduces an object-based network interoperability model in which every system should be designed as a network object. In this thesis a case study of replacing technologies for the existing IPv4 protocol is presented.

At the same time that the demand for interoperability increases, the customer demands that modern communication solutions like telephony- and video-conferencing is implemented to incur savings. Evolving constraint-based routing technology for implementation of a multi-service network that can support full communication interoperability is also investigated as part of this thesis. As a practical example, the Norwegian Defense InterLAN (a nationwide military WAN in Norway) is used to discuss architectural issues and the techniques for migration strategies towards multiservice networks.

**DoD KEY TECHNOLOGY AREA:** Command, Control, and Communications

**KEYWORDS:** Networking, Interoperability, Communication, Converging Networks, Real-Time Services, Quality of Service, Multi-Service Networks, IPv6

### THE ROLE OF PERSONALITY IN DETERMINING VARIABILITY IN EVALUATING EXPERTISE

Christopher Buziak-Lieutenant, United States Navy  
B.S., Rice University, 1993

Master of Science in Modeling, Virtual Environments and Simulation-September 2000

Advisor: Rudy P. Darken, Department of Computer Science

Second Reader: Barry Peterson, Department of Computer Science

This research investigated how different experts in a single domain chose their individual subjective evaluation criteria of a highly aggregate task based upon their individual differences. The Conning Officer Virtual Environment (COVE) was utilized to provide a domain of experts and a subjectively evaluated task. One hundred sixteen expert shiphandlers were investigated to understand how their personality affects their evaluation of a novice performing an underway replenishment (UNREP). The experts were issued a survey that inventoried their personality, UNREP evaluation criteria, and shiphandling style. In general, the participant experts were lower in neuroticism and higher in extraversion and conscientiousness than the average adult. Extraversion appeared to be correlated with the expert's desire to use sensory input as a critical evaluation criterion ( $r = .18$ ) while openness was correlated with analytical input ( $r = .16$ ) and UNREP style ( $r = .16$ ) as critical evaluation factors. Also correlated with UNREP style was agreeableness ( $r = .16$ ). Finally, the expert's level of conscientiousness correlated with the critical evaluation criteria of analytical input ( $r = .17$ ) and sensory input ( $r = .39$ ). Results from this research provide insight to the link between observed behavior and its subjective evaluation and will allow COVE's programmers to develop an intelligent tutoring system (ITS) that will customize the automated training process.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Manpower, Personnel, and Training, Modeling and Simulation

**KEYWORDS:** Shiphandling, Virtual Reality, Intelligent Tutoring Systems, Interactive Learning Environment, Virtual Environment, Surface Warfare, Computer Simulation, Underway Replenishment, Computer Graphics, Personality, Individual Differences, NEO-FFI, Five Factor Model

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### **DESIGN, IMPLEMENTATION, AND ANALYSIS OF THE PERSONNEL, OPERATIONS, EQUIPMENT, AND TRAINING (POET) DATABASE AND APPLICATION PROGRAM FOR THE TURKISH NAVY FRIGATES**

**Yuksel Can-Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 1994**

**Master of Science in Computer Science-March 2000**

**Master of Science in Management-March 2000**

**Advisors: C. Thomas Wu, Department of Computer Science**

**Lee Edwards, Department of Systems Management**

The Turkish Navy frigates have a challenging mission, which encompasses tactical, operational and administrative tasks. Lacking an automated information infrastructure hinders the ships' ability to efficiently perform the administrative activities, to generate the required reports quickly and to make effective decisions based on this information.

The objective of this thesis is to design and implement the Personnel, Operations, Equipment, and Training (POET) Database and Application Program for the Turkish Navy frigates and to analyze the potential benefits that will be obtained by using this system. The POET database system will provide the Turkish Navy frigates with an automated information system that will support the administrative activities, release manpower to perform other duties and reduce the productive power loss by increasing the availability, accuracy, and consistency of the data.

The thesis covers the analysis of requirements, conceptual database design using Semantic Data Model, logical database design on Microsoft Access DBMS, and implementation of the application program using Java and JDBC API. The result of this study is a functional application that will eliminate most of the current problems onboard the frigates and result in considerable savings of personnel power and time while providing the required information to the command quickly.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Manpower, Personnel, and Training

**KEYWORDS:** Database, Relational Database System, Semantic Data Model, Java, JDBC, System Maintenance, Design, Implementation and Analysis of Information Systems

### **FIDELITY OPTIMIZATION IN VIRTUAL ENVIRONMENTS**

**Michael V. Capps-DoD Civilian**

**B.S., University of North Carolina at Chapel Hill, 1994**

**M.S., University of North Carolina at Chapel Hill, 1996**

**S.M., Massachusetts Institute of Technology, 1999**

**Doctor of Philosophy in Computer Science-June 2000**

**Dissertation Supervisor: Michael J. Zyda, Department of Computer Science**

**Committee Members: Donald P. Brutzman, Undersea Warfare Academic Group**

**Rudolph P. Darken, Department of Computer Science**

**Theodore G. Lewis, Department of Computer Science**

**David Stotts, University of North Carolina**

In virtual environment systems, the ultimate goal is delivery of the highest-fidelity user experience possible. This dissertation shows that is possible to increase the scalability of distributed virtual environments (DVEs), in a tractable fashion, through a novel application of optimization techniques. Fidelity is maximized by utilizing the given display and network capacity in an optimal fashion, individually tuned for multiple users, in a manner most appropriate to a specific DVE application.

This optimization is accomplished using the *QUICK* framework for managing the display and request of representations for virtual objects. Ratings of representation Quality, object Importance, and representation Cost are included in model descriptions as special annotations. The *QUICK* optimization computes the fidelity contribution of a representation by combining these annotations with specifications of user task and platform capability.

This dissertation contributes the *QUICK* optimization algorithms; a software framework for experimentation; and associated general-purpose formats for codifying Quality, Importance, Cost, task, and

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platform capability. Experimentation with the *QUICK* framework has shown overwhelming advantages in comparison with standard resource management techniques.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Distributed Virtual Environment, Linear Programming, Computer Graphics, Resource Management

### **COMPUTER-AIDED RECOGNITION OF MAN-MADE STRUCTURES IN AERIAL PHOTOGRAPHS**

**Luiz Alberto Lisoba da Silva Cardoso-Lieutenant Commander, Brazilian Navy**  
**B.S.E.E., Military Institute of Engineering, 1985**  
**M.S.E.E., Catholic University of Rio de Janeiro, 1992**  
**Master of Science in Computer Science-December 1999**  
**Advisor: Neil C. Rowe, Department of Computer Science**  
**Second Readers: Robert B. McGhee, Department of Computer Science**  
**Roberto Cristi, Department of Electrical and Computer Engineering**

Aerial image acquisition systems are producing more data than can be analyzed by human experts. Most of the images produced by remote sensing satellites, including military ones, never get seen or inspected. In this work, automated detection and recognition of buildings in aerial photos is explored. Connectivity analysis is performed on graphs derived from line segment representations of the original images, obtained with the use of the Radon Transform. The model is experimentally validated using 2-meter panchromatic aerial photographs from the National Aerial Photography Program (NAPP), which is a marginally adequate resolution for the recognition of small buildings.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software

**KEYWORDS:** Aerial Photograph Analysis, Pattern Recognition, Imagery Intelligence

### **DEMONSTRATION OF A CONCURRENTLY PROGRAMMED TACTICAL LEVEL CONTROL SOFTWARE FOR AUTONOMOUS VEHICLES AND THE INTERFACE TO THE EXECUTION LEVEL CODE**

**William D. Carroll-Lieutenant, United States Navy**  
**B.S., Oregon State University, 1993**  
**Master of Science in Computer Science-June 2000**  
**Advisor: Man-Tak Shing, Department of Computer Science**  
**Second Reader: CDR Michael J. Holden, USN, Department of Computer Science**

The desire for use of autonomous robotic vehicles has undergone tremendous growth in the past decade. One of the greatest challenges to the successful development of truly autonomous vehicles is the ability to link logically based high-level mission planning with low-level vehicle control software, without a labor intensive programming effort for each mission.

This challenge can be effectively achieved through the use of tri-level control software architecture, as described in the Rational Behavior Model. The control software (in the tactical level) must de-couple the high-level mission planning from the low-level vehicle control software to reduce the programming effort for each mission. This report describes an object-oriented, modular architecture for the middle (tactical) level that uses concurrent programming techniques and multi-language interfacing. This design enables the control software to handle the intense data management effort required to operate in an autonomous fashion and interface with code already perfected for use in the strategic (top) and execution (bottom) levels.

The design was evaluated by providing the tactical level with a simple execute order statement that was then used to drive the actions of the vehicle. The software package demonstrates the validity of the design and provides the framework for full implementation on an actual vehicle.

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## THESIS ABSTRACTS

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**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Surface/Under Surface Vehicles - Ships and Watercraft, Other (Autonomous Vehicle Control Software)

**KEYWORDS:** Autonomous Vehicle, Robot, AUV, Rational Behavior Model, RBM, Concurrency, Ada 95, Control Software

### **INTELLIGENT AGENTS FOR INFORMATION SYSTEM OPERATIONS (U)**

**Susan K. Cerovsky-Lieutenant Commander, United States Navy**

**B.S., University of South Alabama, 1984**

**Master of Science in Information Technology Management-June 2000**

**and**

**Evan A. Hipsley, Jr.-Lieutenant, United States Navy**

**B.S., Old Dominion University, 1993**

**Master of Science in Information Technology Management-June 2000**

**Advisors: Vicente C. Garcia, National Security Agency Cryptologic Chair Professor**

**Dan C. Boger, Department of Computer Science**

**LtCol Terrance C. Brady, USMC, Information Systems Academic Group**

This paper discusses new information operations concepts related to the use of intelligent agents. The basic agent concept involves dispatching a group of processes across a network to service a user's request at remote locations and to return selected results. With the growth of high bandwidth backbones, networks, and the expanded use of mobile computing, agents fill an essential niche as extensions of the user. Agents assist users in coping with the ever-increasing extent of information available from a host of heterogeneous sources including the internet.

Agents operate autonomously, have rules that constrain their operations, and are reactive to changes they detect in their environment. Advanced agents interact and collaborate with other agents and learn from their experiences. Other advances include increasingly sophisticated abilities to adapt their behavior. In networked environments, agents can be mobile to seek the information they need or to follow their user. For mobile users who only connect to a network periodically, the intelligent agent can act as a surrogate representative.

Agent technology depends on the use of standards and technologies to support requested services. In this thesis, 21<sup>st</sup> century aspects of this technology are discussed, including concepts for information acquisition, protection, processing, transport, and management.

**DoD KEY TECHNOLOGY AREA:** Other (Intelligence)

**KEYWORDS:** Artificial Intelligence, Intelligent Agents, Information Operations

### **ARCHITECTURAL DESIGN AND PROTOTYPING OF A WEB-BASED WARGAME SIMULATION FOR CAMPAIGN PLANNING EXERCISES**

**Antonios Chalakatevakis-Major, Hellenic Army**

**B.S., Hellenic Military Academy, 1985**

**Master of Science in Computer Science-September 2000**

**Advisors: Man-Tak Shing, Department of Computer Science**

**MAJ Leroy A. Jackson, USA, TRADOC Analysis Center-Monterey**

The Campaign Planning Exercise (CAMPEX) War Game is being used for the training of the students of the Air War College in the area of the Air Campaign Planning and the Ground Forces Deployment. The CAMPEX life cycle started in 1986 and the last version was released in 1994. Microsoft Basic Version 7.10 Professional Development System was used for its development. CAMPEX was not designed or developed with the Objected Oriented Technique, so further extension and its use as component for Distributed Components Applications is not feasible.

TRADOC Analysis Center (TRAC) of Monterey plans to use a collection of old Wargames as Components of a Distributed Embedded Application. The CAMPEX Employment Module is the first wargame that will form one of the components of this application, so the redesign and implementation of

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CAMPEX Employment Module with Object-Oriented Technique is necessary. This thesis examines the distributed component architectures available to support the Distributed Embedded Application, re-engineers the CAMPEX Employment Module into an object-oriented design, and validates its requirements via a prototype developed using MicroSoft Access 2000. The new design will be the basis for re-engineering the other wargame planning software for the Air War College.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environments, Computing and Software, Modeling and Simulation

**KEYWORDS:** Battlespace Environments, Distributed Components Architecture, Object-Oriented Design, Modeling and Simulation

### HIGH LEVEL ARCHITECTURE PERFORMANCE MEASUREMENT

**Kok Ping Ivan Chang-Major, Singapore Army**

**B.Eng., Loughborough University of Technology, 1993**

**Master of Science in Modeling, Virtual Environments, and Simulation-March 2000**

**Advisors: Michael J. Zyda, Department of Computer Science**

**Eric Bachmann, Department of Computer Science**

High Level Architecture (HLA) uses an implicit Runtime Infrastructure (RTI) that completely encapsulates all simulation systems. This implementation on a networked virtual environment might be limited and could affect the overall system performance. The performance of HLA on PC workstations in a networked virtual environment might not be determined, and therefore the effects and limitations of its implementation could severely hamper the realism of real-time virtual environments. The goal of this thesis is to determine the limitations of the HLA in a networked virtual environment on the Windows NT platform. In identifying the limitations of HLA, we will be able to ascertain the areas in which HLA can be improved. This thesis implements and measures the system performance of three different setups, namely a standalone virtual environment, a networked virtual environment using HLA, and a networked virtual environment using User Datagram Protocol (UDP). The system performance measured includes average CPU, network, graphics and memory processing requirements, frame rate per second, and the reliability of data received. The results indicate the use of heavily threaded processes by HLA significantly reduces overall system performance.

**DoD KEY TECHNOLOGY AREA:** Modeling and Simulation

**KEYWORDS:** High Level Architecture, User Datagram Protocol

### COMPARISON OF VEGA™ AND JAVA3D™ IN A VIRTUAL ENVIRONMENT ENCLOSURE

**Brian K. Christianson-Lieutenant Commander, United States Navy**

**B.A., University of Washington, 1988**

**Master of Science in Modeling, Virtual Environments, and Simulation-March 2000**

**and**

**Andrew J. Kimsey-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1993**

**Master of Science in Modeling, Virtual Environments, and Simulation-March 2000**

**Advisors: Michael V. Capps, Department of Computer Science**

**Michael J. Zyda, Department of Computer Science**

Large enclosures offer a myriad of possibilities for virtual environments and can dramatically improve presence for a number of applications. Scene graphs are accepted as the logical and optimized way to generate and render applications, however most scene graphs are proprietary or platform specific. Open source scene graphs are emerging that are easily used and cross-platform.

This thesis describes the physical construction of a large sized Multiple Angle Automatic Virtual Environment (MAAVE) and the programming of visual simulations using Vega, a powerful commercially

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available software package, and Java3D, an open source scene graph. The two simulations are networked walkthrough virtual environments using the same geometry.

After the MAAVE was built, the two applications were tested on multiple platforms with frame rate being the main measure of performance. Initial expectations were that Vega would be faster, but the ease and speed of development of each application was unknown. Results showed that the Vega application was 10 to 30 times faster on sgi hardware and 4 to 20 times faster on a standard PC. The Java3D application required one third of the development time and was easier to program. Overall, we conclude that Vega is the better development platform for multi-channel walkthrough applications.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Virtual Environment, Visual Simulation, Scene Graph, Networking, CAVE, MAAVE

### **DECISION SUPPORT FOR SOFTWARE PROCESS MANAGEMENT TEAMS: AN INTELLIGENT SOFTWARE AGENT APPROACH**

**Lori A. Church-DoD Civilian**

**B.S.E.E., San Diego State University, 1992**

**Master of Science in Software Engineering-March 2000**

**Advisors: J. Bret Michael, Department of Computer Science**

**John S. Osmundson, Command, Control, Communications, Computers, and Intelligence Academic Group**

Currently, SPAWAR Systems Center is lacking a unified software development environment that would assist software developers to effectively manage software development projects, across a heterogeneous development environment. This unified environment is needed to provide up-to-date accurate information to the right people at the right time, increase the process knowledge base, increase productivity, decrease time-to-market, eliminate redundancy, and ease job stress.

This thesis proposes a conceptual model for software process management decision support in the form of an intelligent software agent network. The intelligent software agent network, called MENTOR, provides the knowledge base that is integral to the software development team, providing for a repeatable, defined, managed, and optimized development environment. This concept provides SSC software development managers and team members with the ability to work in a unified and collaborative environment, regardless of organizational diversity or location.

MENTOR will be utilized as an integral software development team member, providing tutorials and mentoring capabilities for management and process assistance, as well as providing process planning, risk analysis, and strategic planning recommendations for the successful completion of a software development effort at all team levels. In addition, MENTOR will provide an effective communication environment that will enable the development team to minimize the time consuming workload involved in tracking individual tasking.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Software Intelligent Agents, Software Management, Software Process Guide

### **DYNAMICALLY DETERMINING DISTRIBUTION STATISTICS IN A DISTRIBUTED ENVIRONMENT**

**Thomas S. Cook-Major, United States Army**

**B.S., State University of New York at Brockport, 1987**

**Master of Science in Computer Science-December 1999**

**Advisors: Taylor W. Kidd, Department of Computer Science**

**Debra Hensgen, Department of Computer Science**

Currently, the Department of Defense runs its special purpose applications on dedicated hardware i.e., on "stovepipe systems." Such hardware has inherent disadvantages. They have an inability to handle the resource contention that often occurs upon the influx of a large number of applications. A new application

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needing to use a given resource must typically wait for any preceding applications to first finish their use instead of searching out another capable resource. An even worse scenario is when the system fails and no applications can run until the system is repaired and brought back on-line. In all the cases, important decisions can potentially be delayed or made without important information. The Management System for Heterogeneous Networks (MSHN) will mitigate these deficiencies. The goal of MSHN is to manage several different types of applications across a changing heterogeneous network. MSHN determines the best resource on which to run an application based on both the application's and overall system's Quality of Service (QoS). The focus of this thesis is to write and demonstrate for MSHN the worth of an algorithm that can determine and update distribution statistics for the end-to-end QoS resource usage of an application program. These distributions are vital in assisting MSHN in the scheduling and rescheduling of applications across a network.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Resource Management System, Distributed Systems, Client Library, Resource Monitoring, Stochastic Algorithms, Distribution, Heterogeneous Computing

### **COM AND XPCOM AS A SOLUTION TO BAMBOO'S VERSIONING PROBLEM**

**Mithat Daglar-Lieutenant Junior Grade, Turkish Navy**

**B. S., Turkish Naval Academy**

**Master of Science in Computer Science-March 2000**

**Advisors: Michael J. Zyda, Department of Computer Science**

**Michael V. Capps, Department of Computer Science**

**Second Reader: Kent Watsen, Department of Computer Science**

Bamboo is a systems toolkit that is primarily concerned with supporting performance-critical applications that must run continuously for extremely long periods of time. Bamboo supports this by managing the loading and unloading of executable code into and out of process memory at runtime. Thus, as application requirements change over time, obsolete code can be replaced without having to restart the application. This technique's flexibility has already been demonstrated, but fails in one critical way. Although the C++ programming language standard defines a consistent syntax, it fails to specify a consistent binary encapsulation. Thus, if the executable code for a C++ base class is dynamically replaced, it is very likely that its in memory layout differs from before and therefore incompatible with whatever derived classes may exist. The only recourse is to recompile and reload the derived classes as well.

Component Object Model (COM) and Cross Platform Object Model (XPCOM) solve C++ weakness by enforcing a complete separation of a class's interface from its implementation. This thesis demonstrates support for dynamic versioning of Bamboo C++ modules using COM and XPCOM.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** The Versioning Problem, Component Object Model, Cross Platform Object Model

### **RE-PURPOSING COMMERCIAL ENTERTAINMENT SOFTWARE FOR MILITARY USE**

**Jeffrey D. DeBrine-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1992**

**Master of Science in Modeling, Virtual Environments and Simulation-September 2000**

**and**

**Donald E. Morrow-Lieutenant, United States Navy**

**B.M.E., Auburn University, 1992**

**Master of Science in Modeling, Virtual Environments and Simulation-September 2000**

**Advisors: Michael V. Capps, Department of Computer Science**

**Michael J. Zyda, Modeling, Virtual Environments and Simulation Academic Group**

Virtual environments have achieved widespread use in the military in applications such as theater planning, training, and architectural walkthroughs. These applications are generally expensive and inflexible in

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design and implementation. Re-purposing these applications to meet the dynamic modeling and simulation needs of the military can be awkward or impossible.

Video games are designed to be both technologically advanced and flexible in design. We evaluated current games and modified Quake 3 Arena™ (Q3A) to serve as both an architectural walkthrough and a primitive team trainer. To accomplish this, a real Naval Postgraduate School building was incorporated into Q3A. The game's source code, characters and their behaviors, weapons models and characteristics, and overall gameplay was modified.

By re-purposing commercial entertainment software, a viable military virtual environment application was produced that is less expensive yet arguably as engaging as current computer-based options. This application was created in approximately 300 man-hours with a cost of \$6780 (including hardware) -far less than the development time and cost of similar military virtual environment applications. Game evaluations included in this thesis facilitate and inform similar modification efforts by highlighting entertainment technology available in the year 2000 game market.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Modeling and Simulation, Software Re-Purposing, Video Games, Entertainment Technology, Architectural Walkthrough, Game Modification

### EFFECTIVE SPATIALLY SENSITIVE INTERACTION IN VIRTUAL ENVIRONMENTS

**Richard S. Durost-Captain, United States Army**

**B.S., United States Military Academy, 1990**

**Master of Science in Computer Science-September 2000**

**Advisors: Rudolph P. Darken, Department of Computer Science**

**Michael V. Capps, Department of Computer Science**

Effective interaction techniques are critical for productive use of virtual environments for business, manufacturing, and training. This thesis addresses the need to match the dimensionality of tasks performed in a virtual environment to the dimensionality of the techniques used to perform the tasks.

In order to demonstrate the performance benefits of matching the dimensionality of task and technique, an experiment was conducted in which twenty-seven subjects were asked to perform a series of two and three-dimensional tasks. Subjects were required to perform all tasks using only three-dimensional techniques, then only two-dimensional techniques, and finally a combination of both techniques.

The results clearly showed that matching the dimensionality of the task to the dimensionality of the interaction technique achieved the best performance in a virtual environment. Of 27 subjects, 90% preferred to use a technique whose dimensionality matched the requirements of the task. More importantly, 100% demonstrated improved performance when the dimensionality of task and technique matched.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Human Systems Interface, Modeling and Simulation

**KEYWORDS:** Virtual Environments, Interaction, Interaction Techniques

### EXAMINATION OF THE INTERNET MESSAGE ACCESS PROTOCOL (IMAP) TO FACILITATE USER-FRIENDLY MULTI-LEVEL E-MAIL MANAGEMENT

**Theresa M. Everette-Lieutenant, United States Navy**

**B.S., Florida Agricultural and Mechanical University, 1991**

**Master of Science in Computer Science-September 2000**

**Advisor: Cynthia E. Irvine, Department of Computer Science**

**Second Reader: David J. Shifflett, Department of Computer Science**

Information systems within the Department of Defense (DoD) need trustworthy enforcement of critical security policies against sophisticated attackers. Data, such as e-mail, is processed on these systems on a daily basis. Since this data may contain sensitive information, special handling is required to prevent

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unauthorized disclosure. For these reasons, a high assurance Multi-Level secure (MLS) Local Area Network (LAN) was developed to control the sharing of information at different security levels.

A challenge in multi-level environments is to provide a usable and meaningful interface to users via the e-mail clients. These e-mail clients interact with the high assurance server running on the MLS LAN. The high assurance server returns information at security levels at or below those of the client. An e-mail client is only able to write and manipulate mail at its level. Therefore, client systems should provide users with feedback regarding operations they are able to perform.

In this research, six criteria were established to examine e-mail clients. These criteria evaluated messages displayed to users via the e-mail clients. All of the e-mail clients was able to satisfy at least one of the established criteria.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Multi-Level Secure (MLS), Local Area Network (LAN) Discretionary Access Control (DAC) Policy, Mandatory Access Control (MAC) Policy, Commercial-Off-The-Shelf (COTS), Internet Access Message Protocol (IMAP), POP (Post Office Protocol)

### **DEVELOPMENT OF AN EXPERT SYSTEM AND INTELLIGENT SOFTWARE AGENT FOR AVIATION SAFETY ASSESSMENT**

**Thomas R. Flowers-Captain, United States Army**

**B.A., University of Texas, 1990**

**Master of Science in Computer Science-March 2000**

**and**

**David M. Dowler-Lieutenant, United States Navy**

**B.S., University of Washington, 1993**

**Master of Science in Computer Science-March 2000**

**Advisors: C. Thomas Wu, Department of Computer Science**

**Anthony Ciavarelli, School of Aviation Safety**

**Second Reader: Chris Eagle, Department of Computer Science**

The primary goal of this thesis is to design, develop and test an internet based prototype model for using expert system and software agent technologies to automate some of the analytical tasks in conducting aviation safety assessments using the data collected by the automated Aviation Command Safety Assessment (ACSA) system.

The Aviation Command Safety Assessment is a questionnaire survey methodology developed to evaluate a Naval Aviation Command's safety climate, culture, and safety program effectiveness. The survey was a manual process first administered in the fall of 1996. The survey was then automated in 1999 and is administered over the World Wide Web.

The results of this thesis are a prototype model and a software agent application that evaluates data contained in the ACSA database for organizational safety assessment and for database integrity. All source code is provided and discussed in detail.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Database, Java, Expert Systems, Software Agents, Aviation Safety

### **SECOND GENERATION ULTRA HIGH FREQUENCY (UHF) SATELLITE PROTOCOL**

**Robert L. Franco-DoD Civilian**

**B.S., University of Northern Colorado, 1975**

**Master of Science in Software Engineering-June 2000**

**Advisor: Gilbert M. Lundy, Department of Computer Science**

**Second Reader: John K. O'Leary, Sr., SPAWAR Systems Center-San Diego**

An attempt is being made to provide the reader with an appreciation for the complexity required to upgrade an existing Ultra High Frequency (UHF) 25 kHz tactical communications protocol. This thesis defines the

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satellite discipline and protocols for a second generation of the Officer in Tactical Command Information Exchange Subsystem (OTCIXS II). This thesis provides the detailed information necessary for the implementation of the OTCIXS II communications protocols. It can be used to define and develop the OTCIXS II satellite link software. The OTCIXS II network protocol will consist of distinct protocol layers: Physical, Data Link, and Network layers. The transport layer which provides the actual computer to computer transfer of messages will not be covered in this thesis.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Other (UHF SATCOM)

**KEYWORDS:** OTICXS II Satellite Link Protocol

### **TRUST AND ITS RAMIFICATIONS FOR THE DOD PUBLIC KEY INFRASTRUCTURE (PKI)**

**Leonard T. Gaines-Lieutenant Commander, United States Navy**

**B.S., University of Nevada, 1986**

**Master of Science in Computer Science-September 2000**

**Master of Science in Information Technology Management-September 2000**

**Advisors: J. Bret Michael, Department of Computer Science**

**Rex A. Buddenberg, Information Systems Academic Group**

In order to incorporate trust into e-commerce, public key cryptography, and basic communication, one must understand and effectively manage trust. Various internet security protocols have attempted to address this lack of trust. However, these protocols do not incorporate the user's trust into these protocols. Computational models of trust have been developed in an attempt to automate the logic, variables, and thought processes that a human performs when making a trust-decision. Due to the fact that trust is based on a subjective belief, the models require the assignment of metrics to belief variables or attributes that will have value when evaluating trust. These models address the notion of trust in many different ways and both their definitions and metrics vary significantly. This thesis evaluates the various trust models. It is necessary to understand how trust is defined in each model in order to evaluate how well the operation of a system based on the model satisfies the requirements of the users. Trust models are evaluated based on their characteristics, environmental references, metrics, variables used, and outputs. This thesis concludes with the assessment of a practical application of a trust model to the DoD's PKI system.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Trust Models, Trust Management, Public Key Infrastructure (PKI), Computer Security

### **AN ARCHITECTURAL FRAMEWORK FOR INTEGRATING COTS/GOTS/LEGACY SYSTEMS**

**Karen M. Gee-DoD Civilian**

**B.S., University of California, Davis, 1987**

**Master of Science in Software Engineering-June 2000**

**Advisor: Luqi, Department of Computer Science**

**Second Reader: Man-Tak Shing, Department of Computer Science**

Building distributed systems more effectively and efficiently is an essential goal of the Department of Defense (DoD). We are driven by the push toward greater use of COTS, the need to improve access to legacy data and services, and the new business opportunities offered by web-based technologies and electronic commerce. To fully realize the DoD's goal, a new architectural framework is needed.

This thesis proposes an architectural framework suitable for integrating COTS/GOTS/legacy systems in a distributed, heterogeneous environment. The proposed architectural framework uses The Open Group Architectural Framework (TOGAF) as a basis and includes new tools to support the COTS/GOTS/legacy system development and integration. A case study for the Naval Integrated Tactical Environmental Systems (NITES) program where a prototype is built, demonstrates the effective use of the proposed architectural framework.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** COTS, GOTS, Legacy Systems, Architectural Framework, Distributed Systems, Software Development

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## THESIS ABSTRACTS

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### **A TASK ANALYSIS OF PIER SIDE SHIP-HANDLING FOR VIRTUAL ENVIRONMENT SHIP-HANDLING SIMULATOR SCENARIO DEVELOPMENT**

**Charles R. Grassi-Lieutenant, United States Navy**

**B.A., University of Idaho, 1993**

**Master of Science in Computer Science-September 2000**

**Advisors: Rudolph P. Darken, Department of Computer Science**

**Barry Peterson, Department of Computer Science**

Researchers at the Naval Air Warfare Center Training Systems Divisions (NAWCTSD) in Orlando, FL have developed a testbed for the Conning Officer Virtual Environment (COVE) Ship-Handling Simulator. The purpose of this task analysis was to provide a workable document that they could use in the development of pier side ship-handling scenarios for their simulator. The task analysis not only identified the general procedures and methodologies used by a conning officer during pier side ship-handling evolutions but also provided inventories of the perceptual cues that were used specifically for these evolutions.

The approach taken was to use a Goals, Operators, Methods, Selection Rules (GOMS)-like model to represent the logical sequence of methods used by the conning officer. Critical Cue Inventories (CCI) were then developed to supplement the GOMS model by providing a list of the cues used along with detailed descriptions of why the cue was used and how it was visually or audibly identified. The accuracy of the pier side ship-handling task analysis was then validated by interviewing Surface Warfare Officers with several years of ship-handling experience by using the Critical Decision Method (CDM) knowledge elicitation process.

**DoD KEY TECHNOLOGY AREAS:** Modeling and Simulation, Human Systems Interface, Computing and Software

**KEYWORDS:** Ship-Handling, Virtual Reality, Task Analysis, Surface Warfare, Computer Simulation, Pier Side Evolutions, Computer Graphics, Virtual Environment

### **VALIDATION OF A QUALITY MANAGEMENT METRIC**

**Mary A. Grossman-DoD Civilian**

**B.S.A.A.E., Purdue University, 1985**

**Master of Science in Software Engineering-September 2000**

**Advisors: John S. Osmundson, Command, Control, Communications, Computers, and**

**Intelligence Academic Group**

**J. Bret Michael, Department of Computer Science**

The quality of software management in a development program is a major factor in determining the success of a program. The four main areas where a software program manager can affect the outcome of a program are requirements management, estimation/planning management, people management, and risk management. In this thesis a quality management metric (QMM) was used to measure the performance of ten software managers on Department of Defense (DoD) software development programs. Informal verification and validation of the metric compared the QMM score to an overall program success score for the entire program and yielded positive correlation. The results of applying the QMM can be used to characterize the quality of software management and can serve as a template to improve software management performance. Future work includes further refining the QMM, applying the QMM scores to provide feedback and appropriate training to program managers, and using the QMM scores as an input to program cost and schedule estimation methodologies to provide better program estimates.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Software Management, Requirements Management, Estimation/Planning Management, Risk Management, People Management, Quality Management Metric (QMM)

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## THESIS ABSTRACTS

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### TESTING AND DEVELOPMENT OF A LOW COST, DIGITAL SIGNAL PROCESSOR BASED TORPEDO COUNTERMEASURE

Christopher E. Hand-Lieutenant, United States Navy  
B.S., University of Washington, 1992

Master of Science in Computer Science-March 2000

Advisor: Donald P. Brutzman, Undersea Warfare Academic Group  
Second Reader: Robert B. McGhee, Department of Computer Science

Since the early days of submarines, torpedoes have evolved from simple, straight running weapons into advanced vehicles capable of finding and evaluating potential targets. In contrast, torpedo countermeasures have changed relatively little and do not take advantage of inexpensive signal processing technology available today.

Digital Signal Processor (DSP) technology is used extensively in commercial applications making high performance DSP hardware available at relatively low cost. It is now possible to produce low-cost, DSP-based torpedo countermeasures capable of providing better performance than current fleet countermeasures at a fraction of current prices. By analyzing and responding to a threat torpedo's sonar signal only when the threat is actually present, DSP-based countermeasures provide customized decoy signals without having to flood the water with continuous transmissions.

Work on designing, building and testing such a device began at the Naval Postgraduate School (NPS) in 1997. This thesis describes the development, troubleshooting and testing of the NPS second-generation torpedo countermeasure prototypes. Methodologies are presented for hardware and software design efforts and an OpenGL 3D graphics computer simulation is provided. The hardware and software are described in detail along with the testing results and suggestions for future work in this important area.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Conventional Weapons

**KEYWORDS:** Torpedo Countermeasures, Digital Signal Processing, Acoustic Modem, Acoustic Telemetry, Acoustic Decoy, Signal Analysis

### COMPUTER-AIDED SOFTWARE EVOLUTION BASED ON INFERRED DEPENDENCIES

Meng-Chyi Harn, Lieutenant Commander, Taiwan, R.O.C. Army  
B.S., Chung-Cheng Institute of Technology, Taoyuan, Taiwan, 1980  
M.B.A., National Defense Management College, Taipei, Taiwan, 1986  
Doctor of Philosophy in Computer Science-December 1999  
Dissertation Supervisor: Valdis Berzins, Department of Computer Science

The major problem addressed by this research is how to automate parts of software evolution using dependency rules, especially for large and complex real-time embedded systems. The main topics of this study are the development of a Relational Hypergraph model (RH model) and the design of a Computer-Aided Software Evolution System (CASES). The goals of this dissertation are to explore the existing issues, to formalize software evolution, to reuse software evolution components, and to build a dependency-computing model. We have resolved parts of essential software evolution issues in the following categories: software evolution process, software evolution traceability, software evolution description, software evolution management, and software evolution control.

The RH model can realize automated software evolution in multi-dimensional phases, such as software prototype or product demo, issue analysis, requirement analysis, specification design, module implementation, program integration, and software product implementation. Many types of software evolution objects in each phase, and dependencies among these objects have been defined to describe software evolution processes. We have developed prototypes of C4I systems to conduct and validate our results.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software, Electronic Warfare, Manpower, Personnel, and Training

**KEYWORDS:** Software Evolution, Hypergraph Model, Dependency Rules, Software Reuse, Software Evolution Objects, Software Evolution Processes

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## THESIS ABSTRACTS

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### **IMPLEMENTATION AND INTEGRATION OF THE OBJECT TRANSACTION SERVICE OF CORBA TO A JAVA APPLICATION DATABASE PROGRAM**

**Yildiray Hazir-Lieutenant Junior Grade, Turkish Navy**

**B.S., Turkish Naval Academy, 1993**

**Master of Science in Computer Science-March 2000**

**Advisor: C. Thomas Wu, Department of Computer Science**

**Second Reader: Chris Eagle, Department of Computer Science**

In examining the recent trend of the Client / Server computing technology, it can be seen that distributed object technology is ready to take off. The CORBA (Common Object Request Broker) architecture is the most widely known and readily available candidate for development.

The OMG (Object Management Group), a consortium of object vendors, developed the CORBA standard in the fall of 1990 as a common interconnection bus for distributed objects. Transaction processing is useful not only in database applications but also in building robust mission-critical applications. Utilizing CORBA one can build reliable distributed software systems in a much easier way. CORBA is the most widely accepted standard in this field and there are many CORBA implementations available now. Moreover, the transaction concept is the key to ensure the reliability and availability of Client/ Server applications.

In this thesis transaction properties were applied to a database application program based on Naval Postgraduate School's Course Iteration System. For this purpose an Object Transaction Service was provided based upon the CORBA architecture. It takes advantage of object-oriented programming to help programmers implement transactional applications in a much easier way.

In late 1994, the OMG also published the specification for the object transaction service. This specification is adopted as the blue print for this study. This thesis presents the implementation and integration of the object transaction service based on CORBA.

JDBC (Java Database Connection) was not used for transaction property, because JDBC is currently limited in that it cannot manage transactions across multiple connections. For transaction support across databases or object services, CORBA's Transaction Service provides the best level of abstraction.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Other (Database, Distributed Object Technology)

**KEYWORDS:** Software, Database, Distributed Object, Corba, OTS (Object Transaction Service), JDBC (Java Database Connectivity), Java

### **DEVELOPMENT OF A SOFTWARE EVOLUTION PROCESS FOR MILITARY SYSTEMS COMPOSED OF INTEGRATED COMMERCIAL-OFF-THE-SHELF (COTS) COMPONENTS**

**Barry J. Hensley-DoD Civilian**

**B.S.E.E., North Carolina State University, 1983**

**Master of Science in Computer Science-March 2000**

**Advisor: John S. Osmundson, Command, Control, Communications, Computers, and Intelligence Academic Group**

**Second Reader: Man-Tak Shing, Department of Computer Science**

Department of Defense (DoD) acquisition policy requires that military system acquisitions incorporate commercial-off-the-shelf (COTS) components into system architectures. Traditional DoD source code development and evolution methodologies do not effectively support COTS-intensive systems. To fully realize the benefits of COTS technologies and products, the DoD must adopt new ways to sustain system evolution in the face of a dynamic market environment subject to constant change.

The thesis proposes a new software evolution methodology to effectively maintain COTS-intensive military systems. The integrated COTS component evolution (ICCE) model provides evolution processes designed to support the maintainer as a consumer of software instead of a source-code developer. The ICCE model affords proactive risk awareness, market awareness, and user awareness activities. The ICCE model also supports a three-tier test and evaluation process. A case study for the U.S. Navy/Marine Corps Meteorological Mobile Facility Replacement (METMF (R)) program demonstrates the effectiveness of the ICCE risk management process.

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## THESIS ABSTRACTS

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**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software

**KEYWORDS:** COTS, GOTS, Software Evolution, Software Management, Risk Management, Software Evolution Model

### **TARGET IDENTIFICATION ALGORITHM FOR THE AN/AAS-44V FORWARD LOOKING INFRARED (FLIR)**

**Jessica L. Herman-Ensign, United States Navy**

**B.S., Stanford University, 1999**

**Master of Science in Computer Science-June 2000**

**Advisor: Neil C. Rowe, Department of Computer Science**

**Second Reader: Wolfgang Baer, Department of Computer Science**

Accurate identification of unknown contacts is a crucial issue in military intelligence. In order for this task to be accomplished by human observers, each one must be specially trained and regularly re-qualify. Even with training, their decisions are subject to human error: bias, expectations, or even a lack of sleep may compromise their accuracy. If an automated system could quickly and accurately determine the identity of a contact, it would be a great benefit. This thesis explores some of the problems which must be addressed in producing such a system. We detail an approach to an algorithm which compares a picture of an unknown ship to an established database and determines its most likely classification. In particular, we use infrared images from FLIR video taken at sea, and obtain classification results for a small test set. We tested eighteen images with success rates varying between seventy-three and eighty-nine percent.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Image Recognition, Ship Identification, Hough Transform, Edge Detection

### **EVALUATION OF THE EXTENSIBLE MARKUP LANGUAGE (XML) AS A MEANS FOR ESTABLISHING INTEROPERABILITY BETWEEN HOMOGENEOUS DEPARTMENT OF DEFENSE (DOD) DATABASES**

**David R. Hina-DoD Civilian**

**B.A., DePauw University, 1987**

**Master of Science in Software Engineering-September 2000**

**Advisor: Valdis Berzins, Department of Computer Science**

**Second Reader: CAPT Paul Young, USN, Department of Computer Science**

This thesis evaluates the application of current Extensible Markup Language (XML) tools and technologies toward solving data interoperability issues between legacy data repositories. Past efforts to address these issues have largely failed. XML has the capability to address many of the past problems, but this can only be accomplished when the supporting COTS tools and technologies are available.

The thesis first establishes the underlying issues that need to be addressed. It then evaluates the current state of technologies and COTS products and describes the advantages and disadvantages of each. Finally, it focuses in on the schema for a specific relational database, demonstrates a process by which data exchange can be implemented, and outlines the issues remaining to be solved.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software

**KEYWORDS:** Extensible Markup Language, Interoperability, Database Management, COTS, Database Interoperability

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## THESIS ABSTRACTS

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### ANALYSIS AND DESIGN OF A UNIVERSAL TRAFFIC NETWORK

John B. Hunter-Lieutenant, United States Navy

B.A., Virginia Polytechnic Institute and State University, 1993

Master of Science in Computer Science-September 2000

and

Holger Großmann-Lieutenant Commander, German Navy

Dipl.-Ing. Luft- und Raumfahrttechnik, University of the German Armed Forces Munich, 1990

Master of Science in Computer Science-September 2000

Advisor: Gilbert M. Lundy, Department of Computer Science

Second Reader: Wolfgang Baer, Department of Computer Science

As the field of computer networking has evolved, so too has the use of these networks. Modern networks must be capable of performing more than simple data transfer. To be of value, a network must be able to handle the convergence of different types of traffic – voice, video, and data – and the Quality of Service requirements associated with each type.

This thesis performs a detailed analysis of the different types of traffic, the two primary transmission media, fiber optical and copper based connections, and the connection-orientation technology to route the traffic. Presented in this thesis is a fiber-based hybrid network consisting of Asynchronous Transfer Mode at the backbone layer and Frame Relay and Passive Optical Networking at the local access layer. The proposed Universal Traffic Network, based on present-day technology, is a viable solution to the challenge imposed by the convergence of different traffic types.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Computer Networks, Asynchronous Transfer Mode, Frame Relay, SONET, Fiber Optics, Passive Optical Networks, Gigabit Ethernet, Multimedia Communication, Transmission Media

### THE ROLE OF EXPERT SYSTEMS IN FEDERATED DATABASE SYSTEMS

Levent Ince-Lieutenant, Turkish Navy

B.S., Turkish Naval Academy, 1994

Master of Science in Computer Science-March 2000

Advisor: J. Bret Michael, Department of Computer Science

Second Reader: C. Thomas Wu, Department of Computer Science

A shared information system is a series of computer systems interconnected by some kind of communication network. There are data repositories residing on each computer. These data repositories must somehow be integrated. The purpose for using distributed and multi-database systems is to allow users to view collections of data repositories as if they were a single entity. Multidatabase systems, better known as *heterogeneous multidatabase systems*, are characterized by dissimilar data models, concurrency and optimization strategies and access methods. Unlike homogenous systems, the data models that compose the global database can be based on different types of data models. It is not necessary that all participant databases use the same data model. Federated distributed database systems are a special case of multidatabase systems. They are completely autonomous and do not rely on the global data dictionary to process distributed queries. Processing distributed query requests in federated databases is very difficult since there are multiple independent databases with their own rules for query optimization, deadlock detection, and concurrency. Expert systems can play a role in this type of environment by supplying a knowledge base that contains rules for data object conversion, rules for resolving naming conflicts, and rules for exchanging data.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Multidatabase Systems, Federated Databases, Expert Systems, Semantic Networks

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## THESIS ABSTRACTS

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### COMPARISON OF PERFORMANCE MEASURES IN THE VIRTUAL ENVIRONMENT AND REAL WORLD LAND NAVIGATION TASKS

Saltuk Bugra Karahan-First Lieutenant, Turkish Army  
B.S., Turkish Army Academy, 1995

Master of Science in Modeling, Virtual Environments, and Simulation-September 2000

Advisors: Rudolph P. Darken, Department of Computer Science  
Barry Peterson, Department of Computer Science

Spatial knowledge acquisition is an integral part of navigation related studies. With the improvement of technology, the researchers gained the capability of testing the spatial ability in a virtual world as well. However, little research has been conducted to understand whether VE performance can predict Real World performance or not and amongst the measures used what measures are most predictive.

This thesis research addresses the validity of performance measures used in virtual and real environments. Ten subjects have participated in two experiments. The first experiment was a navigation task in a building type virtual environment. With some modifications, Hermann Hall model was used for this experiment. The second experiment was a navigation task in a real building. For this experiment Middle East school in DLI was used. Measures of landmark, survey and route knowledge were taken for each participant.

The results did not suggest a correlation in overall performance measures. However a correlation is observed in the performance for the landmark knowledge. The acquisition of survey knowledge by time is also seen in the results of the study.

**DoD KEY TECHNOLOGY AREA:** Modeling and Simulation

**KEYWORDS:** Virtual Environments, Land Navigation, Spatial Knowledge

### FAULT TOLERANT APPROACH FOR DEPLOYMENT OF SERVER AGENT-BASED ACTIVE NETWORK MANAGEMENT (SAAM) SERVER IN WINDOWS NT ENVIRONMENT TO PROVIDE UNINTERRUPTED SERVICES TO ROUTERS IN CASE OF SERVER FAILURE (S)

Efraim Kati-First Lieutenant, Turkish Army  
B.S., Turkish Military Academy, 1992

Master of Science in Computer Science-March 2000

Advisor: Geoffrey G. Xie, Department of Computer Science  
Second Reader: J. Bret Michael, Department of Computer Science

The current data networks are mainly based on sophisticated stand-alone routers that provide best effort service. However, with the explosive growth of the Internet and high demand on real-time network applications, the need for integrated service networks has emerged. For this purpose the Next Generation Internet (NGI) Project and as a part of this project the Server Agent based Active network Management (SAAM) project was initiated. SAAM is a server based hierarchical routing architecture designed to provide Quality of Service (QoS) routing services for network resource intensive applications. In the SAAM architecture, a small number of dedicated SAAM servers perform most of the network management tasks on behalf of the routers. The SAAM server has a great responsibility in the SAAM architecture and failure of the SAAM server can have a devastating effect on the performance of the entire network. In order to tolerate the failure of the SAAM server and provide uninterrupted services to routers, this thesis examines the fault tolerance for the SAAM server in two phases: local area fault tolerance, and remote area (disaster recovery) fault tolerance. For the local area fault tolerance, after a survey of the literature and commercial offerings, a recommended solution is proposed. For the remote area fault tolerance, a backup server model is designed and prototyped. The prototyped model provides robust error detection and a fast recovery from the failure of the primary SAAM server.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Command, Control, and Communications

**KEYWORDS:** Fault Tolerance, Heartbeat Protocol, Next Generation Internet, Networks

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## THESIS ABSTRACTS

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### **DESIGN OF A DYNAMIC MANAGEMENT CAPABILITY FOR THE SERVER AND AGENT BASED ACTIVE NETWORK MANAGEMENT (SAAM) SYSTEM TO SUPPORT REQUESTS FOR GUARANTEED QUALITY OF SERVICE TRAFFIC ROUTING AND RECOVERY**

**Dao-Cheng Kuo, Lieutenant Colonel, Republic of China Army**

**B.S., Chung Cheng Technology Institute, 1988**

**Master of Science in Computer Science-September 2000**

**and**

**John H. Gibson-Lieutenant Colonel, United States Air Force**

**B.A., Point Loma Nazarene College, 1977**

**M.S., Naval Postgraduate School, 1990**

**Master of Science in Computer Science-September 2000**

**Advisor: Geoffrey G. Xie, Department of Computer Science**

**Second Reader: Gilbert M. Lundy, Department of Computer Science**

The use of interconnected networks has permeated most aspects of society. Along with this explosion in the use of computer networks the demands for increasingly capable applications has placed great demands upon the network transport protocols to ensure to the user high throughput, reliable service, and virtual real-time response. The current Internet, the descendent of the Advanced Research Projects Agency Network, is routed in the Transport Control Protocol/Internet Protocol. This protocol stack has no mechanism for providing guarantees to network clients regarding the quality of service provided. Further, the routing of traffic across the network is router centric, providing no mechanism for optimization of resource allocation to client service requirements. This thesis provides a method for dynamically controlling the allocation of network resources within an autonomous system by a central server. The algorithm significantly improves the performance of the server over the previous prototype and enables the server to add or remove routers from the network topology on the fly in response to status messages from the participating routers.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Next Generation Internet, Integrated Service, Guaranteed Service, Differentiated Service, Best Effort Service, Quality of Service, Flows, Networks, Routing, Path Information Base, Link State Advertisement, Network Resource Allocation

### **3D VISUALIZATION OF THEATER-LEVEL RADIO COMMUNICATIONS USING A NETWORKED VIRTUAL ENVIRONMENT**

**David W. Laflam-Captain, United States Army**

**B.S., Keene State College, 1989**

**Master of Science in Modeling, Virtual Environments, and Simulation-September 2000**

**Advisors: Donald Brutzman, Undersea Warfare Academic Group**

**Michael V. Capps, Department of Computer Science**

**Don McGregor, Department of Computer Science**

The military is heavily reliant on the transfer of information among various networks in day-to-day operations. Radio-based communications networks that support this volume of information are complex, difficult to manage, and change frequently. Communications network planners need a way to clearly visualize and communicate mobile operational network capabilities, particularly to network users.

By using the DIS-Java-VRML simulation and modeling toolkit, visualizations of radio-frequency energy and radio path-profiling data can be quickly generated as 3D models. These animated 3D visualizations can be loaded into a networked virtual environment, so that communications planners can detect a variety of problems such as radio frequency interference and gaps in coverage. Planners can also brief senior staff, plan within their own staff, and collaborate with communications staff planners in distant locations using such virtual environments.

DIS-Java-VRML visualization tools can provide a clear picture of the battlespace with respect to the deployed communications architecture. The prototypes presented in this thesis demonstrate the ability to generate a shared visualization that can show a radio communications network in 3D. Such dynamic visualizations increase communications planning information bandwidth and yield more intuitive ways of

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## THESIS ABSTRACTS

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presenting information to users. Higher information density in a more intuitive format enables better understanding with quicker reaction times. This thesis and the visualization tool discussed provide the foundation for fundamental improvements in visualizing radio communications environments.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environments, Command, Control and Communications, Computing and Software, Human Systems Interface, Sensors, Modeling and Simulation

**KEYWORDS:** Virtual Environments, Visual Simulation, Signal Planning, VRML, Java, DIS-Java-VRML, X3D

### **DESIGN OF A PERSISTENCE SERVER FOR THE RELATIONAL HYPERGRAPH MODEL**

**Hanh Cong Thi Le-DoD Civilian**

**B.S., San Diego State University, 1997**

**Master of Science in Software Engineering-December 1999**

**Advisor: Valdis Berzins, Department of Computer Science**

**Second Reader: Douglas Lange, Space and Naval Warfare Systems Center-San Diego**

The fundamental purpose of this research is to develop an automated software evolution tool, CASES, for large and complex systems. CASES (Computer-Aided Software Evolution System) is based on the Relational Hypergraph model that is a formal model for describing software evolution processes. This model provides the preliminary mathematical definitions to support the development of CASES. There are five basic functions related to software evolution steps: step refinement, project evaluation, constraint management, personnel management, and step management. There are also five functions related to software evolution components: component management, component traceability, version control and configuration management, dependency management, and inference rule management. CASES is implemented by using Java JDK 1.1.7 and Swing 1.0.3 under the Visual Café version 3.0 environment. The primary contributions of this research include: (1) providing an automated tool for software evolution; (2) validating a software evolution model, the RH model; (3) allowing reuse of software evolution components; (4) describing the software evolution processes; (5) automating the version control of software evolution objects; (6) tracing the software evolution activities; and (7) managing and controlling job scheduling and assignment.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Software Evolution, Computer-Aided Software Evolution System (CASES)

### **DEVELOPMENT OF A QUALITY MANAGEMENT METRIC (QMM) MEASURING SOFTWARE PROGRAM MANAGEMENT QUALITY**

**Martin Joseph Machniak-DoD Civilian**

**B.S./E.E.C.S., University of California, 1984**

**Master of Science in Software Engineering-December 1999**

**Advisors: J. Bret Michael, Department of Computer Science**

**John S. Osmundson, Command, Control, Communications, Computers, and Intelligence Academic Group**

The quality of software management in a development program is a major factor in determining the success of a program. The four main areas where a software program manager can affect the outcome of a program are requirements management, estimation/planning management, people management, and risk management. By using current researched practices, interviews with senior program managers, and focus group data, the thesis examines the four areas for practices and structure that a software program manager may implement to positively affect the program. The thesis develops a Quality Management Metric (QMM) to measure the performance of the software manager. The QMM score is determined via a survey consisting of a two-part questionnaire for each of the four main areas examined. The thesis evaluated three software programs for a QMM score. Informal verification and validation of the metric compared the QMM percentile score to an overall program success score for the entire program and yielded positive

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## THESIS ABSTRACTS

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correlation. The establishment of this methodology to quantify the quality of software management is an important step in evaluation of how past and current programs are managed and can serve as a template to improve software management performance in the future.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Software Management, Requirements Management, Estimation/Planning Management, Risk Management, Quality Management Metric (QMM)

### **AN EXTENDED KALMAN FILTER FOR QUATERNION-BASED ATTITUDE ESTIMATION**

**João Luís Marins-Lieutenant Commander, Brazilian Navy**

**B.S., University of São Paulo, Brazil, 1991**

**Electrical Engineer-September 2000**

**Master of Science in Electrical Engineering-September 2000**

**Advisors: Xiaoping Yun, Department of Electrical and Computer Engineering**

**Eric R. Bachmann, Department of Computer Science**

**Robert G. Hutchins, Department of Electrical and Computer Engineering**

This thesis develops an extended Kalman filter for real-time estimation of rigid body motion attitude. The filter represents rotations using quaternions rather than Euler angles, which eliminates the long-standing problem of singularities associated with those angles. The process model converts angular rates into quaternion rates, which are in turn integrated to obtain quaternions. Gauss-Newton iteration is utilized to find the quaternion that best relates the values of linear accelerations and earth magnetic field in the body coordinate frame and the earth coordinate frame. The quaternion obtained from the optimization algorithm is used as part of the observations for the Kalman filter. As a result, measurement equations become linear. The computational requirements related to the extended Kalman filter developed using this approach are significantly reduced, making it possible to estimate attitude in real-time. Extensive static and dynamic simulation of the filter using Matlab proved it to be robust. Test cases included the presence of large initial errors as well as high noise levels. In all cases the filter was able to converge and accurately track attitude.

**DoD KEY TECHNOLOGY AREAS:** Human Systems Interface, Sensors, Modeling and Simulation

**KEYWORDS:** Inertial Navigation, Extended Kalman Filter, Quaternion

### **DEVELOPMENT OF DIGITAL DATA ACQUISITION MODULE AND INTERFACE FOR ANALOG BEARTRAP MISSION DATA**

**Richard N. Massie-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1993**

**Master of Science in Computer Science-June 2000**

**Advisors: Michael K. Shields, M.K. Shields Company**

**J. Bret Michael, Department of Computer Science**

This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into a system residing in a Microsoft Windows NT environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. While current BEARTRAP mission analysis requires a timescale of weeks, this new solution will enable actual tactical use of the data by units at sea. This thesis develops the module and user interface responsible for digital data acquisition of BEARTRAP mission data from multi-track analog sonobuoy tapes as well as a module to access buoy indexing information from the Orion II maritime surveillance software. This work describes the development process as well as the integration and testing of the interface, acquisition, and indexing functionality for the BEARTRAP Post Mission Processing System 2000 (S2K) using Microsoft Visual C++ as the implementation language.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Sensors

**KEYWORDS:** Acoustics, BEARTRAP, DSP, Sound Pressure Level

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## THESIS ABSTRACTS

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### **RISK ASSESSMENT IN INCREMENTAL SOFTWARE DEVELOPMENT**

**Eric K. Matsuo-DoD Civilian**

**B.S., California State Polytechnic University, 1995**

**Master of Science in Software Engineering-December 1999**

**Advisor: Luqi, Department of Computer Science**

**Second Reader: CAPT Juan C. Nogueira, USA, Department of Computer Science**

Cost overruns, schedule slips, and projects with fewer features or functions than originally specified are some of the difficulties that the software community faces in almost all software projects. The application of proper risk management throughout the lifecycle of the software development can drastically improve the chances of success. Risk management is an essential skill that many good managers possess. Utilizing proper risk management provides early risk detection, which in turn gives the manager more flexibility to mitigate and resolve the risks within the software development project.

This thesis presents a disciplined and systematic risk management tool that can be utilized to assess risk in incremental software development projects from cradle to grave. This methodology can be applied with limited resources, and is adaptable and flexible enough to be used on all software intensive projects. The methodology incorporates the Software Engineering Institute's proven risk taxonomy and questionnaire. It also provides a project manager or project decision-maker an efficient way of assessing risk in incremental software development. Further, this thesis implements the risk assessment framework on a software development project and validates the validity and usefulness as a risk management tool.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Software Engineering, Risk Management, Systematic Risk Assessment Tool

### **A SOCKETS APPLICATION PROGRAMMING INTERFACE FOR THE PETITE AMATEUR NAVAL SATELLITE**

**Fernando J. Maymí-Captain, United States Army**

**B.S., United States Military Academy, 1989**

**Master of Science in Computer Science-June 2000**

**Advisor: Gilbert M. Lundy, Department of Computer Science**

**Second Reader: Jim Horning, Space Systems Academic Group**

The Petite Amateur Naval Satellite (PANSAT) is an operational communications microsatellite designed at the Naval Postgraduate School (NPS). PANSAT's communications software was intended to be developed after orbital insertion and transmitted to the satellite.

The Sockets Application Programming Interface (API) developed at the University of California, Berkeley is the de facto standard API for network applications. It provides a strong and flexible platform on which to develop a wide variety of programs. It accelerates the development of new applications by providing a standard set of features and isolating the program from the underlying networking mechanisms.

This thesis studied the viability of implementing of a Sockets API for PANSAT based on the Berkeley Sockets. PANSAT's Sockets API was built on BekTek's Spacecraft Operating System (SCOS). Because SCOS source code was not available, network protocols had to be implemented in user mode. SCOS is optimized for multiple small tasks, not the complex processes required for Internet programming. Because of SCOS' limitations in memory management, the development of this protocol stack and API was not successful. SCOS does not have the features required for an implementation like this.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Space Vehicles

**KEYWORDS:** PANSAT, Internet, TCP/IP, Sockets

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## THESIS ABSTRACTS

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### MANAGEMENT OF ORGANIZATIONAL CHANGE: THE CASE OF HUNGARIAN AUTOMATION AND RADAR DEPARTMENT

Jozsef Mezosi-Lieutenant Colonel, Hungarian Army

Master of Science in International Resource Planning and Management-June 2000

Advisors: Nancy A. Roberts, Department of Systems Management

Dan C. Boger, Department of Computer Science

Nowadays, military decisionmakers are forced to spend more and more resources on planning and managing organizational change. In order to avoid failure, managers have to diagnose the needs of the organization, to analyze the appropriate method for change and to manage the planned change process. This thesis overviews different approaches and theoretical frameworks applicable to system assessment and diagnoses. The thesis applies the McCaskey model, the organizational system framework, to the case of the Hungarian Institute of Military Technology Automation and Radar Department. It diagnoses the department's status, identifies the gap between the actual and desired status, and it analyses the conducted changes in 1996 and the following years. The thesis concludes with recommendations for improving the management of organizational changes in general.

**DoD KEY TECHNOLOGY AREA:** Command, Control, and Communications

**KEYWORDS:** Assessment, Diagnoses, Management, Organization, Change

### AUTOMATED GENERATION OF WRAPPERS FOR INTEROPERABILITY

Cheng Heng Ngom-Ministry of Defense, Singapore

B.Eng., Nanyang Technological University Singapore, 1995

Master of Science in Computer Science-March 2000

Advisor: Valdis Berzins, Department of Computer Science

Second Reader: Swapan Bhattacharya, Department of Computer Science

Interoperability between software systems is the ability to exchange services from one system to another. In order to exchange services, data and commands are relayed from the service providers to the requesters. Presently, there are some interoperability techniques that aid the exchange of information, ranging from low-level sockets and messaging techniques to more sophisticated middleware technology like object resource brokers. Middleware technology uses higher abstraction than messaging, and can simplify the construction of interoperable applications. It provides a bridge between the service provider and requester by providing standardized mechanisms that handle communication, data exchange and type marshalling. However, the current interoperability techniques, data and services are tightly coupled to a particular server. Furthermore, most developers are trained in developing stand-alone applications rather than distributed applications. This thesis aims at developing a generic interface wrapper that can be used to separate the data and services from the server, and allows the developers to treat distributed data and services as those they are local within an application process space. In addition, the research developed a program to fully automate the process of generating the interface wrapper directly from a specification language such as Prototype System Description Language (PSDL).

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software

**KEYWORDS:** Interoperability with JavaSpace, Jini, Loosely-Coupled Distributed Systems, Prototype System Description Language, Computer Aided Prototype System

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## THESIS ABSTRACTS

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### COMMERCIAL-OFF-THE-SHELF (COTS)/LEGACY SYSTEMS INTEGRATION ARCHITECTURAL DESIGN AND ANALYSIS

**Thomas M. Nguyen-DoD Civilian**

**B.S., University of Missouri-Rolla, 1992**

**Master of Science in Software Engineering-September 2000**

**Advisor: Man-Tak Shing, Department of Computer Science**

**Second Reader: Luqi, Department of Computer Science**

The nature of COTS products often falls short of achieving the unique requirements of the Department of Defense (DoD). The focus of this thesis is on the use of distributed component middleware technology within the framework of integrating COTS/Legacy system architecture. One of the main problems facing distributed computing is software component integration. There is no single, standardized framework for achieving component integration. However, technologies such as Common Object Request Broker Architecture (CORBA) and Microsoft's Component Object Model (COM) are emerging as solutions to component integration. These methodologies provide a sort of software communications bus for components, supporting platform and language independency. A case study developed within the Navy Integrated Tactical Environmental System I (NITES I) architecture was used to show the integration and communication of COTS/Legacy software components using distributed component technology. This resulted in a distributed object architecture supporting location, platform, and programming language transparencies.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Commercial-off-the-shelf (COTS), Legacy System, Distributed Components, Middleware, Heterogeneous System Integration

### STATIC-TASK SCHEDULING INCORPORATING PRECEDENCE CONSTRAINTS AND DEADLINES IN A HETEROGENEOUS-COMPUTING ENVIRONMENT

**Michael D. Niedert-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1990**

**Master of Science in Computer Science-June 2000**

**Advisor: Neil C. Rowe, Department of Computer Science**

**Second Reader: CDR Deborah R. Kern, USN, Department of Computer Science**

Distributed systems have grown in popularity due to the rapid increase in networking of personal computers. A mixture of computers consisting of different architectures can be more powerful, reliable, and scalable than a single supercomputer. The problem of optimally scheduling jobs on a cluster of heterogeneous machines to minimize the time at which the last machine finishes is NP-complete. Nonetheless, the choice of a heuristic algorithm greatly affects the speed of solution. This work evaluates a greedy algorithm, an A\* algorithm, and a simulated annealing algorithm applied to the heterogeneous scheduling problem with deadline and dependency constraints. Tradeoffs of speed and schedule quality were noted between the algorithms. The greedy algorithm produced results quicker than the A\* and simulated annealing algorithms, but with a lower schedule quality. Because of these offsetting performance criteria, an analysis was conducted to determine which algorithms should be used for which input cases.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Scheduling, Algorithms, Artificial Intelligence, Distributed Computing

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## THESIS ABSTRACTS

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### A FORMAL MODEL FOR RISK ASSESSMENT IN SOFTWARE PROJECTS

Juan Carlos Nogueira-Captain, Uruguay Navy

B.S., Universidad de la República, 1985

M.S., Universidad O.R.T., 1994

Master of Science in Software Engineering-September 2000

Advisor: Luqi, Department of Computer Science

The current state of the art techniques of risk assessment rely on checklists and human expertise. This constitutes a weak approach because different people could arrive at different conclusions from the same scenario. The difficulty of estimating the duration of projects applying evolutionary software processes adds intricacy to the risk assessment problem. This thesis introduces a formal method to assess the risk and the duration of software projects automatically, based on measurements that can be obtained early in the development process. The method has been designed according to the characteristics of evolutionary software processes, such as efficiency, requirement volatility and complexity. The formal model based on these three indicators estimates the duration and risk of evolutionary software processes. The approach introduces benefits in two fields: a) automation of risk assessment and, b) early estimation methods for evolutionary software processes.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Risk Assessment, Formal Models, Software Estimation Models, Software Metrics, Project Management

### IMPLEMENTATION AND EVALUATION OF A NETWORK ACCESS PROTOCOL

David I. Odom-Lieutenant, United States Navy

B.S., Norfolk State University, 1994

Master of Science in Computer Science-September 2000

and

Joseph A. Wronkowski-Captain, United States Marine Corps

B.S., University of Southern Illinois, 1992

Master of Science in Computer Science-June 2000

Advisor: Dennis Volpano, Department of Computer Science

Second Reader: J. Bret Michael, Department of Computer Science

Traditional Ethernet networks are wired networks. There is now an increasing need, however, for hosts on the network to be mobile without losing network connectivity. This is where wireless technology comes in. The basic idea is to allow a portable device, equipped with an Ethernet transceiver, to relocate while “connected” to the network. Connected here means being within radio range of another transceiver, called an access point, which acts as a relay for the portable device. Its relocation is entirely transparent. Currently, there is a standard that defines how wireless devices communicate within a Local Area Network. This standard is called IEEE 802.11. The standard, however, is not scalable due to the level at which security is handled.

This thesis examines an alternative security solution, the Network Access (NA) Protocol, developed by Associate Professor Dennis Volpano. It runs on mobile devices and designated hosts called bridges and has the potential to scale up to meet the demands of mobility while ensuring secure network access.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Mobile IP, Wireless Computing, IP Mobility Support, IP Encapsulation, IpSec, IPChains, Home Agent, Mobile Host, Foreign Agent, Tunneling, Care-of-Address, MAC, IEEE 802.11, Route Optimization, Intra-Subnet Roaming

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## THESIS ABSTRACTS

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### **AN AD HOC WIRELESS MOBILE COMMUNICATIONS MODEL FOR SPECIAL OPERATIONS FORCES**

**Cetin Ogut-First Lieutenant, Turkish Army**

**B.S., Turkish Military Academy, 1993**

**Master of Science in Computer Science-September 2000**

**Master of Science in Defense Analysis-September 2000**

**Advisors: J. Bret Michael, Department of Computer Science**

**John Arquilla, Information Warfare Academic Group**

The digitization of the battlefield enables special operators to use improved communications supported by computer networks across a range of missions. The communications paradigm is evolving toward mobile wireless ad hoc networks. This development enables an autonomous system of mobile nodes supporting peer-to-peer communications in forward-deployed military networks. Ad hoc networks have to establish a reliable, secure, instant, and usually temporary, communication infrastructure and to be able to access in a global communications infrastructure.

Our model describes a global communication network supporting the special operator in mobile wireless communications. The main purpose is to provide a handheld wireless communications node which is capable of transferring voice, data, and imagery to and from parallel and vertical command structures within an environment replete with electronic countermeasures. The model will support the representation of requirements such as throughput, quality of service with low power consumption, and low probability of detection/interception. Special Forces are moving toward using commercial-off-the-shelf products and services based on availability and cost effectiveness.

Using GloMoSim tool, simulations for a direct action scenario are ran and the efficiency of on-demand and table-driven routing protocols under different bandwidths and communications loads is compared.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Special Operation Forces, Ad Hoc, Wireless, Mobile Communications, Information Operations, Electromagnetic Pulse Weapons, EMP

### **DESIGN AND IMPLEMENTATION OF A THREE-TIERED WEB-BASED INVENTORY ORDERING AND TRACKING SYSTEM PROTOTYPE USING CORBA AND JAVA**

**Ahmed Otoom-Captain, Jordanian Air Force**

**B.S., Mu'tah University, 1992**

**Master of Science in Computer Science-March 2000**

**Master of Science in Information Technology Management-March 2000**

**Advisors: Daniel R. Dolk, Information Systems Academic Group**

**J. Bret Michael, Department of Computer Science**

Many enterprises are still running and maintaining several operating system and platform dependent legacy applications. The variety of platforms and operating systems poses a challenge to system-wide interoperability and performance, increases the cost of maintenance, locks enterprises into certain vendors, and leads to a lack of an adequate information infrastructure which results in a waste of computer resources, manpower, and time. In this thesis, a component-based three-tiered Web-based Inventory Ordering and Tracking System (IOTS) prototype has been designed and implemented that demonstrates the technical feasibility of making an enterprise's applications both interoperable and scalable on a system composed of multiple platforms and different operating systems. The prototype uses CORBA, an industry-backed, non-proprietary, standard-based distributed architecture and Java, a high-level object-oriented language that enables enterprises to leverage the use of the Internet and benefit from the enhancements in the client/server and the decrease in the prices of desktop computers. The prototype demonstrates how to overcome the problem of the stateless nature of HTTP and build the Object Web where Java applets run on the IIOP. The prototype's source code can be tailored to some specific business requirements and enterprises having problems similar to those addressed may benefit from this research and adopt its development methodology.

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## THESIS ABSTRACTS

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**DoD KEY TECHNOLOGY AREA:** Other (Interoperability, Re-Engineering, Inventory Ordering and Tracking)

**KEYWORDS:** Interoperability, Re-Engineering, Inventory Ordering and Tracking, CORBA, Java, Database, Electronic Commerce, Internet, Web-Database Connectivity

### INTERNET TELEPHONY

**Richard Paul Perri-Lieutenant Commander, United State Navy  
B.S., SUNY Maritime College, 1986  
Master of Science in Computer Science-December 1999  
Advisors: Gilbert M. Lundy, Department of Computer Science  
Wolfgang Baer, Department of Computer Science**

During the mid- '90s, data and voice began to merge, propelled by advances in compression technology. The ubiquity of routed Internet Protocol (IP) networks, and the desire to trim telephony costs are the major driving forces of the deployment of Voice over IP (VoIP).

One major advantage of VoIP technologies is that they leverage existing network resources and dramatically reduce, or eliminate telephone costs. If there is an existing Wide Area Network (WAN) then VoIP could be employed over the WAN. However, a WAN link may not be available at each node location. Then only local point of presence (POP) for router based Internet connectivity would be required for VoIP over the Internet. The Internet could be the part of the backbone for the routing of the voice packets.

The advantages of deployment of VoIP are evident. The issue of whether or not to deploy VoIP is more concerned with technical implementation and Quality of Service (QoS) that with a cost-benefit analysis.

This thesis analyzes some of the technical issues surrounding the use of Internet Telephony. Specifically, the Internet Architecture and required QoS for reliable voice, and issues that arise from a dynamic network such as the Internet, and both software and hardware approaches to workstation solution to Internet Telephony.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software

**KEYWORDS:** Internet Telephony, Voice Over Internet Protocol Networks

### TRANSPARENT DETECTION OF QOS VIOLATIONS FOR CONTINUOUS APPLICATIONS

**Kendal V. Polk-Captain, United States Army  
B.S., United States Military Academy, 1990  
Master of Science in Computer Science-June 2000  
Advisor: Cynthia E. Irvine, Department of Computer Science  
Second Reader: Timothy Levin, Anteon Corporation**

Resource Management Systems have the task of determining the structure, resource allocation, and scheduling of applications within their scope. One such system is the Management System for Heterogeneous Networks (MSHN) which uses its Client Library to gather knowledge of its environment. The Client Library is wrapped around each application to gather application status and resource usage information by intercepting and interpreting system calls. In previous work, the Client Library was utilized to provide status of an application at the end of the application's execution. This research focuses on a method to gather QoS information on continuous applications within mission-critical systems, while applications are running rather than after execution, without modification to the application's source code.

The Client Library has been modified to provide application execution information that is evaluated and compared against user-defined specifications. Any QoS violations result in a notification. This is an indicator for MSHN's scheduler to take corrective action such as adapting to use different resources or data formats.

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## THESIS ABSTRACTS

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When wrapped applications are used in conjunction with continuous monitoring, overhead is increased, which may be acceptable if transparent QoS monitoring is essential.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Command, Control, and Communications

**KEYWORDS:** Quality of Service, Resource Management System, MSHN, Desiderata Wrapper, QoS Violations, Client Library, Resource Monitoring

### **QOS MANAGEMENT WITH ADAPTIVE ROUTING FOR NEXT GENERATION INTERNET**

**Henry C. Quek-Ministry of Defense, Singapore**

**B. Eng., University of Leeds (UK), 1995**

**Master of Science in Computer Science-March 2000**

**Advisor: Geoffrey G. Xie, Department of Computer Science**

**Second Reader: J. Bret Michael, Department of Computer Science**

Up until today, the Internet only provides best-effort service, where traffic is processed as quickly as possible, with no guarantee as to timeliness or actual delivery. As the Internet developed into a commercial infrastructure, demands for quality of service (QoS) has become apparent. Several QoS service models have been developed to provide and support QoS in the Internet, namely: Integrated Service (IntServ), Differentiated Service (DiffServ) and MultiProtocol Label Switching (MPLS). QoS routing, such as Widest-Shortest Path, Shortest-Widest Path and Shortest-Distance Path, is required in order to support QoS and optimize the resource utilization.

The Server and Agent based Active network Management (SAAM) system is a network management system designed for the next generation Internet. It is capable of supporting all types of service class. It will be able to control and optimize the utilization of the network through resource allocation and adaptive QoS routing.

This thesis describes a design and implementation of the QoS Management component of a SAAM Server. This component optimizes the network resources and supports the various service classes in a cohesive manner, utilizing adaptive routing to balance the network load.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Other (Command, Communications, Control, Computers, and Intelligence)

**KEYWORDS:** Next Generation Internet, Integrated Service, Differentiated Service, MPLS, Quality of Service, Flows, Networks, Routing

### **A MAIL FILE ADMINISTRATION TOOL FOR A MULTI-LEVEL HIGH ASSURANCE LAN**

**Richard Kip Rossetti-Lieutenant, United States Navy**

**B.A., University of Colorado, Boulder, 1993**

**Master of Science in Computer Science-September 2000**

**Advisors: Cynthia E. Irvine, Department of Computer Science**

**Paul C. Clark, Department of Computer Science**

Department of Defense official communications often require special protections to prevent accidental disclosure to unauthorized personnel. A Multilevel High Assurance LAN provides a framework for secure electronic communications, and obviates the need for multiple single level networks. A high assurance trusted computing base (TCB), allows untrusted commercial off-the-shelf (COTS) software, such as an Internet Message Access Protocol (IMAP) server, to run untrusted while access to the file system is mediated by the TCB. Control of creation and deletion of hierarchical structured objects, such as those in the file system, is based on the ability to write to the directory containing the object. For a mail server, this directory structure corresponds to a mailbox hierarchy. The mailbox hierarchy must be designed to allow users to read, create, and send mail at multiple levels. The purpose of this research is to develop a trusted process that automatically creates the mailbox hierarchy for any system user. A Mail File Administration Tool for a Multi-Level High Assurance LAN allows administrators to easily set up IMAP-compatible

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## THESIS ABSTRACTS

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mailboxes for each user. The tool assists in the management of the file structure and enables account administration for multiple LAN users and group accounts at multiple security levels.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Electronic Mail, Multi-Level, High Assurance, IMAP

### **REFINING A TASK-EXECUTION TIME PREDICTION MODEL FOR USE IN MSHN**

**Blanca A. Shaeffer-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1995**

**Master of Science in Computer Science-March 2000**

**Advisor: J. Bret Michael, Department of Computer Science**

**Second Reader: Man-Tak Shing, Department of Computer Science**

Nowadays, it is common to see the use of a network of machines to distribute the workload and to share information between machines. In these distributed systems, the scheduling of resources to applications may be accomplished by a Resource Management System (RMS).

In order to come up with a good schedule for a set of applications to be distributed among a set of machines, the scheduler within an RMS uses a model to predict the execution time of the applications. A model from a previous thesis was analyzed and refined to estimate the time that the last task will be completed when scheduling several tasks among several machines. The goal of this thesis was to refine the model in such a way that it correctly predicted the execution times of the schedules while doing so in an efficient manner.

The validation of the model demonstrated that it could accurately predict the relative execution time of a communication-intensive, asynchronous application, and of certain compute-intensive, asynchronous applications. However, the level of detail required for this model to predict these execution times is too high, and therefore, inefficient.

**DoD KEY TECHNOLOGY AREAS:** Computer and Software, Modeling and Simulation

**KEYWORDS:** Resource Management System, Operating Systems, Distributed Systems, Scheduling

### **OBJECT SIGNING IN BAMBOO**

**Marlon L. Smith-Lieutenant Commander, United States Navy**

**B.S., Bowling Green State University, 1982**

**Master of Science in Modeling, Virtual Environments, and Simulation-March 2000**

**Advisors: Michael J. Zyda, Department of Computer Science**

**John S. Falby, Department of Computer Science**

The rapid growth in the Internet has been fueled by an exorbitant number of users, organizations and individuals alike, many relying on e-commerce to conduct business including the transport of files. Public Key Infrastructure (PKI) technology has emerged to the forefront as the basis for ensuring secure transactions throughout the Internet. However, this technology is prohibitively expensive for the majority of users. Object signing technology, a subset of PKI technology, provides a veritable means for file transfer ensuring non-repudiation, authentication, and content integrity at an amenable cost.

This thesis provides an introduction to computer security with a specific focus on PKI and object signing technology. It details the selection and implementation of an object signing system layered on Bamboo, namely Pretty Good Privacy (PGP) v2.6.2. Procedures for establishing a Key Server for certificate distribution are also illustrated. It also introduces security pitfalls associated with PKI systems and identifies the security weaknesses of this object signing implementation. For further research, recommendations are provided to improve the overall functionality of this security system and the potential impact any such migration may have on current users.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation

**KEYWORDS:** Object Signing, Public Key Infrastructure, PKI, PGP

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## THESIS ABSTRACTS

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### THE APPLICATION OF A VIEWPOINTS FRAMEWORK IN THE DEVELOPMENT OF C4I SYSTEMS

Sheila A. Smith-Lieutenant, United States Navy

B.S., Illinois State University, 1994

Master of Science in Computer Science-June 2000

Master of Science in Systems Technology-June 2000

Advisors: J. Bret Michael, Department of Computer Science

William G. Kemple, Command, Control, Communications, Computers, and  
Intelligence Academic Group

In the development of large distributed systems, both the detection and resolution of inconsistency in policy, requirements, and specifications pose major challenges. The purpose of this thesis is to examine the inconsistencies in policy, requirements, and specifications in the development of information/Joint Command, Control, Communications, Computers, and Intelligence (C4I) systems. This thesis explores the application of a "viewpoints" framework to aid in the development of distributed information systems.

A viewpoints framework methodology that was developed to aid in the development of distributed systems is the Reference Model of Open Distributed Processing (RM-ODP). This thesis is concerned with the application of the five viewpoints of RM-ODP and the translation of policy into requirements and specifications. In this thesis, the Ballistic Missile Defense (BMD) system is used as a case study to explain how RM-ODP can be used to develop distributed information systems. It was found that identifying inconsistencies regarding interoperability amongst the subsystems of BMD necessitated the use of multiple viewpoints and that firm conclusions could not be made until the system was viewed at the lower levels.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software

**KEYWORDS:** Ballistic Missile Defense, C4I, Interoperability, Policy, Reference Model of Open Distributed Processing, Requirements Engineering, Viewpoints

### REQUIREMENTS REUSE IN SUPPORT OF THE AVIATION MISSION PLANNING SYSTEM MIGRATION TO THE JOINT MISSION PLANNING SYSTEM

Eric J. Stierna-Captain, United States Army

B.A., Brown University, 1989

Master of Science in Computer Science-September 2000

Advisors: Man-Tak Shing, Department of Computer Science

Neil C. Rowe, Department of Computer Science

Developing correct, complete, consistent and clearly defined requirements is expensive and time-consuming, but is critical to the success of software development. Existing written requirements represent a vast source of domain knowledge that a software analyst can extract for the design of new systems. This thesis describes a modeling process and tool set to identify similar requirements in two requirement documents. The methods developed were tested in a comparison of the Aviation Mission Planning System (AMPS) legacy software and the new Joint Mission Planning System (JMPS). The analysis process creates domain entities, a requirements repository, and statistical matching information for a domain analyst to evaluate reuse potential. Several key tools were automated. The results show that the proposed process and tools significantly shorten the time needed to reuse software requirements.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Human Systems Interface

**KEYWORDS:** Requirements Reuse, Keyword Matching, Aviation Mission Planning System, Joint Mission Planning System, Domain Modeling, Domain Analysis

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## THESIS ABSTRACTS

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### REPRESENTING TACTICAL LAND NAVIGATION EXPERTISE

Jason L. Stine-Major, United States Army

B.S., United States Military Academy, 1989

Master of Science in Modeling, Virtual Environments, and Simulation-September 2000

Advisors: Rudolph P. Darken, Department of Computer Science

Barry Peterson, Department of Computer Science

Tactical land navigation is a very important, but extremely difficult task performed daily by small unit leaders. In an effort to find ways to develop expertise more efficiently, a detailed description of expert performance is presented and contrasted with novice and intermediate performance. This definition fits the Recognition Primed Decision model of human cognitive behavior. Then, through use of the Critical Decision Method of knowledge elicitation, interviews with experts at the U. S. Army Special Forces Qualification Course formed the basis of a detailed cognitive model of expert tactical land navigation. Four important characteristics of experts emerge: (1) they rely on high-fidelity mental maps; (2) they blend multiple cues; (3) they adjust and recalibrate tools dynamically; and (4) they visualize spatial information. Finally, a multi-agent system computationally represents the route planning portion of the performance model.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environments, Computing and Software, Human Systems Interface, Ground Vehicles, Modeling and Simulation

**KEYWORDS:** Agent Based Modeling, Land Navigation, Multi-Agent System, Human Performance Modeling

### A PATH-BASED NETWORK POLICY LANGUAGE

Gary N. Stone-DoD Civilian

B.S., State University of New York at Buffalo, 1987

M.S., Johns Hopkins University, 1990

Doctor of Philosophy in Computer Science-September 2000

Dissertation Supervisors: Gilbert M. Lundy, Department of Computer Science

Geoffery G. Xie, Department of Computer Science

Committee Members: J. Bret Michael, Department of Computer Science

John C. McEachen, Department of Electrical and Computer Engineering

Murali Tummala, Department of Electrical and Computer Engineering

Network policies are “traffic regulations” for the networks which make up the Internet. These are necessary for managing the flow of data, for access control to the network, and for managing the network to achieve other types of quality of service goals. However, with the myriad of different policies and networks, all with varying needs, conflicts can arise between network policies. Detecting and correcting these conflicts can be quite difficult for human administrators. Thus, there is a need for a theoretically sound method for specifying policy and for automatically detecting policy conflicts.

This dissertation presents a path-based policy language that is more comprehensive than earlier languages for describing network policy. The Path-Based Policy Language (PPL) is a formal language for constructing models of Internet service and access control. This path-based language is extensible and allows for an unambiguous representation of network policies based on both the static and dynamic attributes of today’s networks. To support this language, both a compiler and policy conflict tester were developed. These tools accept network policies specified in PPL, translate them into formal logic, and using a theorem prover to test for policy conflicts. PPL allows for the efficient representation of large networks with its abbreviated path format. This path format allows multiple paths to be represented with one statement.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Policy Language, Path-Based, Network Management, Conflict Detection, Conflict Resolution

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## THESIS ABSTRACTS

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### AUTHENTICATION IN SAAM ROUTERS

**Peter J. Szczepankiewicz-Lieutenant, United States Navy  
B.A., Boston University, 1994**

**Master of Science in Information Technology Management-June 2000  
and**

**Luis E. Velazquez-Captain, United States Marine Corps  
B.S., Jacksonville University, 1992**

**Master of Science in Computer Science-June 2000**

**Advisors: Geoffrey G. Xie, Department of Computer Science  
Rex A. Buddenberg, Information Systems Academic Group**

Server and Agent based Active network Management (SAAM) is a network protocol developed at the Naval Postgraduate School to address the router software requirements for the Next Generation Internet (NGI). A working prototype has existed for over nine months to materialize abstract research ideas in the field of active networking.

Authentication is particularly important because SAAM uses mobile code, called resident agents. These resident agents are loaded onto SAAM routers dynamically, and execute on the destination SAAM router. Mobile code in the SAAM system requires an authentication scheme to prevent an outsider from sending a malicious resident agent. Two issues explored are time synchronization and authentication. This thesis focuses on authentication.

With authentication, SAAM can be used as the technical network infrastructure to support Network Centric Warfare (NCW) as described in JV2010. The NCW network must allow mobile code to securely execute on the fly. The prototype developed in the thesis authenticates new nodes that join a SAAM network using Kerberos. Signaling data, also called control traffic, is certified with a dynamic signature key that changes every two minutes. Once a SAAM node is authenticated, its identity is protected throughout the battle. In the same way that Allied forces use Identification Friend or Foe (IFF) traffic today, SAAM authentication could support NCW. The NCW network must also be self-healing. Autoconfiguration is already integrated into the SAAM prototype. Network failures are detected within 500ms. Probing agents are also deployed to investigate suspicious activity within the network. Future probes could fingerprint a specific group of hackers while on-line, using genetic algorithms.

The effects of SAAM on the organizational behavior of a tactical Information Warfare (IW) organization are explored in this thesis.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Authentication, Encryption, Routing, Java, Key Distribution, Kerberos, Secure Time Synchronization

### DESIGN AND IMPLEMENTATION OF A PLATFORM INDEPENDENT PROTOTYPE SPECIFICATION EDITOR

**Shen-Yi Tao-Captain, R.O.C. Air Force  
B.S., R.O.C Air Force Academy, 1991**

**Master of Science in Computer Science-September 2000**

**Advisor: Man-Tak Shing, Department of Computer Science  
Second Reader: C. Thomas Wu, Department of Computer Science**

The Computer Aided Prototyping System (CAPS) developed by the Computer Science Department, Naval Postgraduate School, is an integrated set of tools that is used for rapid prototyping of real time systems. The PSDL editor, a key component of CAPS, allows users to specify prototype design graphically through data flow diagrams and data flow component property menus, and automatically translates the graphical objects into textual specification written in the Prototype System Description Language (PSDL).

This thesis builds upon the previous work done on the CAPS editor design and develops an improved Java based graphic/text editor for the PSDL. New functionality is added to increase the user friendliness of the editor and maintain design consistency in real time. The new enhanced editor provides undo/redo and other essential editing functionality, automatic completion of stream types, as well as automatic checking and propagation of the timing constraints.

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## THESIS ABSTRACTS

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The new editor is more powerful than ever. It tested successfully in classroom to generate prototype and has been used as a tool for software engineering graduate students to design their computer aided prototype project.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Computer-Aided Rapid Prototyping, Software Specification, Real Time System, Graphic Editor, Java

### **TOWARD AN OBJECT-ORIENTED ARCHITECTURE FOR THE ENHANCED MULTI-SEGMENT TRACKER (EMST)**

**Bradley S. Tidwell-Lieutenant, United States Navy  
B.S., United States Naval Academy, 1990**

**Master of Science in Computer Science-March 2000**

**Advisors: Murali Tummala, Department of Electrical and Computer Engineering  
Deborah R. Kern, Department of Computer Science**

This work is part of an ongoing effort to integrate the separate BEARTRAP post-mission analysis tools into an application operating in a Microsoft Windows environment. The new integrated system will replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis is the initial effort toward reengineering the Enhanced Multi-Segment Tracker (EMST) module to incorporate object-oriented capabilities and architecture. The module is an algorithm implemented in the C++ programming language for reconstructing a submarine's track through the water based on analysis of collected magnetic and acoustic data.

The first step requires reverse engineering the existing source code in order to understand the module. The hypothesis is that by reverse engineering the EMST source code, the attributes, behaviors and relationships that characterize the system can be identified, which will enable the future construction of objects for reengineering the system into an object-oriented architecture. The thesis describes the reverse engineering tasks performed on the existing EMST source code and presents methods for determining the attributes, behaviors and relationships that characterize the algorithm.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Software Engineering, Software Reverse Engineering, Software Re-Engineering, Object-Oriented Technology, Unified Modeling Language, BEARTRAP

### **INTEROPERABILITY AND SECURITY SUPPORT FOR HETEROGENEOUS COTS/GOTS/LEGACY COMPONENT-BASED ARCHITECTURE**

**Tam M. Tran-DoD Civilian**

**B.S., San Diego State University, 1996**

**Master of Science in Software Engineering-September 2000**

**and**

**James O. Allen-DoD Civilian**

**B.A., University of California, 1970**

**Master of Science in Software Engineering-September 2000**

**Advisor: Luqi, Department of Computer Science**

**Man-Tak Shing, Department of Computer Science**

There is a need for Commercial-off-the-shelf (COTS), Government-off-the-shelf (GOTS) and legacy components to interoperate in a secure distributed computing environment in order to facilitate the development of evolving applications.

This thesis researches existing open standards solutions to the distributed component integration problem and proposes an application framework that supports application wrappers and a uniform security policy external to the components. This application framework adopts an Object Request Broker (ORB) standard based on Microsoft Distributed Component Object Model (DCOM). Application wrapper

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## THESIS ABSTRACTS

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architectures are used to make components conform to the ORB standard. The application framework is shown to operate in a common network architecture.

A portion of the Naval Integrated Tactical Environmental System I (NITES I) is used as a case study to demonstrate the utility of this distributed component integration methodology (DCIM).

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** COTS, GOTS, Application Wrapper, Security Model, Network Architecture, Component Interface, Open Standards

### **RE-TARGETING THE GRAZE PERFORMANCE DEBUGGING TOOL FOR JAVA THREADS AND ANALYZING THE RE-TARGETING TO AUTOMATICALLY PARALLELIZED (FORTRAN) CODE**

**Pedro T.H. Tsai-DoD Civilian, Naval Research Laboratory, Monterey  
B.S., University of Washington, 1984  
Master of Science in Computer Science-March 2000  
Advisor: Debra Hensgen, Department of Computer Science  
Second Reader: Rudolph P. Darken, Department of Computer Science**

This research focuses on the design of a language-independent concept, Glimpse, for performance debugging of multi-threaded programs. This research extends previous work on Graze, a tool designed and implemented for performance debugging of C++ programs. Not only is Glimpse easily portable among different programming languages, (i) it is useful in many different paradigms ranging from few long-lived threads to many short-lived threads; and (ii) it generalizes the concept of intervals over Graze's original definition. Glimpse's portability has been validated by demonstrating its usefulness in performance debugging of both Java programs as well as automatically parallelized FORTRAN programs.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Performance Debugging, Java Threads, Automatically Parallelized FORTRAN Applications

### **COMMUNICATION MODELS IN MOBILE COMPUTING SYSTEMS AND MOBILE AGENTS**

**Refik Tufekcioglu-Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 1994  
Master of Science in Computer Science-March 2000  
Advisor: J. Bret Michael, Department of Computer Science  
Second Reader: Gilbert M. Lundy, Department of Computer Science**

This thesis study covers wired and wireless mobile computing environments, introduces the components of the mobile environment, discusses the constraints of mobility, and contains a taxonomy of the current techniques/models that reduce the overheads associated with wireless mobile communication. One of the goals of this thesis study was to identify and define communication techniques and models that are used by mobile computing systems to minimize wireless communication cost. The following communication techniques and models have been covered in this study: caching, screen caching, differencing, protocol reduction, header reduction, data access profile, delayed writes, strict and loose reads, semantic callbacks and validators, data allocation, data compression, data scheduling, proxy process, adaptation strategy, resource revocation, auto connect/disconnect, and adaptive antennas. The trade-offs between these techniques/models have also been presented. Other goals of this study were to introduce scripts and mobile agents, and explore their security features in mobile computing environments. The usage of mobile agents in military applications has been investigated. Finally, conclusions and recommendations have been provided for wireless mobile computing and mobile agent technology.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

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## THESIS ABSTRACTS

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**KEYWORDS:** Mobile Computing, Portable Computers, Mobile Environments, Mobile Agents, Intelligent Agents, Wireless Networks, Caching, Proxy Process, Adaptation, Mobile Communication, Wireless Communication, Disconnected Operation, Energy Consumption, Cellular Communication

### **ANALYSIS FOR A TRUSTED COMPUTING BASE EXTENTION PROTOTYPE BOARD**

**Bora Turan-Lieutenant Junior Grade, Turkish Navy  
B.S.E.E., Turkish Naval Academy, Tuzla Istanbul, 1994  
Master of Science in Electrical Engineering-March 2000  
Advisor: Cynthia E. Irvine, Department of Computer Science  
Second Reader: William A. Arbaugh, WAA Associates, LLC**

Agencies, institutions, individuals are demanding the use of commercial-off-the-shelf (COTS) systems and cannot enforce mandatory security policies with these systems, which are equipped only with discretionary access controls. An inexpensive implementation of a multi-level secure local area network utilizing commercial-off-the-shelf hardware and software does not exist.

The Naval Postgraduate School (NPS) is developing a Multi-level Secure Local Area Network (MLS LAN) to provide secure information sharing, classified at different security levels. The MLS LAN extends the high assurance of an evaluated multi-level secure system to a LAN that is formed by commercial personal computers (PCs) running commercial operating systems and office productivity software. The MLS LAN accomplishes the defined functionality by using custom boards which are designed to be plugged into personal computers. The boards are named the Trusted Computing Base Extension (TCBE). The TCBE is intended to provide trusted path and object reuse supporting services to the network TCB.

This thesis describes the hardware and software components, structures, interfaces required for the TCBE to complete a trusted path and control the client PC. Potential implementations are suggested and analyzed for security implications. A preliminary TCBE prototype has been constructed and tested for selected TCBE functions. It is shown that the TCBE prototype can be made both non-by-passable and tamper resistant.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Electronics

**KEYWORDS:** Multi-level Security, Trusted Path, High-Assurance, Network Client

### **AN ANALYSES OF INTERNET/INTRANET INFORMATION SYSTEM ARCHITECTURES WITH ORACLE 8i FOR TURKISH NAVY**

**Murat Unal-Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 1994  
Master of Science in Computer Science-March 2000  
and  
Talha Oktay-Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 1994  
Master of Science in Computer Science-March 2000  
Master of Science in Information Technology Management-March 2000  
Advisors: William J. Haga, Department of Systems Management  
C. Thomas Wu, Department of Computer Science**

Turkish Navy has made a strategic commitment to Oracle DBMS, by making an enterprise contract with Oracle Corporation, which places Oracle DBMS at the heart of all information processing in Turkish Navy. Ten years later currently established Oracle DBMS based information systems will be legacy systems and Turkish Navy will be bound to under Oracle proprietary lock-in, unless careful approach in deploying these new systems is not made.

Oracle 8i is the latest version of the Oracle Corporation's DBMS can be solution to this problem. With Oracle 8i's Java-enabling components-Object Request Broker (ORB), Java Virtual Machine (JVM), and embedded JDBC Driver- Turkish Navy have a wealth of technologies at its disposal. Turkish Navy has a choice of several programming models - PL/SQL, JDBC, SQLJ, CORBA, and EJB; and a choice of

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## THESIS ABSTRACTS

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protocols - Net8 and CORBA-IIOP. Selecting model over another can be a daunting and very important task. Each model has strengths and weaknesses for a particular task.

This research surveys Oracle Java Platform and researches different development architectures with their pros and cons, and points out the direction that should be taken in order to ensure scalability, maintainability, interoperability and extensibility of the future systems which will prevent the proprietary lock-in of the certain vendors and their products.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Other (Information System Management)

**KEYWORDS:** Oracle, Oracle 8i, Enterprise Java Beans, CORBA, Information System Architectures, Microsoft vs. Oracle, Turkish Navy, EJB, Java, PL/SQL

### **A MODEL FOR GENERATION AND PROCESSING OF LINK STATE INFORMATION IN SAAM ARCHITECTURE**

**H. Huseyin Uysal-First Lieutenant, Turkish Army**

**B.S., Turkish Military Academy, 1992**

**Master of Science in Computer Science, March 2000**

**Advisors: Geoffrey G. Xie, Department of Computer Science**

**Gilbert M. Lundy, Department of Computer Science**

This thesis presents a model of link state advertisement generation for the SAAM (Server and Agent Based Network Management) architecture. The model includes generation and processing of link state data. In a SAAM network, a central server manages a region of 20-40 lightweight routers. The server learns the link performance of the routers from processing Link State Advertisement messages that are periodically sent by the routers. The server uses the information to maintain a Path Information Base to manage routing within the region. A router also sends a triggered Link State Advertisement message when one of its interfaces fails.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Quality of Service, Networks, Flows, Link State Advertisement

### **APPLICATION OF FAULT-TOLERANT COMPUTING FOR SPACECRAFT USING COMMERCIAL-OFF-THE-SHELF MICROPROCESSORS**

**Kimberly Davenport Whitehouse-Captain, United States Marine Corps**

**B.S., University of Florida, 1990**

**Master of Science in Computer Science-June 2000**

**and**

**Susan E. Groening-Lieutenant, United States Navy**

**B.A., University of Florida, 1989**

**Master of Science in Computer Science-September 2000**

**Advisors: J. Bret Michael, Department of Computer Science**

**Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair**

Low availability, high cost, and poor performance of radiation hardened (rad-hard) equipment has driven the market to rely on commercial-off-the-shelf (COTS) equipment for the computing needs of today's spacecraft. This thesis describes the tailoring of a COTS embedded real-time operating system and design of a human-computer interface (HCI) for a triple modular redundant (TMR) fault-tolerant microprocessor for use in space-based applications. One disadvantage of using COTS hardware components is its susceptibility to the radiation effects present in the space environment, and specifically, radiation-induced single-event upsets (SEUs). In the event of an SEU, a fault-tolerant system can mitigate the effects of the upset and continue to process from the last known correct system state. The TMR basic hardware design used for this research is an acceptable fault-tolerant design candidate for the main processor for space-based applications. We found that a COTS embedded real-time operating system could be tailored to

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support the TMR hardware. The HCI accepts serial data from the TMR, correctly identifies the source of the error, allows for processor mode selection and provides system- and board-level reset capabilities. The tailored operating system combined with the HCI is a viable software implementation to support hardware-based fault-tolerant computing in a space environment.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Space Vehicles, Human System Interface

**KEYWORDS:** Fault Tolerance, Embedded Operating System, Human Computer Interface, Triple Modular Redundant Hardware, Spacecraft Design

### **THE SHARP EVOLUTION: DEVELOPMENT OF THE SIERRA HOTEL AVIATION REPORTING PROGRAM FROM THE DECK PLATES**

**Christopher L. Williamson-Lieutenant, United States Navy  
B. S., United States Naval Academy, 1991**

**Masters of Science in Software Engineering-September 2000**

**Advisor: Luqi, Department of Computer Science**

**Second Reader: Oleg Kiselyov, National Research Council Senior Research Associate**

Due to constant changes in the military environment, operations tempo, resource limitations, and leadership directives, the fashion in which the military computes its training and readiness is constantly in flux. Previous readiness calculations were accomplished from simple two-dimensional models of qualifications by dates. With the increase of more sophisticated requirements, a new six-dimensional model of training and readiness was invented to compute and even predict future readiness levels, for aviation as outlined in the Training and Readiness (T&R) Manual CNAP INST/CNAL INST 3500 Series.

Due to the complex requirements of the new T&R Manual, a software tool was required to track post-flight data and compute aviation combat readiness. The T&R Manual is revised at irregular intervals by independent type wings, resulting in a constant requirement to re-develop existing readiness models and tracking programs. To fulfill this requirement, a team of Naval Aviators with a combination of software engineering expertise, military operations, and project management experience was created to develop a modular based rapid prototype application.

This thesis will review the unique software development models utilized in rapid military application development, contrasting with existing application development models, and the utilization of non-traditional techniques to meet defense readiness requirements. This thesis will also review other readiness tracking systems to compare and contrast the ability to meet the diverse needs of fleet readiness models through efficient software development.

**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications, Computing and Software, Manpower, Personnel, and Training

**KEYWORDS:** Software Engineering, Combat Readiness, Software Management, COTS, Software Evolution Model

### **A TRUSTED CONNECTION FRAMEWORK FOR MULTILEVEL SECURE LOCAL AREA NETWORKS**

**Jeffery D. Wilson-Lieutenant Colonel, United States Marine Corps  
B.A., Bluefield College, 1982**

**Master of Science in Computer Science-June 2000**

**Advisors: Cynthia E. Irvine, Department of Computer Science**

**Second Reader: Timothy Levin, Anteon Corporation**

The Naval Postgraduate School is developing a Multilevel Secure Local Area Network (MLS LAN) that incorporates commercial-off-the-shelf client workstations to provide multiple users with simultaneous secure access to stored data of different sensitivity levels. The MLS LAN uses a Trusted Computing Base Extension (TCBE) in the LAN's client workstations to extend the TCB from the trusted server across the

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network to these workstations. Connections between elements of the LAN are under TCB control and are conducted by way of several new communications protocols.

Using a realistic System Requirements Document and a High Level Protocol Analysis, this thesis presents a framework of communications protocols that will enable the components of the MLS LAN to securely interact. The framework first presents a communications channel protocol that protects all data transmitted on the network. Following this, three other protocols are described that enable MLS LAN users to safely login and negotiate a secure session, access Application Protocol Servers that provide services such as e-mail or WWW services, and to use typical LAN-based office automation services. Finally presented is an analysis of both TLS and IPSec, which provides evidence that IPSec is best suited to provide MLS LAN communications protection.

**DoD KEY TECHNOLOGY AREA:** Other (Computing and Networks)

**KEYWORDS:** Multilevel Security, Trusted Path, High-Assurance, Network Client-Server

**HELICOPTER URBAN NAVIGATION TRAINING  
USING VIRTUAL ENVIRONMENTS**  
**George T. Wright, Jr.-Major, United States Marine Corps**  
**B.S., University of West Florida, 1984**  
**Master of Science in Computer Science-June 2000**  
**Advisor: Rudolph P. Darken, Department of Computer Science**  
**Second Reader: Barry Peterson, Department of Computer Science**

Helicopter missions are never defined as "...successful navigation to and return from a location." Navigation, in and of itself, is not the mission – it is, however, a skill that all helicopter pilots are expected to master in order to function as pilots. *Navigation is a means to an end.*

Helicopter operations, being inherently expensive and unforgiving of mistakes, are prime candidates for such innovative training techniques as virtual (3-D) fly-throughs. This thesis, as a logical extension of previous research, seeks out ways to enhance current training methods for urban helicopter navigation using state-of-the-art-technology. Using empirical data from pilot surveys and controlled experiments, principles can be formulated to determine the level of computer graphics fidelity necessary for helicopter crews to conduct a virtual flight in an urban setting that is a credible, effective tool in preparation of an actual flight.

This research does not seek a replacement method of training helicopter terrain navigation – pilots must still be taught the fundamental skills of map interpretation and terrain association using conventional training techniques. However, it is the intent of this research to explore methods of enhancing and supplementing site-specific helicopter navigation training through the transfer of spatial knowledge from the virtual world to real-world applications.

**DoD KEY TECHNOLOGY AREAS:** Air Vehicles, Computing and Software, Manpower, Personnel, and Training, Modeling and Simulation

**KEYWORDS:** Helicopter, Urban Terrain, Virtual Environments, Navigation Training, Mission Rehearsal, Spatial Orientation, Situational Awareness

**IMPLEMENTATION AND EVALUATION OF A NETWORK ACCESS PROTOCOL**

**Joseph A. Wronkowski-Captain, United States Marine Corps**

**B.S., University of Southern Illinois, 1992**

**Master of Science in Computer Science-June 2000**

**and**

**David I. Odom-Lieutenant, United States Navy**

**B.S., Norfolk State University, 1994**

**Master of Science in Computer Science-September 2000**

**Advisor: Dennis Volpano, Department of Computer Science**

**Second Reader: J. Bret Michael, Department of Computer Science**

Traditional Ethernet networks are wired networks. There is now an increasing need, however, for hosts on the network to be mobile without losing network connectivity. This is where wireless technology comes in. The basic idea is to allow a portable device, equipped with an Ethernet transceiver, to relocate while “connected” to the network. Connected here means being within radio range of another transceiver, called an access point, which acts as a relay for the portable device. Its relocation is entirely transparent.

Currently, there is a standard that defines how wireless devices communicate within a Local Area Network. This standard is called IEEE 802.11. The standard, however, is not scalable due to the level at which security is handled.

This thesis examines an alternative security solution, the Network Access (NA) Protocol, developed by Professor Dennis Volpano. It runs on mobile devices and designated hosts called bridges and has the potential to scale up to meet the demands of mobility while ensuring secure network access.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Mobile IP, Wireless Computing, IP Mobility Support, IP Encapsulation, IpSec, IPChains, Home Agent, Mobile Host, Foreign Agent, Tunneling, Care-of-Address, MAC, IEEE 802.11, Route Optimization, Intra-Subnet Roaming