Student Paper:
Shared Situational Awareness Environment for Tactical Level Humanitarian Emergency Operations

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ABSTRACT

The Naval Postgraduate School (NPS) is exploring key factors that affect how teams, particularly distributed teams, develop shared situational awareness (SSA) in a Complex Humanitarian Emergency (CHE) environment. This research develops the foundation for deploying the following: Network-Centric Human-Agents in CHE habitats, an integrated environment of mobile operators, deployable wireless networks, sensors, collaborative tools, and multiagent systems. We experimentally explored how to integrate a deployable wireless network with peer-to-peer (P2P) collaborative tools and situational awareness agents. This was done to establish shared awareness of the events that were taking place during the CHE operation. The major findings include the following: a better understanding of the critical role of peer-to-peer communication, network performance monitoring, and innovative agent-based architecture for maintaining seamless access to the remote data bases and expert sources.

1. INTRODUCTION

Within the Department of Defense (DoD), shared situational awareness (SSA) is generating a lot of interest as a new paradigm for Command and Control (C2) and developing a common operating picture (COP) at the small unit level. The U.S. Defense Advanced Research Projects Agency (DARPA), Advanced Technology Office (ATO) researches, demonstrates, and develops high payoff projects in maritime, communications, special operations, and information assurance and survivability mission areas. The ultimate goal is to develop superior cost-effective systems that the military can use to respond to new and emerging threats. Currently, ATO is working on a SSA project for small unit operations to provide mobile communication system with high data-rate capacity and optimized for use in restrictive terrain. (1)

The Naval Postgraduate School (NPS) is exploring key factors that affect how teams, particularly distributed teams, develop SSA in an operational environment. In 2002, the Joint Futures Laboratory of the Joint Forces Command (JFCOM) Joint

Experimentation Directorate and NPS conducted the Limited Objective Experiment (LOE) over a period of several months culminating with a role-playing scenario 12-14 March 2002. We defined SSA as the real-time ability to acquire and process a host of different data in a constantly shifting environment, and the ability to translate an assessment into action aimed at maintaining integrity (of self, of dependants, of mission) - knowing what is going on around you and adapting to it. Some of the objectives of the LOE were to explore these key factors in SSA, determine the situational awareness (SA) of the individual team members, the overall generic SA of all teams (together), the SA of the en route Supporting Area Commander , and the JFCOM headquarters in Norfolk, Virginia.

Achieving high levels of battlespace awareness and knowledge lies at the foundation of Joint Vision 2010. Battlespace knowledge is derived from shared battlespace awareness and involves the fusion of information to form a COP. NPS shares this vision with DoD. By continuing to develop what we call the CHE situational awareness tool (SAT) and conducting field experiments, NPS hopes to contribute to the DoD effort of achieving Joint Vision 2010.

2. BACKGROUND AND APPROACH

As far back as 1996, DoD recognized the key role technology could play in the effort to improve communication between International Organizations (IO), Non-Governmental Organizations (NGO) and the military in humanitarian and peace operations. After CHEs such as those in Northern Iraq, Somalia and Haiti, the National Defense University's (NDU) Institute for National Strategic Studies (INSS) Directorate for Advanced Concepts, Technologies, and Information Strategies (ACTIS) attempted to capitalize on lessons learned. As a result of these efforts, several subsequent technological research efforts relevant to the military were developed. These efforts included, but are not limited to, the CIMILink Project, the Virtual Information Center (VIC), the Peace Operations Support Tool (POST), and the Virtual Operations Coordination Center (VOCC). These tools were conceptualized and continue to be developed because the need exists to have a framework within which CHE participants can collaborate, share information and conduct communications.

The underlying issues that spawned the CIMILink project back in 1996 are still relevant today. This is clearly evident in forums such as the Virtual Diplomacy Initiative 2000 (2) and the Symposium on Best Practices in Humanitarian Information Management and Exchange 2002. (3) Although we still wrestle with complex cultural issues and the challenges of coordination, technology has matured to the point that we now have the capability of sharing information and building operational SSA unlike ever before.

The power of SSA was captured during the final phases of our thesis, *Field Level Information Collaboration During Complex Humanitarian Emergencies and Peace Operations,* where a Technical Evaluation was conducted to demonstrate how our proposed solution would facilitate the effective communication and information sharing

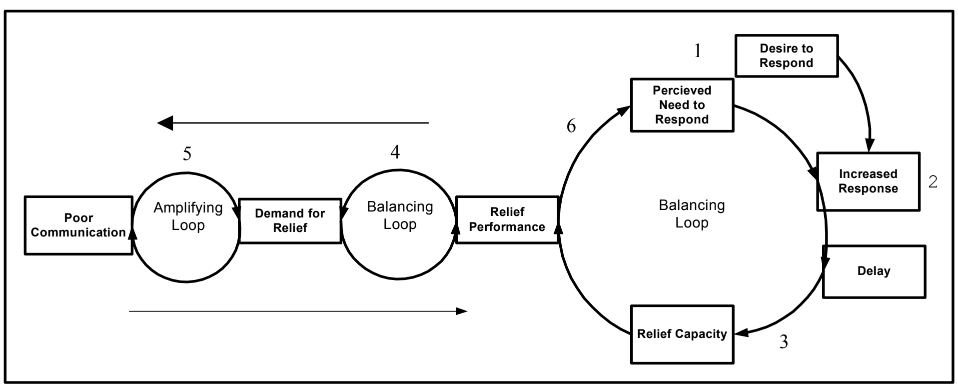

Figure 1. System Archetype

and collaboration between CHE participants.

The archetype model pictured above describes the current state of a relief effort based on the need to respond. Starting at #1, there is a need that arises. This triggers the desire to respond by various organizations. There is no communication or coordination at this point so the response may either exceed or fall short of the actual need. All we know is that by #2 the level of effort has increased from where we started at #1. At #3 there still hasn't been any coordination and this is coupled with any delay it may have taken in responding to the initial need at #1. The situation can be exacerbated at this point if there is a perception the need is not being met and the call will go out again asking for organizations to respond. At #4 we see the level of relief capacity providing a level of relief performance balanced against the current demand for relief support. If the capacity to respond matches the demand in both scale and quality, then performance will be acceptable. The demand, capacity and level of performance all depend on the communication channels available shown at #5.

These communication channels are the critical link and essential to coordinating the *need* with the *response*, the *demand* to the *capacity* and ensuring an acceptable level of performance. The quality of this communication will determine how well the needy are helped and how efficient and timely an organization's response will be. Currently, the communication process in a CHE is not sufficient to always meet an acceptable level of performance and results in inefficiencies and unfulfilled needs. By the time we get back to #6 no one has a clear understanding of what has been met and what hasn't. This can result in redundant efforts or worse yet a need that receives no response at all.(4)

In light of the information presented above, there needs to be a change in the mindset of the organizations involved in CHEs. The interaction between the CHE participants is unstable at best and needs to be improved. A recommended solution that could assist in the humanitarian assistance realm is an open system model diagramming the preferred environment. This model will be helpful in understanding the environment and may encourage all the organizations involved to initiate an internal change to work together in a synergistic fashion. In addition, we believe that, with the use of technology, the creation of a habitat would aid in restoring trust and confidence among the CHE participants, and encourage communication between every organization involved.

A habitat is a dynamic virtual construct that allows a set of collaborating components to come together and form a team to solve a specific problem. The habitat resides within the global information grid (GIG), using smart information exchange infrastructure technologies, to facilitate the intelligent tailoring and dissemination of knowledge. Simply networking components together does not create a habitat. Components must be able to share resources (information, services, etc.) in a way that optimizes their ability to carry out their assigned tasks effectively within constraints imposed by security or policy. A habitat is dynamically created to support a specific operational mission. It interfaces with other habitats as well as all other “legacy” systems, assets, organizations, or individuals (equipped with a compatible interface or “wrapper”).

2. COMLEX HUMANTARIAN EMERGENCY HABITAT COMPONENTS

The first component to fulfill the construct requirements of the Tactical Humanitarian Relief Operations habitat is a collaborative tool called “Groove.” A Groove Workspace is a virtual space for small group interaction. In a Groove Workspace, users make immediate and direct connections to perform a wide variety of activities – from working on a project, brainstorming, planning an event, discussing issues, sharing drafts and proposals, coordinating schedules, to just getting stuff done. This is all done using a networking technique called peer to peer (P2P). The essence of P2P is establishing a direct connection between people, so IT isn't necessarily involved. There are tools in the Groove Workspace that facilitate the sharing of content (files, images, maps), conversations on that content (discussions, instant messages, live voice, text-based chat), and working together on shared activities (real-time co-editing and co-viewing of documents, co-browsing, group project management and tracking, meetings management). By bringing these tools together in a single construct, the Groove Workspace streamlines work and communication so that teams can speed up their decision-making and cycle time.

Groove Workspace’s awareness capabilities promote serendipitous as well as planned collaboration. Each shared space shows the online status of all members, so that when two or more members ‘find’ themselves in the same shared space at the same time, they are able to quickly take advantage of the situation and work together in real time. Likewise, a single user can glance at a single view of all shared spaces to see if there are any ‘active’ members. The ability to know who is currently and actively working on certain projects is a new and powerful catalyst for enhanced productivity.(5)

While using Groove as the habitat’s construct program, the next components of the Tactical Humanitarian Relief Operations habitat are two web-based applications called the “Relief Operation Coordination Center” (ROCC) and "Virtual Civil Military Operation Center" (VCMOC).” The ROCC and VCMOC are technological tools that use central HTML and Active Server Pages (ASP) to interface with a database to insert, edit, view, delete and manipulate information to enhance multi-participant communications and the sharing of data. The application will improve the overall dissemination of vital information leading to a breakdown in communication barriers and a focus on mission success.

The ROCC and VCMOC are designed to promote and support better information transparency and exchange to reduce operational security risks and avoid duplication of efforts. Both applications have the capability of keeping information on organizations' activities, plans, and resources available and up to date. The ROCC and VCMOC can provide the location for field assessments and databases to assist planners, pre-deployment actors, implementers, and post-crisis analysts. Furthermore as a web-based application, it is mobile and accessible with internet connectivity. The main reason that the ROCC and VCMOC are embedded in Groove is to enhance the ability of geographically distributed users' to plan, organize, and team up for problem solving.

3. CHESAT AGENT-BASED ARCHITECTURE

In response to an interest in exploring SSA, a web agent based application titled "Complex Humanitarian Emergency (CHE) Situational Awareness Tool (SAT)" was created at NPS to study SSA in the field environment. The purpose of the CHESAT is to give CHE participants the capability of having SSA of each other's location and common knowledge of events in their area of work. The tool is designed to use either the Microsoft Internet Explorer or Netscape Navigator browser as the graphical user interface (GUI). The user of the CHESAT determines which browser they will use to interface with the CHESAT.

Flash application is the technology that is used to bring pictures and icons into the web browser in the CHESAT. Additionally, flash is used to develop interactive animated graphics for the SA Management Agent to display. This application is bandwidth-friendly and has browser-independent vector-graphic technology. Flash requires Microsoft Windows as the operating system and the flash plug-in has to be downloaded if a CHE participant doesn't have it as a standard feature with their web browser. Within the

CHESAT, Flash takes the input/output of the agents through the sockets to work to support the display functionality provided by the SA Management Agent.

The CHESAT exists in two different spaces at the same time. The web server (client/server) is the first space that we will discuss. The client/server software architecture was chosen for one of the spaces for the CHESAT, because it is a versatile, message-based and modular infrastructure that is intended to improve usability, flexibility, interoperability, and scalability in information technology networks. A client is defined as a requester of services and a server is defined as the provider of services. A single machine can be both a client and a server depending on the software configuration. Another major advantage of making this tool a web based application is that clients do not have to download any software to use. So we get the best of both worlds by taking advantage of the benefits of client/server architecture while not requiring clients to download the CHESAT as an application. As long as the CHE participant can access the network where the CHESAT server resides, they will have access and use of the CHESAT.

Control of Agent-Based Systems (CoABS) grid is the second space that the CHESAT resides. (CoABS) is a program of DARPA to develop and demonstrate techniques to safely control, coordinate, and manage large systems of autonomous software agents. The CoABS Grid is middleware that integrates heterogeneous agent-based systems, object-based applications, and legacy systems. It includes a method-based application programming interface to register agents, advertise their capabilities, discover agents based on their capabilities, and send messages between agents. The grid is only one part of the overall CoABS program; the grid is the plumbing that connects the components of legacy systems to solve real world problems. Therefore, one can also think of the grid as this infrastructure layer that has all of the agents and services running on it. (1)

The CHESAT consists of several software agents that perform a number of functions. All of the agents reside on the CHESAT web server. The first agent is called the Tracking Agent. This agent provides position-location information to the SA Management Agent for display in the browser. The data that the Tracking Agent collects come from one of two input sources. The first source is simply manual inputs from the user. This is done by the user and is accomplished by clicking and dragging a user icon to a location on the display. The icon is then dynamically displayed to everyone accessing the CHESAT.

The second input source is from a GPS receiver. This is accomplished by enabling a software agent that takes the GPS receiver input and transmits it to the SA Management Agent in the CHESAT, which subsequently moves the user icon to the correct location on the display. This method is much more accurate and requires no user input to adjust position information. This method of input is obviously hindered when a CHE participant is obstructed from GPS input (e.g. inside a building) or does not have a GPS receiver. In this situation, the user can easily switch to manual inputs by clicking the appropriate button on the CHESAT display.

The SA Management Agent is the second agent in the CHESAT. This agent provides the visual interface display for all CHE participants through their web browser. This agent supports the SSA of all the users. The SA Management Agent uses input from the Flash and the Tracking Agent to display the location of CHE participants and significant events. The power of SSA is captured with this agent. Users have the ability to gain access to a wealth of information through the display of the CHESAT through this SA Management Agent. For example, one can view the capabilities of other users (e.g. identify what communications capabilities other users have), post an alert for other users to view, or view events posted by other users. This awareness allows for a user to make informed decisions on how to assist in a particular event or provides the necessary information to coordinate assistance.

The CoABS Grid Agent is the third agent in the CHESAT. This agent performs the liaison role between the CHESAT and the CoABS grid. The CoABS Grid Agent makes bridges to different systems, because of its ability to wrap legacy systems and interfaces to other components (or agents) and legacy systems. This allows the CHESAT to use data from any database that is apart of the grid. This approach was taken to overcome the challenges of stove-piped legacy systems.

The Text Messaging Agent is an additional agent in the CHESAT. This agent allows users to communicate simple text messages to other users participating in the

CHESAT. Simply typing a message in the appropriate screen and then clicking a dragging the messaging icon over the desired recipient enables this agent functionality. The recipient of the message is notified with an audio message and a visual pop up message.

The Agent Database is the final agent in the CHE SA tool. This agent is the manager of the database repository for all the events that occur in the CHE SA tool. For example, when a CHE participant wants to use the CHESAT they will have to log-in to the tool via their web browser. This log-in event along with all the actions of the CHE participant in the CHESAT are captured and stored by the Agent Database in a database.

4. EXPERIMENTAL STUIDES

The first experimental scenario was executed on an ad-hoc wireless local area network (WLAN) that was setup at Marine Corps Base Hawaii (MCBH). The purpose of this scenario was to demonstrate the ability of a CHE participant to effectively conduct humanitarian relief efforts within the Tactical Humanitarian Relief Habitat. The scenario consisted of three CHE participants in the habitat representing the following organizations: military civil affairs, NGO and IO. Two of the CHE participants had a laptop computer and one had a PDA configured to function on an ad-hoc WLAN. Furthermore, the PDA user had a GPS receiver.

4.1 Developing SSA Through Peer-to-Peer Collaborative Applications

The CHE participants worked in remote area of MCBH which contained a few buildings and basic services such as running water, restrooms, electricity, and two telephones. This was done to simulate a CHE working environment. However, it was noted that some CHE environments during the early phase of execution lack most of the basic services listed in the previous sentence. The only reach-back capability that the CHE participants had were cellular phones and the two telephone lines that could be used to make long distance calls and establish internet connectivity at rates varying between 28Kbps and 45Kbps.

Prior to the start of the scenario, a few basic assumptions were established. First, the NGO and IO representative had already conducted the required coordination for approval to join the Tactical Humanitarian Relief Habitat. This would be accomplished via telephone calls and emails based off the information provided on the log-in page of the VCMOC. Previous CHE after action reports have pointed out the importance of the need for preplanning when it comes to NGO and IO who want to provide assistance during a CHE. When these organizations arrive in country without participating in any planning conferences for the CHE, there is normally a great disparage in the logistic coordination of matching up the critical needs at a particular time with the proper resources. The VCMOC registration process was designed specifically to deal with this issue.

The second assumption is that all the members of the habitat would have received the training and software needed to be productive members of the habitat. The components of the habitat were designed for non-technical computer users. Two to three hours of training would have to be conducted to give a new member of habitat a good understanding of all the functionality that is resident within the CHESAT, VCMOC and Groove. The only software license that would have to be given to new habitat users is Groove. The CHESAT GPS poster was developed at NPS and does not require a license to distribute to habitat members who desire to use GPS receivers for positional reporting.

Most of the executed tasks were based on the premise of the habitat being a virtual environment in which the members of the habitat could collaborate and coordinate with each other without the direct control of a centralize authority. During scenario A, the members of the habitat were able to use all the functionality of the CHESAT, Groove, and the VCMOC. Face to face meetings at the CMOC (physical operation center) were done primarily for final coordination of issues that were discussed in the VCMOC. As requirements were posted in the VCMOC, the members of the habitat had the freedom to either fulfill or not fulfill the requirement.

All of the habitat members were impressed with the combined capabilities of technology tools that existed in the habitat. The ability to share files, conduct Microsoft PowerPoint briefs, and use voice over IP while browsing internet web pages with the use of Groove was a combat multiplier in the humanitarian sense. The CHESAT ability to show the location of the members of the habitat based off a manual or GPS input is tremendous. Figure 2 is a screen shot of a program that uses CoABS wrappers and software agents to take positional information and post it to the ROCC viewer web display. The red and blue people icons represent actual CHE participants. This displaying of this type of information enhances the shared situational awareness of the members of the habitat.

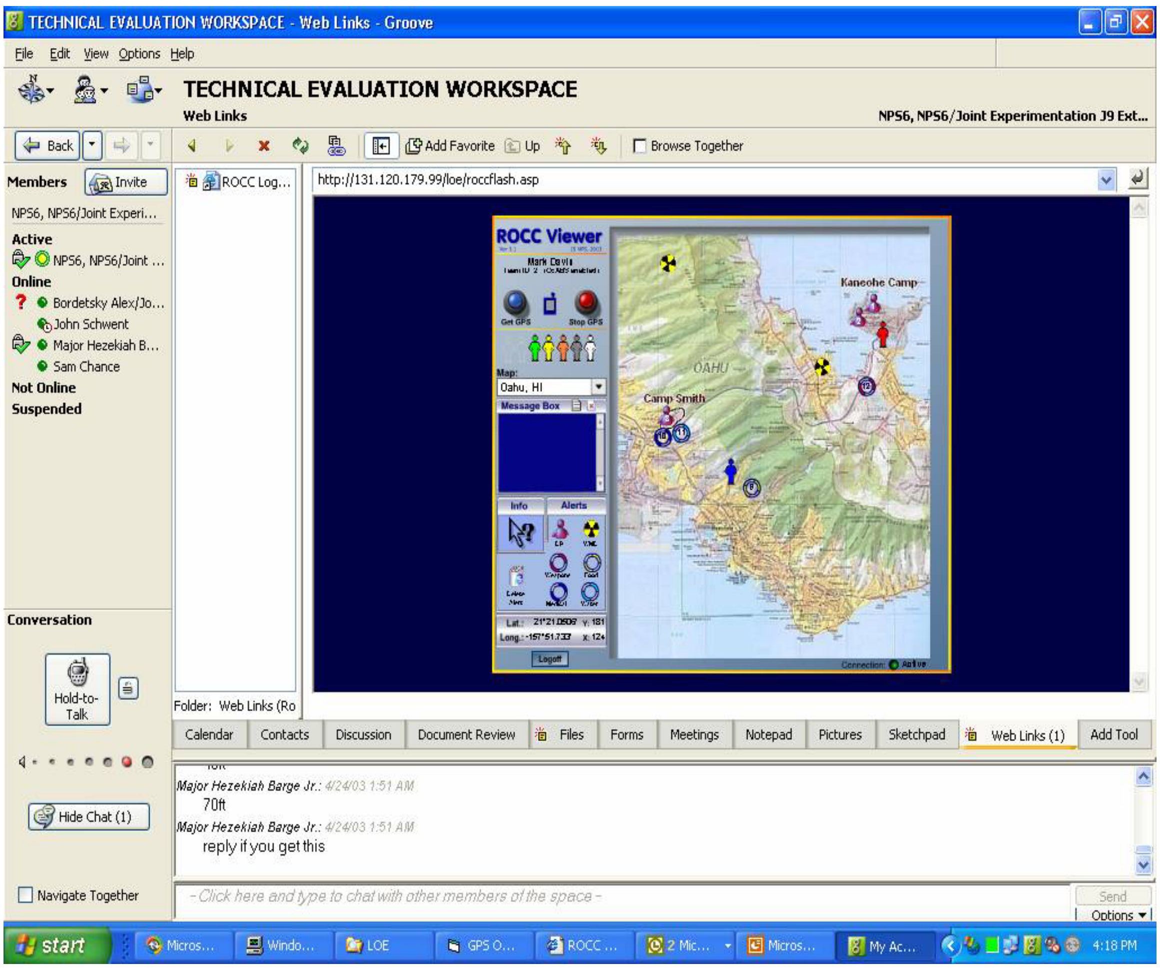

Figure 2. CHESAT display within Groove.

The next screen shot in figure 3 is a visual depiction of the CHESAT in the Internet Explorer web browser. Additionally, the red line between the people icons (red and blue) shows that members of the habitat are communicating with each other through the use of the text messaging functionality embedded within the tool.

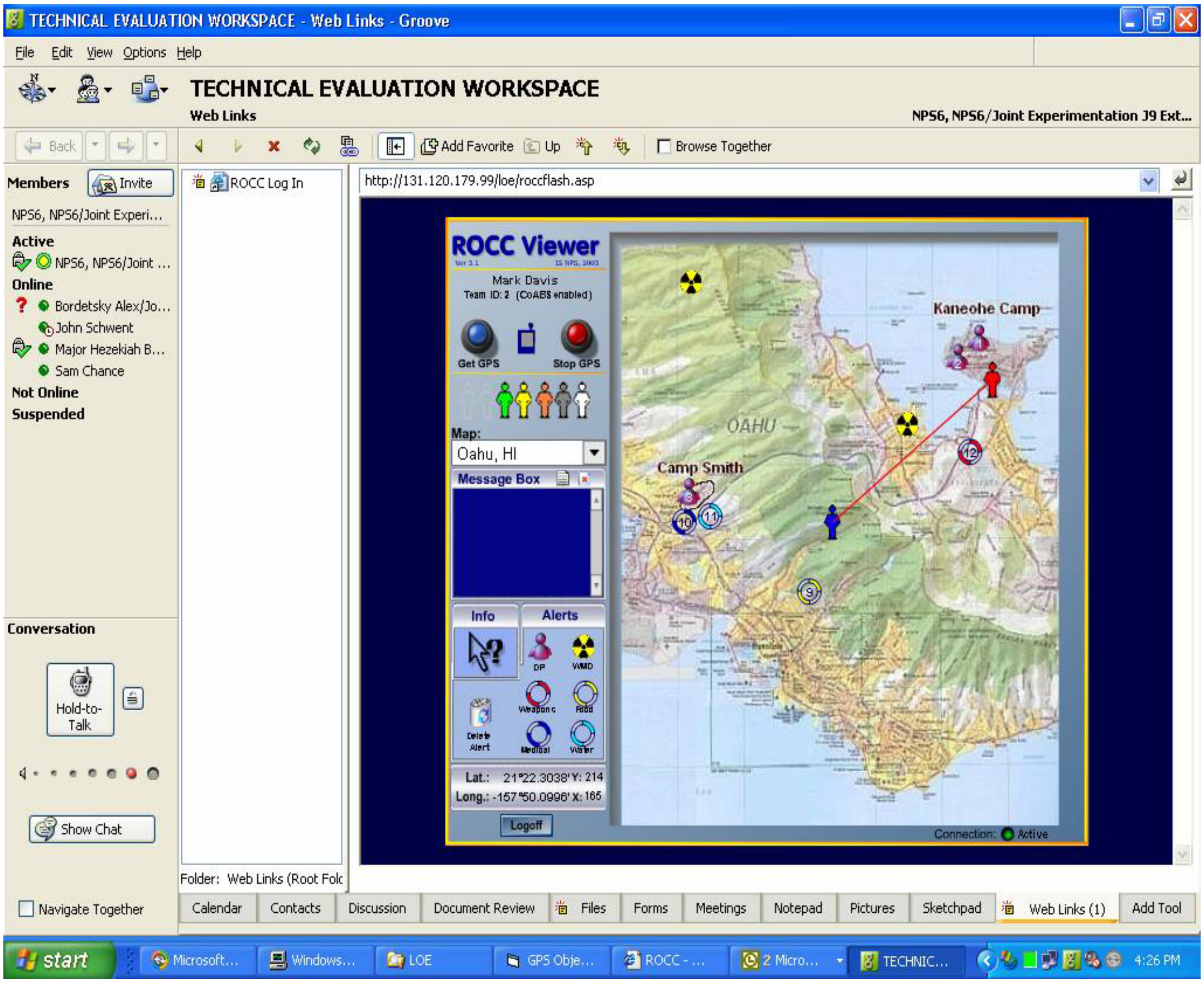

Figure 3. CHESAT display with message line.

The next screen shot in figure 4 shows what happens when you place the informational arrow on an alert icon. These icons are posted by members of the habitat. There are six alert icons for the following the categories: displaced person, food, medical, water, weapons dump, weapons of mass destruction, and other.

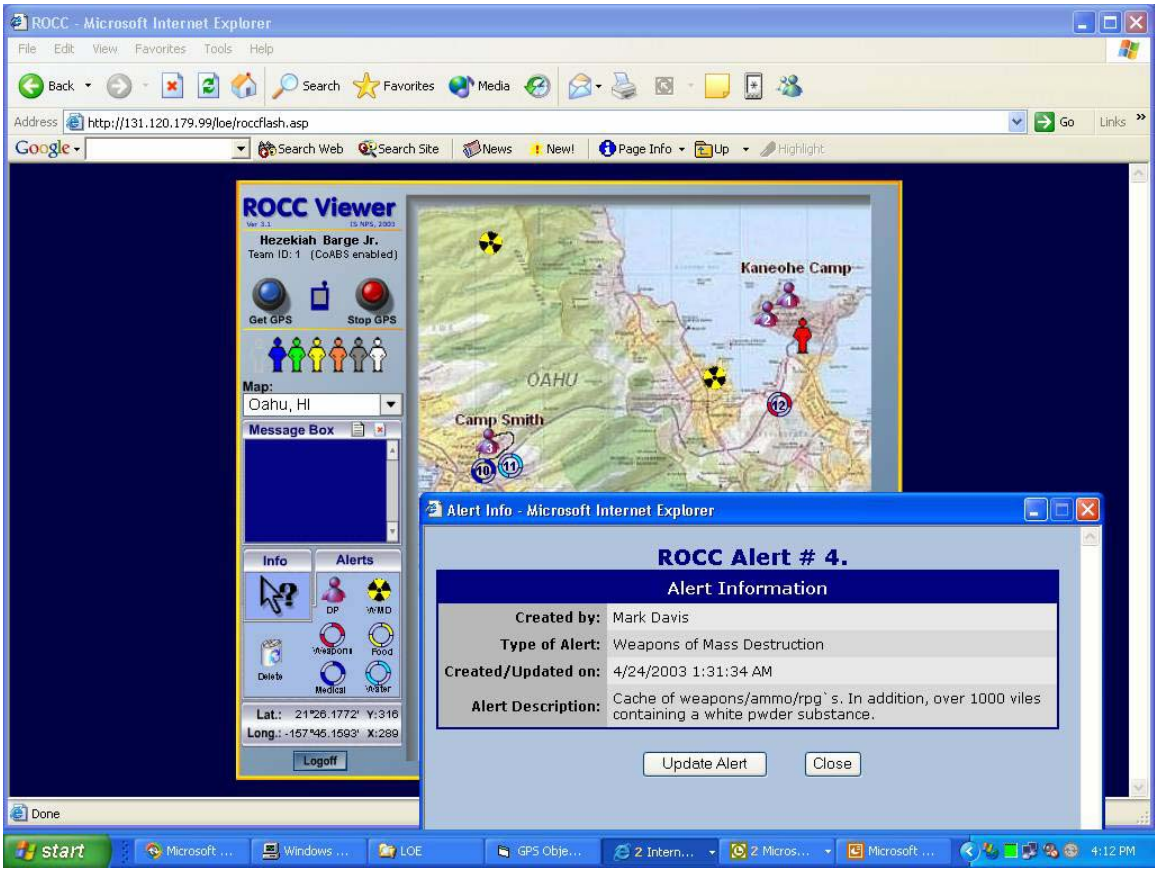

Figure 4. Alert Information on posted icon

The next screen shot in figure 5 shows what happens when you place the informational arrow on a person icon. Each member of the habitat has a biographical profile. This information is provided to allow the members of the habitat to contact each other based off the communication devices that the habitat member possesses. For example, the profile displayed in figure 6.6 states that ROCC Team 1 has the capability to conduct video teleconferencing conduct Groove sessions, and have their position posted by a GPS receiver.

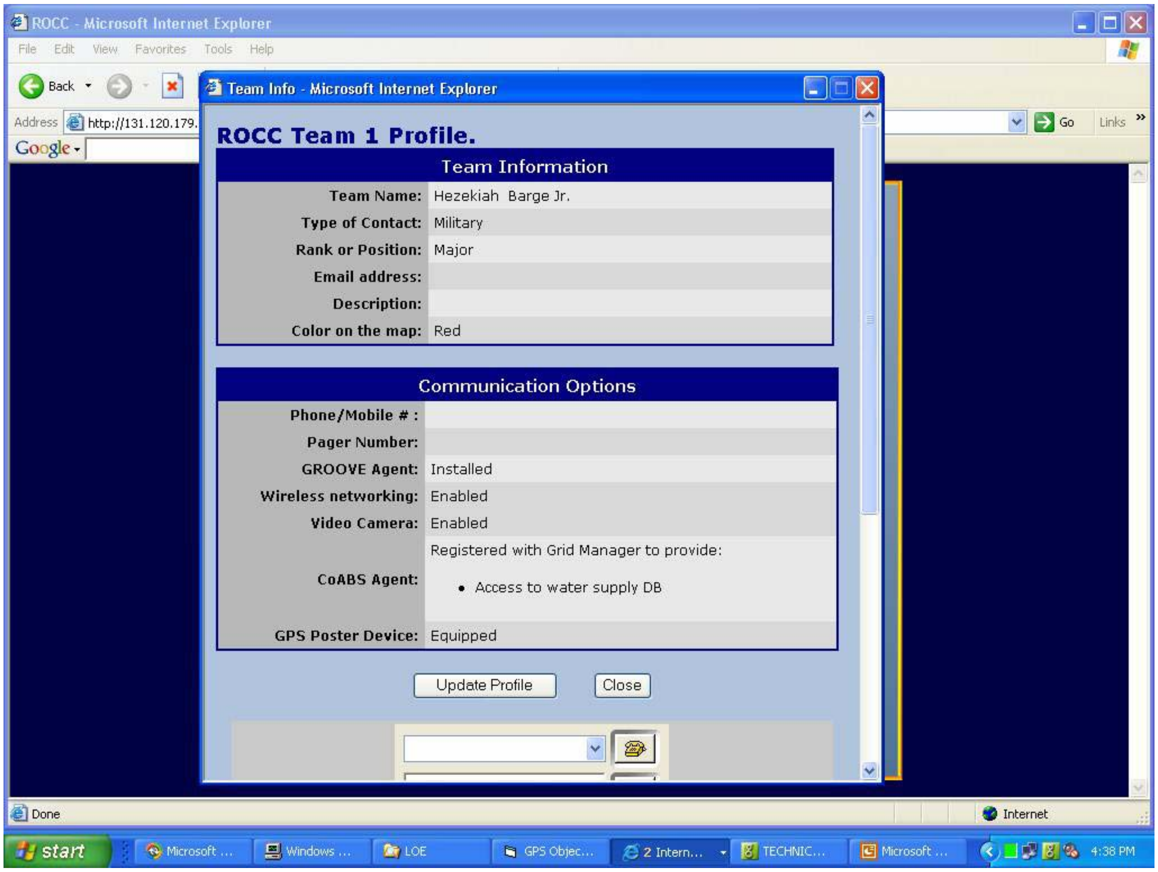

Figure 5. Habitat member profile

As friendly fire incidents continue to plague coalition forces in Iraq during Operation Iraq Freedom as in it did in Afghanistan and previous CHE events, this tool greatly enhanced the SSA of the physical location of all the members of the habitat. No one wants a repeat of what happened during Operation Enduring Freedom in Afghanistan when a Red Cross warehouse was mistaken as a Taliban arms warehouse and bombed by coalition forces. The dynamic database of the VCMOC was a great aid to the members of the habitat when it came to tracking displaced persons and maintaining the most current information on meetings, requirements, and points of contact.

Our integrated solution of peer-to-peer collaborative tools and SA agents provided almost 100% of SA sharing. However, our observations of human performance during the experiment, indicate, that taking full benefit of 100% SSA environment would require well structured distribution of roles among the CHE habitat members when operating this integrated suite of tools.

4.2 Integrating Network Awareness

The second scenario was executed on the ad-hoc WLAN used by the members of the Tactical Humanitarian Relief Habitat. The purpose of the scenario was to demonstrate the ability of the habitat network manager to effectively administer the network.

The transmission speeds for sending data varied between 2-11Mbps depending on the distance and obstructions (buildings, vehicles, etc..) between the nodes. The average travel time between when a text or voice message was sent and received using Groove was 4 seconds. On the other hand, the average travel time between when a text or voice message was sent and received using the CHESAT was 2 seconds. When sharing files in Groove, the average time for a 25K file that was posted in a Groove workspace to be synchronized in the workspace of the other members of the habitat was 90 seconds (Fig. 6).

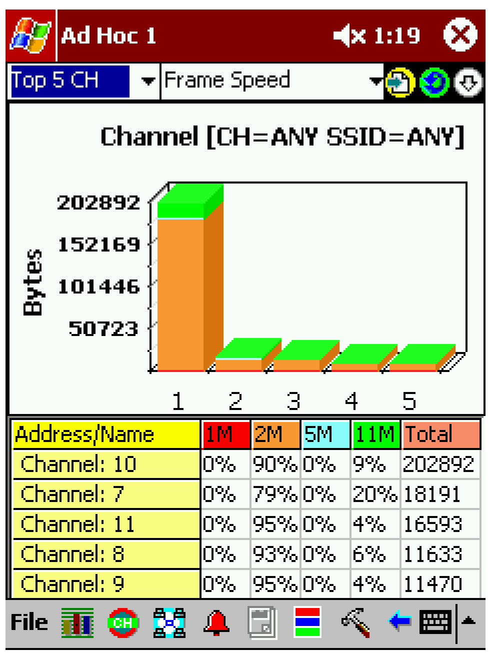

Figure 6. Chart of Frame Speed by Channel

Air Magnet was used as the network management tool through the use of a PDA. While the members of the habitat were executing the collaborative application tasks Air Magnet was used to monitor the network performance. Over the monitoring period of approximately two hours, AirMagnet collected data in a real-time manner (Fig. 7). Using a program called “Pocket Screen Capture” we were able to capture “screen shots” of the discovery, performance, and security events. The greatest indicator of network flow was the analysis of the network transmission rate.

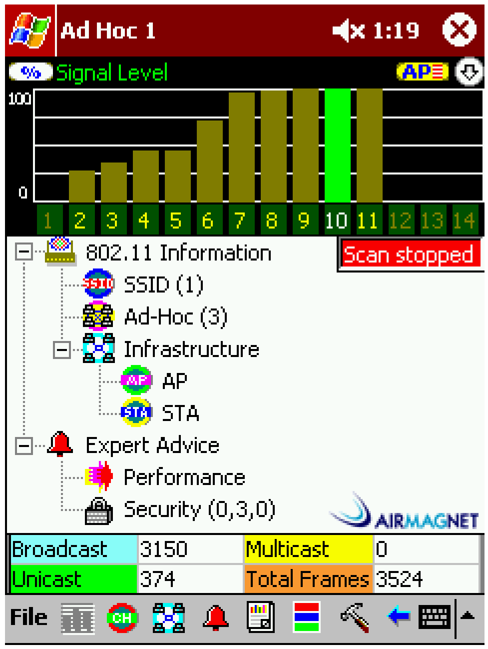

Figure 7. Live Capture Discovery Function

In order to communicate this vital network performance information with the CHE unit members in a timely manner we had to split the roles in managing the habitat software environment and designated one person for handling the network management feedback.

5. CONCLUSION

Overall, all of the experiment participants agreed that the Tactical Humanitarian Relief Habitat is an impressive approach to solving the traditional problem of bringing CHE participants together in a self-organizing environment to work effectively in providing aid to those in need. Despite not having internet reach-back connectivity, the habitat members who were in charge of camp management functions were able perform their jobs as camp managers. All the other role players were able to self organize and collaborate with each other on a WLAN without access points even when the wide area satellite link went down. This was all made possible through the use of the P2P applications such as Groove and the CHESAT and timely awareness on network performance. This result validates the concepts of P2P communication survivability and the ability to have shared awareness in an austere environment.

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