

MASTER OF SCIENCE IN COMPUTER SCIENCE

VIRTUAL REALITY TRANSFER PROTOCOL (VRTP): IMPLEMENTING A MONITOR APPLICATION FOR THE REAL-TIME TRANSPORT PROTOCOL (RTP) USING THE JAVA MEDIA FRAMEWORK (JMF)

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The Real-time Transport Protocol (RTP) supports the transmission of time-based media, such as audio and video, over wide-area networks (WANs), by adding synchronization and quality-of-service (QoS) feedback capabilities to the existing transport protocol. RTP has been widely used in the Multicast Backbone (MBone), a virtual network that has become a shared worldwide medium for Internet multicast communications.

This work presents the design patterns, architecture and implementation of an RTP monitor application using the Java Media Framework (JMF), a new Java Application Programming Interface (API) for multimedia support. An RTP monitor is an application that receives packets from all participants in a multicast session in order to estimate the quality of service for distribution monitoring, fault diagnosis and both short and long-term statistics.

This new RTP monitor is available as a component of the Virtual Reality Transfer Protocol (VRTP), a protocol being developed to support large-scale virtual environments (LSVEs) over the Internet. Initial test results are satisfactory for audio and video streams, as well as prototype RTP-compliant Distributed Interactive Simulation (DIS) protocol streams. Future work includes automated monitoring across WANs and standardizing structured data formats to comply with Management Information Base (MIB) requirements using Extensible Markup Language (XML) target set definitions.

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

KEYWORDS: Multicasting, Real-time Transport Protocol, Virtual Reality, Java, Multimedia, RTP, VRTP

FRAMEWORK FOR A HIGH-ASSURANCE SECURITY EXTENSION TO COMMERCIAL NETWORK CLIENTS

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The Department of Defense and U.S. Government have an identified need to securely share information classified at differing security levels. Because there exist no commercial solutions to this problem, NPS is developing a Multilevel Secure Local Area Network (MLS LAN). The MLS LAN extends the high assurance capabilities of an evaluated multilevel secure system to commercial personal computers (PCs)

running commercial operating systems and office productivity software by using a 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 physical interfaces required for the TCBE to complete a trusted path and control the client PC. Potential implementations for each interface are suggested and analyzed for security implications. Also presented is a detailed analysis of methods for delivering the Windows NT operating system (including the suitability of Terminal Server Edition) to the client PC in the MLS LAN with high assurance of properly controlled object reuse and operating system integrity.

DoD KEY TECHNOLOGY AREA: Computing and Software

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

THE EFFECT OF PRESENCE ON THE ABILITY TO ACQUIRE SPATIAL KNOWLEDGE IN VIRTUAL ENVIRONMENTS

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It is unclear what impact presence has on a virtual environment's (VE) ability to enhance learning and performance. Currently, there are many theories and conjectures about the effects of presence in VEs. To better the effectiveness of VEs, it is imperative that we determine the impact, both positive and negative, of presence on our ability to perform in VEs. Therefore, we must study how presence affects a person's ability to acquire skills and knowledge. This must include our ability to navigate and perform spatial tasks as well as any other aspect of the real world that may be represented by a VE.

To begin understanding how presence affects performance, forty individuals participated in an experiment to determine how presence affects the ability to acquire spatial knowledge in a VE. The purpose of the experiment was to determine if the level of presence in a VE increased or decreased a person's ability to acquire spatial knowledge, to include landmark recognition, procedural knowledge, and survey knowledge. Each participant received one of the following VE treatments: (1) No sound, (2) Verbal cues with topical information, (3) Verbal cues with spatial information, or (4) A combination of both topical and spatial information. They were administered by a series of spatial tests. Finally, they were given a presence questionnaire to measure their self-assessed level of presence.

The results indicate that as the level of presence in the VE varies, there is no effect on a person's ability to acquire spatial knowledge. A person's spatial performance is more likely the result of their innate spatial abilities and visual memory. Additionally, including non-spatialized sound in a VE increased the reported level of presence by 15.1 percent. When that sound was exclusively related to the primary task the level of presence increased by 17 percent. Finally, the inclusion of non-spatialized sound has no affect on the ability to perform spatial tasks.

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

KEYWORDS: Virtual Environments, Training, Presence, Spatial Knowledge

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ADDRESSING THE UNITED STATES NAVY NEED FOR SOFTWARE ENGINEERING EDUCATION

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Computer technology use as a highly effective tool is ever increasing in the modern world, including the warfare arena. Manning issues due to budget concerns mandate a smaller future military workforce, while theater conflicts will continually grow in complexity. Computers are powerful tools that can aid the warrior's ability to fight amidst this onslaught of information.

Unfortunately, a computer cannot simply be dropped onto a ship to create miracles on its own. Computers are only as intelligent and useful as they are engineered to be. The costs of this highly difficult and expensive task can be mitigated by proper utilization of personnel specifically educated to plan and produce these systems and the associated software. The Navy can produce these personnel from within its ranks, via a curriculum in Software Engineering at the Naval Postgraduate School; however the effectiveness of this program is not currently being maximized.

This thesis develops and implements a program to address the Navy's needs for software engineering, helping successfully combat the Navy's current void in software engineering education. This should ultimately lead to an increase in the Navy's knowledge assets, and subsequently to better opportunities for Naval utilization of the technology available to improve warfare capabilities.

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

KEYWORDS: Software Engineering, Navy Subspecialty System, Curriculum Development, Graduate Education, Computer Technology

MOBILE INTERNET PROTOCOL ANALYSIS

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Mobile Internet Protocol (IP) is a proposed standard that builds on the current Internet Protocol by making the fact that a user is mobile transparent to applications and higher level protocols such as Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).

Mobile IP allows mobile computers to send and receive packets addressed with their home network IP address, regardless of the IP address of their current point of attachment on the Internet while maintaining any current connections even if the point of attachment changes while the current connection is still active. Additionally, it is independent of the physical medium over which the mobile computer communicates. In order to meet the goals of location transparency and connection durability each mobile node has a permanent IP address. This unchanging address allows conventional Internet hosts, which are unaware of mobility issues, to communicate with the mobile node. When the mobile node is at home, it functions like a normal non-mobile Internet node. When it is away from home, it communicates through the use of home agents and foreign agents.

This thesis will explain Mobile IP and analyze the protocol to determine strengths and weaknesses of the protocol.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Network Systems, Mobile Internet Protocol

OPTIMAL SIZE OF JOB POOL FOR INITIATING A SCHEDULING EVENT

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In today's military with its dwindling resources, making the best use of computers, particularly to support real-time commercial off-the-shelf (COTS) applications, is becoming critical for success. Resource Management Systems (RMS) strive to address this issue. The RMS job scheduler is needed to ensure good quality of service (QoS) to all applications. This research uses discrete event simulation experiments to investigate the cost tradeoff between improving system performance through grouping incoming jobs to create better schedules, versus both (1) the time spent waiting for the group to accumulate and (2) the additional cost of computing schedules involving more jobs. A MaxMin $O(MN^2)$ greedy scheduling algorithm attempting to minimize the total time in system was used in these experiments. We analyzed the data generated from numerous experiments that used typical input parameters. As a result of this effort, we conclude that job grouping should be used when the utilization factor for the system is near 1.0, or precisely when the mean arrival rate is comparable to the total mean service rate of the processors. At this utilization rate, the group size should be equal to the number of machines in the system. However, when the utilization factor is significantly different from 1.0, each job should be scheduled as it arrives.

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

KEYWORDS: Heterogeneous Computing, Resource Management System, JAVA, Modeling and Simulation, Scheduling, Discrete Event Simulation

AUTOMATING THE SIGN-OUT SHEET AS A PART OF THE TACTICAL COMBAT TRAINING PROGRAM AS AN INFORMATION SYSTEM FOR COMMANDING PERSONNEL IN A NAVAL AIRSTATION

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Presently, the German Navy Airwings lacks the automated computer infrastructure required to process administrative flying specific data in the squadrons and administer data from deployed aircrews on foreign airfields. Thus, flying data are obsolete quickly, especially if aircrews are deployed, and administering personnel must create the forms. Owing to this inefficiency, delays of several days can occur. In this thesis, a prototype of a database and a client-server application was designed and developed showing the feasibility of implementing a system that transfers data quickly and securely over long distance and can store the data accordingly.

With several technologies available to create and implement such a system, the goal was to employ currently available components efficiently and economically. Thus, three-tier client-server implementations are introduced and compared, where the RMI network protocol best provides a robust and efficient answer for the required needs. Java RMI enables the software developer to create distributed Java-to-Java applications in which the methods of remote Java objects can be invoked from objects in other Java Virtual Machines (JVM). RMI can be programmed to provide services to a database by establishing a listener process to handle access requests. RMI uses the built-in Java security mechanisms, making the computer system safe when code is downloaded. Every RMI-based system is portable to any JVM. The system incorporates the JDBC™ to establish a connection to a database.

DoD KEY TECHNOLOGY AREA: Air Vehicles

KEYWORDS: Tactical Combat Training Program, RMI, Java, JVM, Servlets, Client-Server, JDBC™

**AN EXPLORATION OF OPEN-SOURCE TOOLS FOR
INFORMATION WARFARE (U)**

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Abstract is classified.

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

KEYWORDS: Computer Network Attack, Computer Security, Information Warfare, Information Operations, Hacker, Tools, SCADA

**A LINUX-BASED APPROACH TO LOW-COST SUPPORT OF
ACCESS CONTROL POLICIES**

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It is vital to our country's political and economic future to adequately protect corporate and government information from unauthorized disclosure and modification. Unfortunately, the current state of computer security is weak, especially when novice adversaries can perform successful infiltrations of sensitive systems. Systems that enforce Mandatory Access Control (MAC) policies are known to reduce some known security weaknesses, but such systems have seen limited use within the United States Government, and they are rarely applied in the private sector. Some of this limited use is caused by a lack of exposure to systems able to enforce MAC policies. This thesis presents an inexpensive approach to providing a system supporting MAC policies, allowing users an opportunity to have hands-on experience with such a system. A detailed design for modifying the Linux operating system is given, allowing for the flexible and simultaneous support of multiple policies. In particular, a design and detailed specification for the implementation of label-based interfaces for the mandatory portions of the Bell and LaPadula secrecy model and the Biba integrity model have been developed. Implementation of portions of this design has demonstrated the feasibility of this approach to label-based interfaces. This design has potential for widespread use in computer security education, as well as broad application as a component in the ongoing Department of Defense research of trusted computer system interfaces.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Mandatory Access Control, Security Policy, Linux, Education

A ROUTING-BASED SOLUTION TO SIMULATING AN ACCESS POINT

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Military environments require flexible network configurations that must adapt under dynamic and mobile operating conditions. Wireless data networks offer some solutions. A wireless network typically requires an access point to bridge network traffic between wireless and wired media. These devices though are

often too inflexible for use in such dynamic conditions. One major problem is that they are dedicated to a single type of wired network, usually Ethernet, which prevents them from being used to bridge traffic to other kinds of networks, for example, ATM or even cellular.

This thesis shows how any device running a recent Linux kernel can be configured to route packets in way that simulates an access point. The advantages of such a configuration are described and its potential for military use is discussed.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Wireless, Networking, Access Points, Bridge

CYBER FI: CYBERWAR, CYBERMERCENARIES, AND RED TEAM OPERATIONS

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This paper looks at the evolving threat of cyberwar – the use of computers and networks to wage war. Specifically, it examines the threat that cybermercenaries, or “hackers for hire,” present to U.S. military operations. This study also finds that the current methodology for conducting “Red Team” operations, or the simulation of enemy capabilities, does not realistically portray the full range of threats that cyberwar poses to military operations. Finally, this thesis calls for the formulation and use of Information Warfare “Ghost Teams,” representing the IW threat from non-traditional forces such as cybermercenaries, in concert with traditional red team activities to present a more realistic picture of the actual IW threat faced by today’s military.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Electronic Warfare, Other (Terrorism)

KEYWORDS: Cyberwar, Cyberterrorism, Cybermercenary, Information Warfare, Red Team, Ghost Team, Information Infrastructure, C4I Infrastructure, Critical Infrastructure, Vulnerability Assessment

A NETWORK DESIGN ARCHITECTURE FOR DISTRIBUTION OF GENERIC SCENE GRAPHS

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Sharing a common view while collaborating in networked virtual environments is complex. The SOFT project examines a new approach: using generic scene graphs as a bus, for graphics distribution. This thesis (as part of the SOFT project) examines network architecture for distribution of generic scene graphs.

A network architecture with a centralized Java server was designed and implemented. This server provides scalability, persistence, reliability, and latecomer support. The server provides interoperability and can support any SSGs on any platform. The extraction of information from the network layer is implemented in two ways. In the first, we use Java’s inherent serialization mechanisms; in the second, we use the Dial-a-Behavior (DaBP) protocol.

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The server's overhead with both network mechanisms were tested. The conclusion is that using DaBP significantly reduces the server's overhead by a factor of six but only for less than 50,000 packets. Moreover, the use of DaBP provides implementation flexibility because data format can change dynamically without requiring re-compilation. Finally, DaBP, while promising, must mature and be shown to reduce overhead for large number of packets before it is ready to be incorporated into the final architecture solution for SOFT.

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

KEYWORDS: Computer Graphics, Virtual Reality, Client/Server, Networks

ANALYSIS OF INTERNET TELEPHONY AND THE H.323 MULTIMEDIA STANDARD

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Internet Telephony is an emerging and promising technology, which enables the transport of voice over data networks. If it is going to be successful, standardization will be critical. The purpose of this study is to assess the suitability of the H.323 standard for establishing and performing real-time voice conversations over IP networks. The goals of the study were to (1) examine the current status of Internet Telephony, (2) conduct research on the current Internet Telephony software solutions in terms of quality, performance, interoperability and H.323 compliance, (3) analyze and evaluate the H.323 standard, (4) compare H.323 with Session Initiation Protocol, and (5) provide recommendations for further improvements of H.323. The study shows the complexity of H.323 and highlights the areas where more considerations are required. Part of the study includes the testing of 10 Internet Telephony programs. The tests show that H.323 compliance does not guarantee interoperability and voice quality. Also it is shown that the standard is not yet mature despite its popularity. However, it is assessed that Internet Telephony is a technology which will experience tremendous expansion during the forthcoming years. Based on the analysis and evaluation results, recommendations are provided in order for the H.323 to be more suitable for Internet Telephony.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: H.323 Standard, Internet Telephony, Voice Over IP, Multimedia Communication

AUTOMATED COMMUNICATIONS INTERCEPT, ANALYSIS, AND DIRECTION FINDING SYSTEM

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As communications continue to grow in complexity and speed, we need more and more automated tools to intercept, classify, and locate signals transmitted by potential and current adversaries. For this research project, we designed and built a system that automatically identifies and calculates bearings to all signals detected in a programmed scan or general sweep of the RF spectrum from 0.1 MHz to 2000.0 MHz. We have built a working prototype of the system and the associated user interface with most of the basic functionality included. This prototype is intended as a working model that can be used to design and build a fully operational version of the system. Our design is based on Commercial-Off-The-Shelf technology and is centered around a 300MHz CPU desktop PC architecture. Key components include an AR5000

scanning receiver, a PCR-1000 analysis receiver, a Cubic 4400 direction finding (DF) receiver, a DF antenna array, a GPS receiver, and a KVH fiber optic gyroscope (FOG).

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

KEYWORDS: Direction Finding, Signals, Communication, Demodulation, C++, Microsoft Foundation Classes

A FORMAL SPECIFICATION AND ANALYSIS OF THE RESOURCE RESERVATION PROTOCOL

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This thesis explores the practicality of using the Resource ReSerVation Protocol (RSVP) model to prove quality of service guarantees over IP networks. An overview of the requirements to provide quality of service is provided. Using Finite State Machine analysis, the RSVP protocol is formally specified and found to be suitable for reserving resources along a proposed path. However, the distributed nature of the RSVP model and its reliance on quality of service aware routing protocols is problematic. Several examples where RSVP provides less than optimal and/or incorrect results are studied. The framework for alternate model of proving quality of service is proved. This model uses a centralized server for flow path computation. The server-based approach provides more accurate results than the RSVP model and is capable of network optimization; yet it places fewer strains on network resources and appears easier to implement.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Networking, IPv6, Internet Protocol, RSVP, Resource Reservation

ATM SECURITY VIA "STARGATE" SOLUTION

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In today's world of integrating voice, video and data into a single network, Asynchronous Transfer Mode (ATM) networks have become prevalent in the Department of Defense. The Department of Defense's critical data will have to pass through public networks, which causes concern for security. This study presents an efficient solution aimed at authenticating communications over public ATM networks. The authenticating device, "Stargate," utilizes a high speed, low level authentication protocol that offers the low cost, flexibility, and extensibility of software, while still capable of yielding performance comparable to hardware-based authentication.

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

KEYWORDS: Authentication, Asynchronous Transfer Mode, Key Management, Security, Networking

AUTONOMOUS AGENTS FOR DISTRIBUTED INTRUSION DETECTION IN A MULTI-HOST ENVIRONMENT

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Because computer security in today's networks is one of the fastest expanding areas of the computer industry, protecting resources from intruders is an arduous task that must be automated to be efficient and responsive. Most intrusion-detection systems currently rely on some type of centralized processing to analyze the data necessary to detect an intruder in real time. A centralized approach can be vulnerable to attack. If an intruder can disable the central detection system, then most, if not all, protection is subverted. The research presented here demonstrates that independent detection agents can be run in a distributed fashion, each operating mostly independent of the others, yet cooperating and communicating to provide a truly distributed detection mechanism without a single point of failure. The agents can run along with user and system software without noticeable consumption of system resources, and without generating an overwhelming amount of network traffic during an attack.

DoD KEY TECHNOLOGY AREAS: Other (Computer Security, Artificial Intelligence)

KEYWORDS: Intrusion Detection, Artificial Intelligence, Autonomous Agents, Computer Security

IDENTIFYING ACCURATE RESOURCE MONITORING TOOLS AND TECHNIQUES

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Distributed applications concurrently share and compete for resources in heterogeneous systems. The objective of the Management System for Heterogeneous Networks (MSHN) is to use admission control, smart scheduling, and adaptation awareness in applications to successfully cope with the dynamics of resource availability. MSHN therefore requires knowledge of the expected resource utilization of applications that execute within the MSHN environment and the current state of these resources. MSHN relies on the above information to correctly identify resources to be assigned to these applications. This thesis investigates the capabilities of currently available communication resource status monitoring tools for the purpose of identifying those tools that, with low overhead, can provide accurate, end-to-end communication status information in a Windows NT environment.

The techniques used by the various tools are described and the methods for determining the accuracy of these tools are specified. Results of the experiments with the various tools show that they add between 2% - 3% overhead in most cases and as much as 10% overhead in the worst case. Finally, none of the existing commercial tools studied gave an accurate assessment of the end-to-end communication throughput and latency for Windows NT 4.0.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Wrapper, Passive Monitoring, Resource Monitoring, MSHN, Heterogeneous Computing, Resource Management System

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THE TRANSFER OF SPATIAL KNOWLEDGE FROM VIRTUAL TO NATURAL ENVIRONMENTS AS A FACTOR OF MAP REPRESENTATION AND EXPOSURE DURATION

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Terrain navigation is a critical skill in the military. Virtual environments (VEs) have been suggested as a possible tool in training spatial knowledge. However, little research has been conducted into the ability of VEs to impart spatial knowledge of a real world area.

This thesis research addresses the utility of VEs to impart spatial knowledge of a natural terrain area compared to traditional methods. Twenty subjects were divided into four training conditions in two experiments. The first experiment had a VE and map-only group and trained to a set standard rather than to a time. The second experiment also had a map-only and VE group, but trained one hour with a low fidelity map (1:24,000 scale as compared to 1:5,000 scale in earlier experiments). Measures were taken of landmark, route, and survey knowledge.

The results suggest that, (1) subjects who trained-to-standard using a VE demonstrated superior route and landmark knowledge to any other group, (2) spatial ability plays a significant role in navigation performance, and (3) adjusting the fidelity of the map causes individuals to adjust their planned routes to the information that is provided. Furthermore, while good-map reading does not guarantee success, poor map reading skills invite failure. Finally, if time is limited, a detailed map is preferable to other methods.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Spatial Knowledge, Virtual Environments, Navigation, Orienteering, Geographic Information Systems, Terrain Visualization, Modeling and Simulation

REQUIREMENTS ANALYSIS AND DESIGN OF A DISTRIBUTED ARCHITECTURE FOR THE COMPUTER AIDED PROTOTYPING SYSTEM (CAPS)

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The Computer Aided Prototyping System (CAPS) developed at the Naval Postgraduate School is a powerful Computer Aided Software Engineering (CASE) tool for examining requirements and timing constraints for hard real-time systems. However, it remains a stand-alone system. Even if it is running on machines in multiple locations, there is no way to coordinate the efforts between the different locations. In today's software development environment, that proves to be a significant disadvantage. Additionally, providing support for more than just hard real-time software development would tremendously enhance CAPS.

Our analysis details the requirements needed to make a distributed CAPS feasible. A distributed CAPS functioning over a network in a coordinated manner would be an invaluable asset to those developing software today, especially in the Department of Defense (DOD). Our work also produced an initial design architecture based on a three tiered client-server model and utilizing Java and the Common Object Request Broker Architecture (CORBA). The Java/CORBA combination greatly simplifies deploying a distributed CAPS over any heterogeneous network. Our preliminary implementation of CAPS with a NT client and a Solaris server demonstrates the efficacy of this design.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Engineering, Distributed Applications, Computer Aided Prototyping, CORBA

**QUANTUM COMPUTERS AND THEIR IMPACT ON THE DEPARTMENT OF
DEFENSE IN THE 21ST CENTURY**

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Computer processor speeds double every eighteen months according to Moore's law. This growth will reach a limit by the year 2020. Quantum computation is one proposed alternative to bypass this limitation. This thesis explores the topic of quantum computation. Specifically, we address what is a quantum computer, its various proposed implementations, its technological feasibility, and its military applications. Recent experiments have provided a proof of concept for quantum computation and some researchers believe that a working model could be developed within a reasonable time period. This success has caused a marked increase in the interest in quantum computers and their proposed potential. We attempt to separate fact from fiction to see what possible benefits the Department of Defense could obtain from it.

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

KEYWORDS: Quantum Computation, Quantum Communication, Quantum Cryptography, Quantum Teleportation, Quantum Parallelism

**AN INTERACTIVE VIRTUAL ENVIRONMENT FOR TRAINING MAP-READING
SKILL IN HELICOPTER PILOTS**

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Currently, Student Naval Aviators are trained to interpret 1:50,000 scale contour maps by watching VHS videotapes. These tapes show a helicopter moving about twice its normal speed over desert terrain. Primarily due to the lack of interactivity in these videos, the student often makes mistakes very early in the videotaped flight. The helicopter does not stop until the tape is over, hence, the training evolution quickly becomes useless because students usually make mistakes during the first minute of the tape and are unable to recover or to learn from those mistakes.

Based on a previous study at the Naval Postgraduate School, a training system that utilizes virtual environment technology was developed that is compliant with the Information for the 21st Century (IT-21) initiative. The system was built using a Windows NT / Intel (Wintel) based computer along with three 24-inch monitors to train the tasks of map interpretation and terrain association. This desktop system was fielded at Helicopter Antisubmarine Squadron 10 (HS-10) for experimentation.

Results of this experiment indicate that student pilots who received VE training performed the navigation task better in the helicopter than students who received only conventional training.. Also, an IT-21 Wintel based computer is capable of rendering a graphically intensive multi-monitor application at frame rates suitable for training.

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

KEYWORDS: Virtual Environments, Terrain Association, Navigation, Map Interpretation, IT-21, MITAC, MITAVES

IMPLEMENTATION OF REAL-TIME MSHN USING ACE AND TAO

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The Management System for Heterogeneous Networks (MSHN) project is a part of the DARPA/ITO QUORUM program. MSHN targets the execution of multiple, disparate tasks that use a set of shared, heterogeneous resources in a way that maximizes a collection of application-specific quality of service (QoS) measures.

This thesis examines some of the architectural requirements demanded of MSHN for it to be able to operate in a real-time environment, and presents an implementation of a MSHN communication schema using components designed for supporting real-time applications. This implementation is built over the Adaptive Communication Environment (ACE), a freely available, open-source, object-oriented (OO) framework for building concurrent communication. To support the communication between MSHN components, we used the Common Object Request Broker Architecture (CORBA), particularly *The ACE ORB* (TAO), a standards-based, CORBA middleware framework. Both ACE and TAO are being developed at the Washington University in St. Louis, MO.

In our experiments, we define and measure the latency (communication time required to start an application) and agility (communication time required to migrate an application given a platform failure). We find that MSHN has the potential for supporting certain types of real-time systems, such as vehicle control.

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

KEYWORDS: Resource Management Systems, RMS, MSHN, CORBA, ACE, TAO, Real-time

**ANALYZING THE INTEL PENTIUM'S CAPABILITY TO SUPPORT
A SECURE VIRTUAL MACHINE MONITOR**

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This thesis addresses the problem of implementing secure virtual machine monitors (VMM) on the Intel Pentium architecture. A VMM allows multiple operating systems to run concurrently under virtual machines on a single workstation. High-assurance VMMs could allow complete isolation of, or data sharing between, virtual machines according to a security policy such as a mandatory secrecy policy.

The Intel architecture was mapped to a set of hardware requirements for VMMs. It was found that the Intel architecture was not virtualizable. However, several techniques are presented that allow the Intel architecture to support a "virtual VMM." A commercial virtual VMM was studied and found to be unable to support secure VMMs. Therefore, a foundation upon which a secure VMM could be built for the Intel Pentium architecture is presented.

A secure VMM for the Intel architecture offers several benefits. First, PC users could work in a more secure environment. Second, PC users could run familiar COTS operating systems and applications. Finally, secure VMMs could save the DoD millions of dollars by eliminating the need for separate systems when both high assurance, and COTS operating systems and applications are required.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Virtual Machines, Virtual Machine Monitors, Intel Architecture, Multilevel Security, Intel Pentium

**DISTRIBUTED SOFTWARE APPLICATIONS IN JAVA FOR PORTABLE
PROCESSORS OPERATING ON A WIRELESS LAN**

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As the wave of future information technology makes its way into the construction and design of new ships and submarines, it is imperative to examine methods to thoroughly economically backfit older platforms with similar technology. Affordable, Commercial-off-the-shelf (COTS) industrial products have provided us with a means to reduce miscommunication and exponentially increase the availability of information via small pen-based computers operating on a wireless LAN. To take full advantage of the communications capabilities of these units and to fill the unique needs of the afloat Navy, the development of software applications is required. These software applications must be effective, tailored, and inexpensive if they are to be made available to older platforms. A distributed JAVA-based Intranet is the solution. The simplicity and economy of web-based software coupled with the power and functionality of pen-based computers, creates a dynamic and effectual architecture.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Other (Wireless Communications)

KEYWORDS: Wireless Local Area Networks, PDAs, Handheld Computers

**MODELING CONTROL CHANNEL DYNAMICS OF THE SAAM ARCHITECTURE
USING THE NS NETWORK SIMULATION TOOL**

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The explosive growth of the Internet and the advent of real-time network applications have stretched the capacity of current network technology. It has become evident that to realize the full potential of the Information Super Highway, a new network architecture will have to be developed. It was for these reasons the Next Generation Internet Project was started. As a part of this effort the Server and Agent based Active network Management (SAAM) Project was started. SAAM is a server based hierarchical routing architecture designed to provide Quality of Service (QoS) routing services for network resource intensive applications. Because the study of this topic entailed emulating large Wide Area Networks, a simulation of the entire architecture would have to be developed. This thesis provides the first step towards achieving that goal. The model developed as the basis for this thesis concentrates on the control traffic overhead required to configure and implement the routing mechanism of SAAM. Specifically it simulates the control channel dynamics required to pass control messages between servers, routers and real-time applications.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: SAAM, Quality of Service, Network Simulation

**A BIOLOGICALLY BASED APPROACH TO THE
MUTATION OF CODE**

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Evolutionary programming is a relatively new problem solving approach in the field of computer science. It attempts to model the processes of natural selection and evolution to solve complex problems. This technique is very powerful because it can be applied to a wide range of problems, and can find solutions that other more traditional techniques cannot.

This research attempts to augment the methodology of an evolutionary programming approach with two new features: (1) dominant and recessive traits and (2) intron and exon regions. These features form the basis of a specialized approach for evolutionary programming which might be able to be applied to new problem areas where evolutionary programming usually performs poorly.

This specialized approach is applied to the well known problem of a series expansion, so that the results are easily compared to a known solution, and that the influence of these additional mechanisms on the population of solutions can be studied. Results from implementing the new mechanisms individually and together are presented, and compared with a baseline evolutionary programming implementation.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Genetic Programming

THE SAAM ARCHITECTURE: ENABLING INTEGRATED SERVICES

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Computer networks of today are based predominantly on the TCP/IP protocol suite that provides best effort service. The current IP protocol excels in its simplicity and network fault tolerance. The way it implements this simplicity and fault tolerance, however, limits the protocol's ability to provide a guaranteed Quality of Service (QoS). A first step in providing this QoS is to incorporate the concept of flow based routing. This thesis describes an implementation of the Server and Agent based Active network Management (SAAM) system architecture that incorporates flow-based routing. The architecture contains servers that maintain a database that is used for assigning each flow to a path that will provide the needed QoS.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Next Generation Internet, Integrated Services, Quality of Service, Flows, Networks, Routing