MASTER OF SCIENCE
IN
COMPUTER SCIENCE

DESIGN AND IMPLEMENTATION OF AN ENTERPRISE INFORMATION SYSTEM UTILIZING A COMPONENT-BASED THREE-TIER CLIENT/SERVER DATABASE SYSTEM

Murat Akbay-First Lieutenant, Turkish Army
B.S., Turkish Military Academy, 1991
Master of Science in Computer Science-March 1999
and
Steven C. Lewis-Lieutenant, United States Navy
B.S., Oregon State University, 1995
Master of Science in Computer Science-March 1999
Advisor: C. Thomas Wu, Department of Computer Science
Second Reader: Chris Eagle, Department of Computer Science

The Naval Security Group currently requires a modern architecture to merge existing command databases into a single Enterprise Information System through which each command may manipulate administrative data. There are numerous technologies available to build and implement such a system. Component-based architectures are extremely well-suited for creating scalable and flexible three-tier Client/Server systems, because the data and business logic are encapsulated within objects, allowing them to be located anywhere on a network. The first tier represents the visual aspects of the data on the client side. The middle tier consists of server objects that represent the persistent data and enforce the business logic functions. The third tier maintains the database management systems. The client interacts with the middle-tier server objects via Common Object Request Broker Architecture. CORBA provides a language and platform independent architecture that enables objects to transparently make requests and receive responses in a distributed environment. Java is an object-oriented, multi-threaded, secure mobile code system that allows applications to run on all major computing platforms. This thesis examines the design of an EIS using Java applets that use Inter-Orb Protocol to communicate with CORBA middle-tier server objects. The third tier will incorporate Java Database Connectivity to communicate with database management systems.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Enterprise Information System, Client/Server

SECURE LOCAL AREA NETWORK SERVICES FOR A HIGH ASSURANCE MULTILEVEL NETWORK

Susan Bryer Joyner-Lieutenant, United States Navy
B.S., Rensselaer Polytechnic Institute, 1991
Master of Science in Computer Science-March 1999
and
Scott D. Heller-Lieutenant, United States Navy
B.A., University of Rochester
Master of Science in Computer Science-March 1999
Advisor: Cynthia E. Irvine, Department of Computer Science
Second Readers: James P. Anderson, Anderson and Company
James Bret Michael, Department of Computer Science

To reduce the cost and complexity of the current DoD information infrastructure, a Multilevel Secure (MLS) network solution eliminating hardware redundancies is required. Implementing a high assurance MLS LAN requires the ability to extend a trusted path over a TCP/IP network. No high assurance network trusted path mechanisms currently exist.

A design and proof-of-concept implementation for a Secure LAN Server are presented that provides the trusted path between a trusted computing base extension (TCBE) servicing a COTS PC and protocol servers executing at single sensitivity levels on the XTS-300. The trusted path establishes high assurance communications (over a TCP/IP network) between a TCBE and the Secure LAN Server. This trusted channel is used first for user authentication, then as a trusted relay between the protocol server and TCBE. All transmitted data passed over the LAN can be protected by encryption, providing assurance of integrity and confidentiality for the data.

This thesis documents the implementation of a demonstration prototype Secure LAN Server using existing technology, including high assurance systems, COTS hardware, and COTS software, to provide access to multilevel data in a user-friendly environment. Our accomplishment is crucial to the development of a full scale MLS LAN.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Multilevel Security, Trusted Path, Secure Session, High Assurance Server, Thin Client

WHEN IS A SIMPLE MODEL ADEQUATE FOR USE IN SCHEDULING IN MANAGEMENT SYSTEMS FOR HETERGENEOUS NETWORKS (MSHN)?

Paul F. Carff-Lieutenant, United States Navy
B.S., Santa Clara University, 1991
Master of Science in Computer Science-March 1999
Advisors: Debra A. Hensgen, Department of Computer Science
Taylor Kidd, Department of Computer Science

Current resource management systems do not provide a way to use measurements taken from an application's execution on one computer to predict that application's performance on another computer. More details are needed in both their application and resource models in order to make this prediction. However, very detailed models are also not desirable. Models that are too detailed incur unnecessary overhead when values corresponding to the detail are being obtained; they are subject to higher variances; and the benefit of computing schedules using them may be outweighed by the time required too compute those schedules.

This thesis proposes a model that balances the level of detail, and therefore the quality of their predictions of resource usage, against the cost of computing schedules. To assess the quality of the proposed model, an application emulator was designed, built, and used.

The results from running the application emulator demonstrated that the proposed model is able to predict the relative resource usage of an asynchronous application that has substantially more computation requirements than communication requirements. However, an even more detailed model is needed to successfully predict resource requirements of both synchronous and communication-intensive applications.

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

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

DESIGN, IMPLEMENTATION, AND TESTING OF A REAL-TIME SOFTWARE SYSTEM FOR A QUATERNION-BASED ATTITUDE ESTIMATION FILTER

Ildeniz Duman-Lieutenant Junior Grade, Turkish Navy
B.S.C.S., Turkish Naval Academy, 1992
Master of Science in Computer Science-March 1999
Advisors: Eric R. Bachmann, Department of Computer Science
Robert B. McGhee, Department of Computer Science

Human limb segment angle tracking requires a system which can track through all orientations. The major problem addressed by this research was to develop a real time inertial motion tracking system based on quaternions to overcome the singularities of Euler angle filters.

This work involves clarification of the theory behind quaternion attitude estimation and development of a system capable of determining the orientation of an object in world coordinates. System sensors were built using miniature accelerometers, rate sensors, and magnetometers. The software system was designed by using Unified

Modeling Language (UML) with object oriented design techniques. The actual implementation created a real time orientation tracking system.

The system was tested with dynamic tilt table experiments. Test results showed that the quaternion attitude estimation filter system can track human limb segments in real time within one degree of accuracy in any orientation and with a 55 Hz update rate.

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

KEYWORDS: Quaternions, Euler Angles, Quaternion Attitude Estimation Filter, Inertial Motion Tracking

IMPLEMENTATION OF A PORTABLE PROTOTYPE SYSTEM DESCRIPTION LANGUAGE EDITOR FOR THE HETEROGENEOUS SYSTEMS INTEGRATOR

Ilker Duranlioglu-Lieutenant Junior Grade, Turkish Navy
B.S.C.S., Turkish Naval Academy, 1993
Master of Science in Computer Science-March 1999
Advisor: Man-Tak Shing, Department of Computer Science

The Computer-Aided Prototyping System (CAPS) is an integrated set of tools that is used for rapid prototyping of real time systems. Prototype System Description Language (PSDL) is the prototyping language that captures the requirements and produces executable prototypes. Prototypes can be created by using specially designed PSDL Editor, which can automatically generate PSDL code from data flow graphs. The Heterogeneous Systems Integrator (HSI) is an extension to CAPS, designed to automate the process of integrating complex distributed systems, where the subsystems can reside on different locations, be implemented in different hardware, operating systems, and programming languages.

It is envisioned that the HSI will be a distributed system itself. Users at remote sites need not install the entire HSI system, but only the User Interface for entering the PSDL specification of the target systems. This research is the first step in the evolution of HSI. The focus is to create a portable user interface, which can be used in any environment (hardware and operating system).

We have designed and implemented a platform independent HSI user interface using the Java programming language. The functionalities of CAPS Release 2.0 PSDL Editor are mainly preserved in this implementation with a few added features. The new editor shows significant improvement in performance and user friendliness over the previous versions of CAPS PSDL Editor.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Rapid Prototyping, User Interface

DEVELOPING A HIGH ASSURANCE MULTILEVEL MAIL SERVER

Bradley R. Eads-Major, United States Marine Corps
B.A., Wabash College, 1983
Master of Science in Computer Science-March 1999
Advisors: Cynthia E. Irvine, Department of Computer Science
Daniel F. Warren, Department of Computer Science

Electronic mail (email) often contains sensitive information, which requires special handling to prevent accidental disclosure to unauthorized personnel. Using multiple systems operating at different classifications has caused a number of inefficiencies in the way email is managed and distributed. Attachments in emails have increased the likelihood that a “Trojan Horse” could be inserted in the system to obtain unauthorized access to information.

To address this problem Commercial-Off-The-Shelf (COTS) software for Internet Message Access Protocol (IMAP), a mail server protocol, has been adapted to a high assurance multilevel base, the Wang Federal XTS-300. The XTS-300 constrains information flow permitting information at different sensitivity levels to be stored securely. Controlled access to mail is provided to client workstations. Enhanced with a trusted computing base extension,

these COTS IBM PC compatibles run a standard office productivity suite. This architecture eliminates the risk that a “Trojan horse” will pass higher sensitivity information to a lower sensitivity level.

The research resulted in an IMAP server application running on the XTS-300 that managed the multilevel mailbox data structure using single level instances. Single level clients are then able to access mail through these instances.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Server, Mail, Networks, Multilevel

METHODOLOGY AND DESIGN OF ADAPTIVE AGENT-BASED SIMULATION ARCHITECTURES FOR BAMBOO OR VISUAL C++

Todd A. Gagnon-Lieutenant, United States Navy
B.S., United States Naval Academy, 1993
Master of Science in Computer Science-March 1999
Master of Science in Modeling, Virtual Environments, and Simulation-March 1999
and
Mark A. Boyd-Major, United States Army
B.S., Oregon State University, 1987
Master of Science in Modeling, Virtual Environments, and Simulation-March 1999
Advisors: Michael Zyda, Department of Computer Science
Rudolph Darken, Department of Computer Science

Zero-sum budgeting, downsizing, and increased mission requirements make it more challenging for U.S. Navy leaders to understand the short and long-term consequences of their decisions. An enterprise model of the Navy could provide decision-makers with a tool to study how their decisions might affect the Navy's ability to conduct worldwide operations. Agent-based simulation technology provides a flexible platform to model the complex relationships between the Navy's many components. Agent-based modeling uses software agents to define each relevant entity of the system. These agents have the ability to interact with their environment and learn or adapt their behaviors while trying to achieve their goals. The aggregate of these interactions results in identifiable behavior patterns known as emergent behaviors. This thesis looks at two methods of designing the underlying architecture for a simple agent-based simulation. A classic predator-prey relationship is modeled using a Windows/C++ implementation and a dynamically extensible Bamboo implementation. While the Windows/C++ implementation is straightforward, it requires definition of all agents before run-time. Bamboo is more challenging to implement, but allows the introduction of agents "on-the-fly," and can easily be extended for distributed implementation. Both appear to be viable implementation architectures for an enterprise model of the Navy.

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

KEYWORDS: Agent-Based Simulation, Autonomous Agents, Bamboo, Emergent Behavior, Adaptive Agents

DESIGN OF A LOAD-BALANCING ARCHITECTURE FOR PARALLEL FIREWALLS

William L. Joyner-Lieutenant, United States Navy
B.S., Virginia Tech, 1989
Master of Science in Computer Science-March 1999
Advisor: Cynthia Irvine, Department of Computer Science
Second Reader: Geoffrey Xie, Department of Computer Science

Because firewalls can become a potential choke point as network speeds and loads increase, the Navy needs a cost-effective means of increasing data rate through firewalls by placing several machines in parallel and balancing the traffic load among them. Current firewall architectures consisting of multiple machines do not balance load among machines and require that each type of traffic be allocated to a machine dedicated to processing specific protocols. This situation creates a performance bottleneck.

This thesis proposes a load-balancing firewall architecture to meet the Navy's needs. It first conducts an architectural analysis of the problem and then presents a high-level system design as a solution. Finally, the thesis provides a detailed system design, targeted for the BSD/OS operating system. The detailed design describes the state transitions, data types and databases, functional interfaces, and threads of execution for a modular layered software architecture.

The result of this thesis is a procedural blueprint for implementation of a firewall architecture, from both software and hardware perspectives, that should mitigate the performance bottleneck. The software architecture is easily verifiable due to its modular, layered design and does not affect either the commercial routers or firewall products; and provides an administrative interface for performance tuning.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Load Balancing, Parallel/Distributed Processing, Firewalls, Routing

PROTOTYPING OF AN ACTIVE AND LIGHTWEIGHT ROUTER

Namik Kaplan-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Naval Academy, 1993
Master of Science in Computer Science-March 1999
Advisor: Geoffrey Xie, Department of Computer Science
Second Reader: Chris Eagle, Department of Computer Science

A new network management system named Server and Agent based Active Management (SAAM) has been proposed. SAAM can locate and fix network problems much more quickly than today's systems. Stand-alone routers are used in current network architectures. In contrast, SAAM employs dedicated servers that collect packet performance information from the routers and use the collected information to predict, detect, and respond to network problems. In other words, SAAM relieves individual routers from most routing and network management tasks. SAAM allows the development of a lightweight router. The primary goal of this thesis is to prototype a lightweight router that is suitable for the SAAM architecture. The Active Networking approach was explored. Active Networking refers to the addition of user-controllable computing capabilities to the network. The result of this thesis is a lightweight router running on a Linux machine. The router is connected to the Active Network Backbone (ABONE) by using a software package called Active NETworks Daemon (ANETD). ABONE is an experimental wide area network, where more in-depth research of SAAM router and server can be conducted. All major active network programming languages and their underlying support were evaluated. Verification of the lightweight router concept was conducted using server-probing experiments. The results demonstrate that it is straightforward for a SAAM server to collect performance information from lightweight routers that support active networking.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Networks, Active Networking, Internet, SAAM, ABONE, ANETD, ANTS, PLAN

AUTOMATED CARTOGRAPHY BY AN AUTONOMOUS MOBILE ROBOT

Mark L. Merrell-Captain, United States Army
B.S., United States Military Academy, 1989
Master of Science in Computer Science-March 1999
Advisor: Yutaka Kanayama, Department of Computer Science
Second Reader: C. Thomas Wu, Department of Computer Science

The major goal of this thesis was to create a map of a room by an autonomous mobile robot using the robot's internal odometry measurements and ultrasonic sensors. Yamabico, an autonomous mobile robot, will be controlled by Model-based Mobile robot Language (MML).

The research for this thesis included the development of an algorithm to use information from the line-fitting capability of MML. It also included research about the inherent errors that are incurred using sonar for precise measurements.

The results of this thesis are that it is possible for a map to be created by an autonomous robot using only ultrasonic sensors. However, the results would be much more accurate if an external source of navigation was used to correct the errors inherent in ultrasonic sensors and the robot's odometry.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Automated Cartography, Autonomous Mobile Robots, Ultrasonic Sensors

AUTOMATING THE AVIATION COMMAND SAFETY ASSESSMENT SURVEY AS AN ENTERPRISE INFORMATION SYSTEM (EIS)

Fred J. Mingo-Commander, United States Navy
B. Phil; Miami University, 1979
Master of Science in Computer Science-March 1999
and
Jonathan S. Held-Lieutenant, United States Navy
B.A., University of Pennsylvania, 1993
Master of Science in Computer Science-June 1999
Advisors: C. Thomas Wu, Department of Computer Science
Anthony Ciavarelli, School of Aviation Safety

The Aviation Command Safety Assessment (ACSA) is a questionnaire survey methodology developed to evaluate a Naval Aviation Command's safety climate, culture, and safety program effectiveness. This survey was a manual process first administered in the fall of 1996. The primary goal of this thesis is to design, develop, and test an Internet-based, prototype model for administering this survey using new technologies that allow automated survey submission and analysis.

The result of this thesis is a web site [http://spitfire.avsafety.nps.navy.mil] that adheres to a three-tier client/server architecture. The back-end SQL server database used to store survey information is accessed via front-end Java applets or Hypertext Markup Language (HTML) forms. Middleware components that complete the connection between client and server include Weblogic's Fastforward JDBC™ driver and Java servlets. The ACSA web site utilitizes many Internet technologies: Active Server Pages (ASP), HTML, Javascript, Active X, Secure Sockets Layer (SSL), CGI scripts, JDBC™, and Java applets and servlets. This thesis leads the reader through the research and development process describing how each of these technologies is used. Thorough review of this material is necessary for lifecycle support and future project revisions. Complete source code can be found in the appendices.

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

KEYWORDS: World Wide Web, Database, JDBC™, Java, Servlets, Active Server Pages, Hypertext Markup Language, Common Gateway Interface, Secure Sockets Layer, Internet Information Server, Windows NT Server, Aviation Command Safety Assessment

EXPLORING THE HUMAN COMPUTER INTERFACE AND PHOTIC DRIVING

Robert B. Peterman-Major, United States Marine Corps
B.S., University of Rhode Island, 1988
Master of Science in Computer Science-March 1999
Advisor: Timothy J. Shimeall, Department of Computer Science
Second Reader: CAPT James R. Powell, Information Warfare Academic Group

The application of a stroboscopic light within a certain frequency range may cause a subject's brain waves to follow or become entrained to the same frequency as the flashing light. This phenomenon is known as photic driving. The objective of this study is to determine if computer monitors can be used as the presentation medium for photic driving, and to investigate whether any measurable cognitive changes can be caused through this photic driving. In

the software design, two Java applets were written which caused the flashing of the screen in both a regular, set frequency and at a random frequency. A web page was developed as a container for a subset of the Kit of Factor-Referenced Cognitive Tests. An empirical study was performed utilizing a light/sound machine, the Java applets as well as the cognitive tests. Twenty-five subjects were divided into three sample groups and their performance during all phases of the study were recorded and analyzed. Analyses of the results indicate that no direct correlation between photic driving and test score can be proved. Subjects' comments following their participation indicate however that there were some significant effects caused by the photic driving that were not reflected in the test scores.

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

KEYWORDS: Human-Computer Interface, Photic Driving, Cognitive Factors, Computer Science

A VIRTUAL COMMANDING OFFICER, INTELLIGENT TUTOR FOR THE UNDERWAY REPLENISHMENT SHIP-HANDLING VIRTUAL ENVIRONMENT SIMULATOR

Karl R. Tenney-Lieutenant, United States Navy
B.S., Norwich University, 1992
Master of Science in Computer Science-March 1999
Advisor: Rudolph P. Darken, Department of Computer Science
Second Reader: Robert McGhee, Department of Computer Science

While developing a Virtual Environment (VE) Ship-handling Simulator for the Surface Warfare Officer School (SWOS) in Newport, RI, researchers at the Naval Air Warfare Center Training Systems Division (NAWCTSD) in Orlando, FL recognized the idea of integrating an Intelligent Tutoring System (ITS) to provide feedback to the student. The system, known as a Virtual Commanding Officer (VCO), would provide instructional feedback to the student to ensure that beneficial training occurs. The VCO would allow a student to conduct valuable training without a human operator present.

The approach taken was to survey cognitive architectures to find a notation to form a specification for feedback generated and delivered from a Commanding Officer to a ship-handler in training during an Underway Replenishment (UNREP). The cognitive architecture called SOAR was selected. A SOAR-like architecture was used to develop a VCO-ITS specification that resembles three Commanding Officer training method profiles. The profiles were then reviewed by qualified Surface Warfare Officers to validate their accuracy.

The result was a specification for a VCO-ITS with validated domain content in the form of three profiles. This specification was provided to NAWCTSD in support of their future efforts in the development of a VE Ship-handling Simulator.

DoD KEY TECHNOLOGY AREAS: Other (Surface Warfare, Computer Simulation)

KEYWORDS: Ship-Handling, Virtual Reality, Intelligent Tutoring Systems, Interactive Learning Environment, Virtual Environment, Surface Warfare, Computer Simulation, Underway Replenishment, Computer Graphics

COMPARISON OF QUATERNION AND EULER ANGLE METHODS FOR JOINT ANGLE ANIMATION OF HUMAN FIGURE MODELS

Umit Y. Usta-Lieutenant Junior Grade, Turkish Navy
B.S., Turkish Navy, 1993
Master of Science in Computer Science-March 1999
Advisors: Robert B. McGhee, Department of Computer Science
Michael J. Zyda, Department of Computer Science

This thesis presents articulated rigid body kinematics models for humans. The main area of research is to investigate models for real-time computer graphics applications in Virtual Environments (VE). Existing models have singularity problems and become too slow once the number of humans in view becomes large.

The approach taken is to develop a full body kinematics model with quaternions. Another common method, Euler angles, has singularity and interpolation problems. Both methods are compared for memory, computation and

user input considerations. The implementation includes joint angle constraints. The model is then manipulated with user inputs by a mouse. As part of this research, the real-time display of human arm tracking with two inertial sensors, human walking, inverse kinematics, and key frame animation is also demonstrated.

The major conclusion of this thesis is that a kinematics model with quaternions can eliminate the singularity problems of existing models. Joint orientation interpolation is also more direct and less convoluted with quaternions. Neither representation exhibits a decisive advantage over the other in terms of computational speed. For memory considerations, the Euler angle method is best. To apply joint constraints, quaternion representations are converted to Euler angles, which causes additional computation for the system.

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

KEYWORDS: Virtual Environment, Articulated Humans, Human Modeling, Kinematics, Sensors, Postural Control

RE-ENGINEERING AND PROTOTYPING A LEGACY SOFTWARE SYSTEM – JANUS VERSION 6.X

Julian R. Williams, Jr.-Major, United States Army
B.S., Hampton University, 1988
Master of Science in Computer Science-March 1999
and
Michael J. Saluto-Captain, United States Army
B.S., United States Military Academy, 1989
Master of Science in Computer Science-June 1999
Advisors: Valdis Berzins, Department of Computer Science
Man-Tak Shing, Department of Computer Science

The U.S. Army is working to develop future generations of constructive combat simulation systems that can take advantage of the wide availability of high-end personnel computers (PC). As part of this research and development process, the U.S. Army looked to re-engineer a verified and validated legacy combat simulation into a version that can operate on a PC using the industry supported and widely used Windows NT operating system. Janus, with its availability, familiarity, and applicability, will serve as that re-engineering test case. The re-engineered version of Janus will maintain its existing functionality, and include additional functionality to support Operations Other Than War (OOTW) and expanded Combat Service Support (CSS). In its final form, the results of this re-engineering project will produce the Warrior Simulation. Warrior will serve as a basis for future simulations.

This thesis describes the re-engineering activities required to reconstruct the Janus architecture from a legacy software simulation system into one possessing an object-oriented architecture that complies with the Department of Defense (DoD) High Level Architecture (HLA) standard.

This research indicates that procedural legacy simulations can be converted into an objected-oriented architecture that complies with the HLA standards.

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

KEYWORDS: Object-Oriented Architecture, Prototyping, Forward Engineering, Reverse Engineering, Combat Simulation, Three-Tier Architecture