DREXEL UNIVERSITY

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MEMORANDUM

To: The Naval Research Laboratory
From: Dustin Ingram
Date: December 3, 2009
Subject: A Multiagent and Service-Based Computing Simulation Testbed Proposal

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Greetings,

Please find attached a proposal submitted to the Naval Research Laboratory by Drexel University for a Multiagent and Service-Based Computing Simulation Testbed.

Regards,

Dustin Ingram
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A Multiagent and Service-Based Computing Simulation Testbed

Dustin Ingram

December 3, 2009

ABSTRACT

Submitted to the Office of Naval Research

Funding is requested to acquire key instrumentation to create a Multiagent and Service-Based Computing Simulation Testbed (MSCST) at Drexel University. The primary purpose of the MSCST will be to support existing Department of Defense (ONR, US Army, and DARPA) sponsored projects in engineering design, wireless networks, telecommunications, software engineering, robotics, scientific computation, and cognitive science. The Drexel MSCST will consist of:

- One high performance computing cluster; and
- Four workstations.

The MSCST will provide exciting capabilities to Drexel University—creating a shared center for high-performance computing, and human-computer interaction. Researchers will use these tools to enhance existing DoD sponsored research by adding capabilities to simulate massive networks up to two orders of magnitude larger than current systems.

The MSCST will greatly enhance the research capabilities in several Department of Defense projects at Drexel and will have a large research impact on Drexel University as a whole. Further, this instrumentation will create significant new research capabilities which will allow for the pursuit of research in service to other DoD programs and research problems. It will be housed in a dedicated facility at the Applied Communications and Information Networking (ACIN) Center. The ACIN Center is operated by Drexel University under a contract with the US Army's Electronics Research, Development and Engineering Center (CERDEC) with the goal of enabling rapid deployment of technologies to the benefit of Warfighters and other First Responders.

Contents

1 Budget

1.1 Hyperform iServ Cluster

Rack mounted cluster with 16 computing nodes, each with two quad-core Intel Xeon processors and 24GB of RAM for a total of 128 processors and 384GB of RAM. One additional node to act as a head and another to act as an InfiniBand storage node with 16TB of drive space. Price includes UPS power source, one InfiniBand switch, a KVM switch, and rack.

Total Cost: $117,449

1.2 Workstations

Four (4) Dell Precision T3400 nSeries 525W Workstations with flat panel LCD monitors for interacting with the cluster. Each workstation has a 4 cores, 8GB of RAM, and 500GB of storage. The workstations will be used to develop, debug, monitor, demonstrate, and visualize simulations performed on the cluster.

Total Cost: $19,046

1.3 Mobile Workstations

Two (2) Dell Precision M6300 mobile workstations, each with 2 cores, 4GB of RAM, and 320GB of storage. Each mobile workstation will also have an LCD, keyboard and mouse such that it can be docked and used as extra workstations for interacting with the cluster. The primary use of the mobile workstations will be for off-site integration visits with our sponsors.

Total Cost: $7,777

1.4 Shipping/Freight

Shipping and freight is estimated.

Total Cost: $700

1.5 Total Actual Cost

Academic prices represent an approximate 4–10% discount to list prices.

Total Actual Cost: $144,972

2 Supporting Information

Funding is requested to acquire key instrumentation to create a Multiagent and Network Simulation Testbed (MSCST) at Drexel University. The primary purpose of the MSCST will be to support existing Department of Defense (ONR, US Army, and DARPA) sponsored projects in engineering design, wireless networks, telecommunications, software engineering, robotics, scientific computation, and cognitive science. The Drexel MSCST will consist of:

In particular, the Drexel MSCST will consist of:

- One high performance computing cluster;
- four desktop workstations; and
- two mobile workstations.

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The MSCST will greatly enhance the research capabilities in several Department of Defense projects at Drexel and will have a large research impact on Drexel University as a whole. Further, this instrumentation will create significant new research capabilities which will allow for the pursuit of research in service to other DoD programs and research problems. It will be housed in a dedicated facility at the Applied Communications and Information Networking (ACIN) Center. The ACIN Center is operated by Drexel University under a contract with the US Army's Electronics Research, Development and Engineering Center (CERDEC) with the goal of enabling rapid deployment of technologies to the benefit of Warfighters and other First Responders. ACIN current customers include the US Army CERDEC, ARL, NRL, AFRL, DARPA, NSA DTO, DISA, NIJ/DoJ, and the DoE/NNSA. ACIN currently has projects supporting two Joint Capability Technology Demonstrations, one Army Technology Objective, and two DARPA offices.

2.1 How Will the Proposed Instrumentation Enhance the Quality of Research and Research-Related Education Currently Funded by DoD?

This proposal will support several major DoD-sponsored projects at Drexel University, each of which involves the modeling and simulation of—and creation of algorithms for—distributed mulatiagent systems running on wireless networks. These projects all fall under the umbrella of the Applied Communications and Information Networking (ACIN) Project[1], on which the PI is a co-PI. ACIN is a collaboration between the Department of Defense, Drexel University and industrial partners. The goal of ACIN is to develop, build and evaluate technologies for the generation-after-next networked battlespace. Project ACIN supports an annual budget on the order of $4M in Drexel University research. The two key activities of this effort related to proposal are in the areas of:

[1] `http://www.acincenter.org/`

- **Ad-hoc wireless networks for mobile telecommunications and battlespace applications**
- **Secure, distributed and survivable multi-agent systems for battlespace applications**

Three ACIN projects would particularly benefit from the proposal's instrumentation; they are introduced in the next paragraphs, followed by a discussion of how they would benefit.

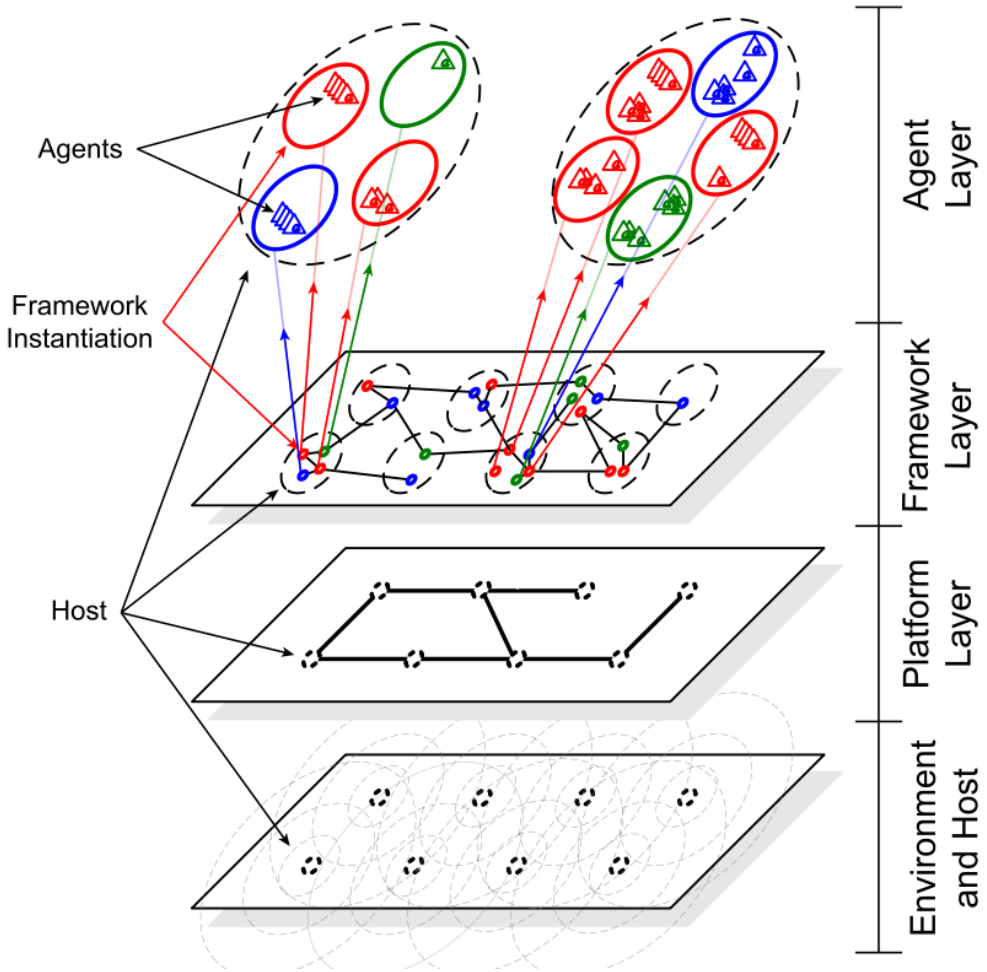
Drexel is in an ongoing collaboration with Joseph Macker of the Naval Research Laboratory in support of group communication to the tactical edge (funded by Cynthia Dion-Schwartz of the OSD). This project is intended to forward intelligent systems running atop tactical networks such that information can be efficiently exchanged between, for example, battleships and air vehicles.

In a similar vain, Drexel is also working in support of the Tactical Service Provider (TSP) Joint Capability Technology Demonstration (JCTD), a project which addresses the issues of "first tactical mile" support to mobile troops. Drexel's specific role is in studying the effects of different hardware types and configurations on network connectivity in varied communications environments.

Drexel is also working on the Tactical Information Technologies for Assured NetOperations (TITAN) program; an Army Technology Objective (ATO) executed out of the US Army CERDEC. The overall goal of this ATO is to demonstrate how emerging information technologies can significantly improve key areas of tactical operations, ultimately resulting in the transition of software developed under the ATO to existing battlefield systems. There are two areas for which Drexel is involved: (1) integration of all the battle command services, and (2) development of the Distributed Battle Command Tracking service (DBCT)/Agent Framework Benchmark.

All three of the projects listed above are similar in that they require analysis and testing of complex systems in tactical environments. While testing such systems in the real world is often possible, it is almost always prohibitively expensive in terms of hardware and manpower. A single eight node mobile ad-hoc network experiment usually requires a dozen people for the better part of a day, resulting in a single data point. Drexel is one of the few institutions—academic or otherwise—that has access to a functioning mobile ad-hoc network testbed, so any data real-world produced will be hard, if not impossible, to be reproduced by a third party. Further complicating experimentation is that data must be collected from—and metrics applied to—each of the layers of a multiagent system, as depicted in Figure 1. Instrumenting live systems to collect the requisite data is far more complex (and error-prone) than performing the equivalent in simulation. What is needed is a testbed in which our models of the real world can be employed to simulate these same experiments in parallel.

The PI and the entire Drexel team at ACIN have extensive experience both instrumenting and simulating live tactical networks. Drexel was one of the first academic institutions to produce a functioning network testbed, called the Secure Wireless Agent Testbed. The testbed has been key in several follow-on programs (including the DARPA ATO/SAPIENT and IXO/SPEYES programs) and was/is part of several major demonstration programs for the United States Army, NATO and the United States Department of Justice. A company,



Layer	Data	Metrics
Agent/Framework	Power Levels, Application Flows, Host Connectivity, *etc.*	Message Overhead, Longevity, Throughput, Coordination Messages, Completion %, System Logs, Application Performance
Platform	Coordination Messages, TCP/IP Messages, Packets, Frames, Re-Transmissions, MANET Behavior, Network Logs, Ethernet Sniffing, *etc.*	Convergence Time, Message Overhead, Coverage %, Latency, Scenario-Based, Completion %, Topology, Frame Counts, Message Sizes, Resilience
Environment	Changes in RF Over Time, Based on Scenarios, Within Physical Structures, *etc.*	Signal Strength at Relays and Coverage Test Points

Figure 1: Data that can be collected from the different layers of a multiagent system.

Drakontas LLP, is successfully commercializing the SWAT technologies in areas of homeland defense, port security and situation awareness for public protectors. Drexel was called upon to employ the SWAT to study mobile tactical networks in an experiment called "SINCE" conducted by US Army CERDEC. The SINCE experiment received the "Best Network-Centric Warfare Program from a Coalition Partner Award" from the Network-Centric Warfare Conference, and also the "International Collaboration Award" from the 25th Army Science Conference in 2006. Despite its success, however, such experiments take months of preparation and hundreds of man-hours of time to produce.

The PI and several others of the ACIN program have been involved in modeling and simulation of such networks. The ACIN team were the recipient of a $1.5M grant to produce the modeling and simulation environment for the COMPOSER ATO of the Warfighter's Information Network-Tactical (WIN-T). This included extensive network simulation on industry-standard systems like OPNET and NS; while these simulators were excellent at modeling the underlying network dynamics, it was very difficult (and computationally expensive) to additionally model the complex agent- and service-based systems that run atop the networks. This led to the creation of our own specialized simulators. Even so, current workstations on which simulations are performed are hard pressed to simulate just networks of more than two hundred nodes, let alone simulation of the complex systems that run atop the networks. It is anticipated that the proposed hardware testbed will be able to simulate systems at least two orders of magnitude larger. The direct impact on the quality of the research in these projects will be to enable a vast increase in Drexel's distributed system modeling and simulation capabilities, thus increasing the statistical significance of our data and reducing the need to perform expensive—and often irreproducible—live experiments.

3 Integration of Proposed Instrumentation with Existing Facilities

The proposed instrumentation requested consists of a high performance computing cluster for modeling and simulation of complex, networked, multiagent and service-based tactical systems. The integration plan is very straightforward.

1. Acquire hardware and furniture, prepare lab space

2. Install and configure hardware, connect to the network, test

The facility can be fully up-and-running within 3 weeks of delivery of the equipment. Once available, it is expected many users will flock to use these devices. The computers equipment will be installed by Drexel personnel. The proposed instrumentation will create a unique simulation facility at Drexel University. Presently, the university does not have this capability.

ACIN has employed over 50 students and 14 faculty across three Colleges, with over an additional 10 research faculty and staff, all of whom are expected to help maintain and employ the proposed instrumentation.

Other Resources: The PIs of the ACIN program have access to expertise and input from numerous industrial and governmental collaborators. This includes: (1) access to individuals that have constructed and use similar systems outside of academia (*e.g.* NRL, US Army CERDEC, and BBN Technologies); (2) access to datasets and datamodels, both from the institutions/companies and their partners/customers; (3) access to informal and formal project input and guidance from industry/military experts; and (4) access to collaborative university-industry research opportunities for the graduate and undergraduate students on the project.

4 Special Information Regarding Installation and Support of the Instrumentation

ACIN and the Camden Waterfront Technology Center will provide new laboratory space to house the proposed instrumentation. In addition, the University will commit financial resources to ensure that the space will meet the system's power and cooling requirements. The ACIN project shall also furnish all requisite furniture for use by the students and scientists employing the facility.

5 Useful Lifespan of the Proposed Instrumentation

The expected lifespan of the acquired instrumentation is between five and ten years. While computing equipment is subject to incredible depreciation due to Moore's Law and economic forces, the cluster is expected to be able to simulate networks on the order of thousands nodes in real time which—given the rate at which interest in network size has increased over the past five years—is foreseen to be sufficient for at least five years of research. It should be noted that the requested funds are to purchase absolutely leading-edge hardware, and, in the probable event that the hardware prices of the specific models described should decline, it is likely that the new state-of-the-art at that point in time will be approximately the same cost.

6 Summary

The MSCST will provide exciting new capabilities to researchers and students throughout Drexel University. The MSCST will create a shared center with current generation tools for high-performance computing for modeling and simulation. Researchers will use these tools to enhance existing DoD sponsored research by adding capabilities to simulate orders of magnitude larger networks and interrogate large software systems.