Ubiquitous Computing: Omnipresent Technology in Support of Network Centric Warfare

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Abstract

The U.S. military is in the midst of a transformation. While business leaders moved quickly to put computing power in the hands of individuals, the military establishment has been less responsive. Network Centric Warfare is a current U.S. Navy initiative to leverage the power of the computer to restructure forces from the bottom up. Instead of a strict hierarchy where decisions are pushed down, networked warfighters will cooperatively pursue the strategic goals of the commander in a much more decentralized fashion. Essential to the idea of Network Centric Warfare is the proliferation of ever-present information systems, or Ubiquitous Computing capabilities, where the computer (or rather, the networked computing capability) is no longer the focus of human attention, but rather, becomes invisible. This paper summarizes the introduction of CommandNet, a group support system, into a large-scale wargaming environment to create networks of concerted actors and develop ubiquitous computing relationships.

1. Introduction

The University of Arizona's Center for the Management of Information (CMI) has been working on board United States Navy ships for the last four years to understand the collaborative requirements of the warfighters and make information technology recommendations to improve interaction effectiveness. To better understand the environment, CMI researchers worked with the U.S. Navy's Commander Third Fleet (COMTHIRDFLT) staff members extensively. CMI researchers went aboard the Third Fleet command ship, the USS Coronado, while it was underway and fleshed out requirements to develop a distributed collaborative logging tool to support the staff's situation awareness. CMI has used decision theories [1, 2, 5, 10, 11] and an action research approach [4] to guide the research team in engineering and implementing technologies to collect, analyze, and distribute critical information throughout the fleet.

Previously, distributed asynchronous collaboration within the fleet staff required a combination of phone calls, face-to-face meetings and electronic message traffic. The complexity and inefficiency of this arrangement severely limited the organization's ability to maintain common situation awareness (SA). To update the operational picture, the leader (commander) personally communicated with numerous staff and support personnel located throughout the ship and other ships in the battle group(s). There was no central repository for operational information. These inefficiencies caused the staff to spend an inordinate amount of time updating the commander rather than planning for future operations and contingencies.

This paper outlines the introduction of a Group Support System (GSS) named CommandNet into an extensive wargame held at the U.S. Naval War College. CommandNet is a simple, yet effective tool for sharing situation awareness throughout a force. This shared SA is a key to ensuring coordinated and concerted effort in today's highly dynamic and lethal battlefields.

2. Network Centric Warfare

The U.S. military is often accused of preparing to fight the last war. Nevertheless, there is a significant and ongoing effort to identify emerging threats, and the technologies and force structure that can best address future military

contenders. The current blueprint for defense thinking is called Joint Vision 2010. One of the key components of this new strategy is the leveraging of technology to achieve Information Superiority [15].

The business world has been transformed by the move from the monolithic mainframe computer to networked workstations that distribute processing power to throughout the organization. This very basic change in the way that businesses have evolved has not escaped the military establishment. Network Centric Warfare (NCW) is predicated on the idea that networking systems and people throughout the military force can provide real benefits in effective and efficient engagement of the enemy.

Specifically, NCW promotes the idea of viewing the weapons systems and warfighters as members of a dynamic network of (1) sensors that find potential targets, (2) command and control that positions and manages forces, and (3) shooters, or weapons systems, that actually engage targets [7].

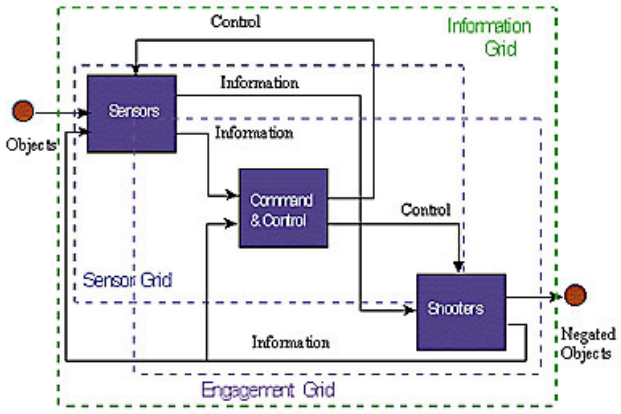

Figure 1 – Network Centric Warfare Grids [7]

By configuring forces in a dynamic network that is arranged from the bottom up, the military hopes to decentralize operations. It is believed that this move will then allow faster and more effective engagement of targets as the traditional bottlenecks of command and control are avoided.

As such, NCW is dependent to a large degree upon the underlying information systems. The goal is to facilitate concerted action throughout the battlespace. Networks and information technologies need to be pervasive in such an environment. They must be carefully designed to meet the operational requirements of NCW, while not usurping the role of the military professional. NCW is an initiative that is focused on providing ever-present information systems that aid warfighters in decentralizing decision-making and action in an effort to multiply the effectiveness of a given force.

3. Collaboration in a Network Centric Operating Environment

With the increasing emphasis on the utilization of a shared knowledge base and consequentially shared situation awareness for the conduct of military or business operations, applications such as CommandNet are proving to be one of the key enabling technologies.

Five tenets characterize Network Centric operations. CommandNet plays a role in fulfilling several of these.

Tenet 1. Knowledge of the competition, or in the case of the military, the adversary.

CommandNet enables the team to systematically develop and concurrently distribute the corporate knowledge base as each team member logs their current activities, actions and observations. In a military environment, which was the original domain for CommandNet, this logging function is a natural part of normal operations. Network centric operations and the implementation of CommandNet elevated the shared nature of these logs, moving them from paper-based notes that could only be read at particular places on the ship, to networked logs that could be read and annotated by any authorized person from any workstation on the network. As business and the military in particular move toward increasing levels of network centricity, these shared assessments can be used by commanders and team leaders to develop a substantially greater understanding of the adversary or competition. Subsequently, as team members develop information from networked documentation, the Internet, intelligence collection, sensors and their subsequent correlation and analysis, this shared knowledge is available to all team members to incorporate into their planning.

Tenet 2. Near real time shared situation awareness.

As with the first tenet of network centric operations, having all authorized team members aware of the overall situation has proven qualitatively and quantitatively beneficial to both the planning and the execution of operations. Now, as additional information is developed, or as changes in the situation occur, team members can adapt their plans and operations to accommodate the changes.

Tenet 3. Communications of the corporate or commander's intent.

Closely related to the enhanced shared situation awareness, is the ability of the commander or corporate leader to clearly and effectively communicate high level intent to subordinates and team members. Delegation is a critical component of successful military and business organizations and operations. Since plans seldom get executed as expected; information used to create those plans is invariably imperfect; and changes occur dynamically; it's imperative that team members understand the commander's or the manager's overall intent for an operation or a corporate strategy.

Then, as the changes occur, as new information about opponents and competition develops, and even as those opponents adapt, subordinates and team members can change tactics and approaches to fulfill the plan without having to rely on micro-management by supervisors and commanders. Furthermore, commanders have sufficient confidence in team members to fulfill the intent as they have maintained an ongoing dialogue about that intent to the extent necessary to ensure understanding. This leads to the fourth tenet of network centric operations.

Tenet 4. Decentralized execution of plans.

In warfare, as in business, operations rely on good plans, well understood goals, and the capability to effectively and rapidly respond to changes. Decentralization of execution becomes possible when the commander's intent is clearly in mind, sound and current situation awareness among all team members exists, effective delegation is enacted, and the commander has confidence in the ability of team members to fulfill the goals.

Decentralization permits subordinates to rapidly adapt plans and respond effectively to the inevitable changes. This capability enables the team to make and enact decisions faster than the opponent who has not adopted or implemented network centric operations.

Tenet 5. Enabling self-synchronization.

The last of the tenets is the most difficult to affect, but in conjunction with the other four provides a substantial benefit even with less than perfect implementation. Self-synchronization is the coordination of activities to the lowest organizational levels, even to individuals. It is enabled by shared situation awareness, a common understanding of the commander's intent, and decentralized execution of plans.

Self-synchronization enables individuals at the lowest independent operating levels to not only execute their plans, but also coordinate that execution with that of other subordinate commanders or team leaders. Even when imperfectly executed, self-synchronization can enable rapid situation assessment and decision processes, affecting an operational tempo that is faster and ultimately more effective than the opponent's.

4. Ubiquitous Computing Environment

Much of what enables network centric operations is a part of what Weiser termed ubiquitous computing in which humans continuously interact with hundreds, thousands, or millions of wired and wirelessly networked computers [17]. These include static devices, mobile devices, robotic devices, sensors of all kinds, large computers, small wearable devices, special and general-purpose devices, and the tools to interact with this enabled environment. However, the computer is no longer the focus of human attention, but rather, becomes invisible or transparent to the user. The problem shifts from graphical user interface (GUI) issues to one of creating a new kind of relationship between people and computers, one in which the computer would have to take the lead in becoming vastly better at getting out of the way, allowing people to just go about their lives [17].

For network centric operations to succeed, especially in military environments, the commander and subordinates who are executing decentralized, synchronous operations must maintain effectively constant communications. However, it's unacceptable for the computer to remain the point of focus as it is in today's computing environment. The task, the information, and the interactions with other team members must be the focus. The computers must get out of the way.

Beyond communications requirements, computers must be context aware. This awareness must govern not only their modes of interaction with humans and other computers, but also the content of those interactions. Furthermore, the computer must adapt, must learn what is important for each individual given the variables of current task, background tasks, context, responsibility, geographic position, alertness, other humans, and attention. This awareness will enable the computing enabled environment to know who to alert to what situations and changes; to know what is important, and what is not.

Collaboration in a ubiquitous computing environment moves beyond text-based records exchanged with other humans. Such approaches require each person to enter the records, read what others have written, and assess the importance of those words; or to talk on a radio or telephone with others when the computers break or are abandoned. In a ubiquitous computing environment collaboration is with thousands or millions of sensors, other important humans, and the vast repository of information necessary for the task. Context aware, automated agents are constantly searching and watching for new information or changes that affect the tasks or missions.

The employment of sensors, whether they are to monitor human physiology, the environment, enemy forces, traffic, weather, or anything else, requires that the information from those sensors be perceptible and actionable by human decision makers. Ubiquitous computing principles include the correlation and communication of information from countless sensors; and the interactive capability to enable humans to control those sensors where necessary.

Even with countless sensors, networked subordinates, and vast networked data sources, situation awareness is invariably going to be imperfect. There will undoubtedly be missing and incorrect information. A critical aspect of ubiquitous computing is the ability of the decision makers to intuitively as well as consciously be aware of what they do not know. The degree to which they do not understand a situation's component uncertainty imprecisely determines the risk associated with any course of action. The commander's assurance in his or her subordinate's capabilities, and his or her confidence in their understanding of his or her intent, in large measure determines the extent of missing information the commander or manager can tolerate in any given situation.

There have been some important but limited steps toward ubiquitous computing made in some companies. Smart rooms and wireless mobile access are key elements of ubiquitous computing. But even with these, the attention, or focus, remains on the computer. The military has conducted some focused experiments on mobile computing; giving networked (wireless) computers to soldiers in the field, handheld devices to staff officers on ships.

The next steps are to turn smart rooms inside out so that the world becomes the room; to rethink our interactions with computers such that they can enable humans to accomplish tasks without demanding that the computer be the focus of attention; to enable the inputs from countless sensor computers be perceptible, be understandable, by humans; and to develop the robust, reliable, ubiquitous wireless networking capabilities upon which these interactions between computers and people depend. Concurrently, we need adaptive, intelligent agents; distributed data stores; and the complex infrastructure to support this environment.

5. Global 2001 Wargame

The focus of the Naval War College in Newport, Rhode Island is to further military thinking by keeping on the cutting edge of modern military advancement. Lieutenant William McCarty introduced the concept of war gaming at the Naval War College in 1886. A major exercise at the Naval War College is the Global War Game that has been conducted for the past twenty-three years. Today's war game is a multifaceted event that capitalizes on technology and future capabilities to answer the Navy's questions on future engagements [8].

The Global 2001 War Game is one of the worlds largest with 400 participants from all-military services, government officials, and knowledgeable civilians from Canada, United Kingdom, Australia and the United States. When the game begins the participants are presented a scenario, tool sets to work the crisis, and are asked to observe, orient, decide, and act given the environment and forces at hand. At various waypoints the game is stopped for evaluation and discussion to facilitate learning.

Figure 2: CommandNet use with the Coalition Joint Task Force

The objective for the Global War Game held in 2001 was to explore Network Centric Operations as they might be expressed in 2011. Specifically, the concept of Network Centric Operations moves the game's focus from the capabilities of platforms such as individual ships, planes and forces to gathering and sharing information (collaborating) in near real-time.

Traditionally, joint forces are structured around functional areas such as the Maritime, Air, Ground and Special Operations. NCW deemphasizes the functional organization in favor of the capability provided by the force. As a result, a critical goal of the Global 2001 war game tested the concept of Joint Forces fighting in collaboration within four cross-functional groups labeled Fires, ISR (Information, Sensors, & Reconnaissance), Logistics, and Maneuver (FILM). These groups were formulated to organize forces along the lines of the core functionality they provided rather than how they move through the battlespace.

CommandNet allowed warfighters distributed across time, space and component to collaborate within these cross-functional "FILM" groups. The application is a tool that

enables warfighters to log critical incidents that can be integrated into the group's SA.

6. CommandNet

The CMI research team was invited to participate in the Global Wargame in March of 2001. This invitation was extended largely as a result of CMI's previous successful work with the navy. CommandNet had been tested and judged a successful application during the U.S. Navy's Rim of the Pacific exercise during the summer of 2000 [3, 13]. This exercise brought CommandNet to the attention of some of the participants in Global. They suggested that it be integrated as the official group logging and SA tool for the exercise.

CommandNet was originally developed during the course of a Defense Advanced Projects Agency research grant to work with the staff of the U.S. Navy's Third Fleet. During the course of this research the CMI team had spend months on board navy ships studying the requirements of battle staffs and commanders. CommandNet grew out of a discovered need for group situation awareness within the intelligence community of the Third Fleet staff.

Traditionally, CMI has been involved mostly with collaborative meetings and electronic meeting software (EMS). During a visit to one of the collaborative spaces onboard the USS Coronado, the Third Fleet's head of intelligence proposed the use of the EMS to support an ongoing twenty-four hour per day meeting for his staff. A test application GSS was approved and implemented soon after.

The intelligence staff aboard the USS Coronado was spread throughout the ship in different small offices. This caused some problems for the staff as integrating all of the information that they shared was key to providing the commander with the information needed to make decisions. To integrate this vast amount of data intelligence watch officers would circulate among the offices gathering data that could then be synthesized into a more complete situational picture of the opposition.

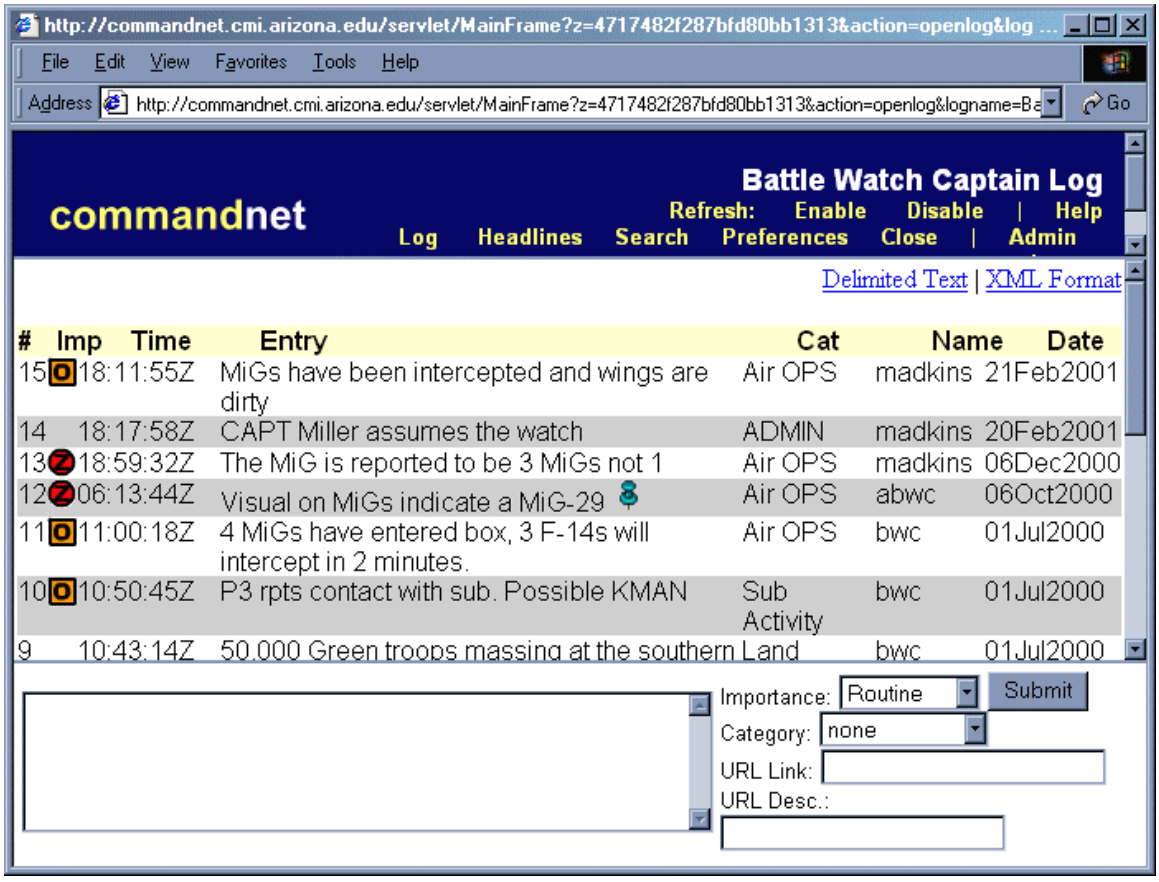

Figure 3 – CommandNet v3.0 Screen Capture

With intelligence staff spread throughout the ship, the watch officers found it difficult to maintain SA. It could easily take watch officers up to half an hour to communicate with all of the other intelligence staff to develop their greater situational picture.

The use of the GSS allowed the entire intelligence staff the ability to immediately enter items of interest in the collaborative log. These data would then be immediately propagated throughout the computers of the other staff members. The watch officers, in turn, would synthesize the data more quickly into knowledge that the commander could use.

Even though the software used was just a general purpose EMS application, this software gave the staff the ability to perform in way that was previously impossible. It was utilized in accordance with the theory of SA and Recognition Primed Decision-making [9, 11]. As a result, it was relatively easy for the intelligence staff to build its information and decision-making processes around the logs.

With the success of the intelligence logs, CMI and the staff then moved to expand the collaboration to other areas and develop a specialized application based on the lessons learned from working with Third Fleet.

CommandNet was developed using Java servlet technology. Servlets are platform independent Java programs that run solely within a web server environment [16]. They can be compared to perl cgi-bin scripts, Active Server Pages, and PHP scripts. Servlets allow the programmer to write in Java, a language that affords the ability to run programs on different architectures without tailoring and recompiling code. The servlet engine and Java programs reside entirely within the web server to create HTML as required by user requests to the system. Java and/or other installed programs (other than web browsers) are *not* required on any client computers. The browser client is unaware that the HTML it is displaying is dynamically created.

By structuring CommandNet with this architecture, the team was able to avoid many of the shortcomings of the collaborative logs on the electronic meeting system. CommandNet requires no client side installation, requires less bandwidth and runs better on congested networks. In a U.S. Navy networked environment there are regulations on what can be installed on computers and bandwidth is a valued commodity. Hence, CommandNet was designed to be client independent and to use minimal bandwidth. Additionally, since the client for CommandNet is a standard web browser it is familiar to most computer users. Finally, CommandNet is specifically focused on the tasks and requirements of a collaborative logging system. As such, it is simpler and requires less training and indoctrination than a full-featured EMS.

7. Wargame Preparation

The CMI research team spent a great deal of time preparing for the Global Wargame. From experience, CMI knew several things were required to participate successfully with new and innovative software. Through previous research the team knew the software had the functionality and simplicity required by the Global war game. There were, however, other considerations that required extensive preparations.

The primary consideration was that the application be absolutely reliable. Users will not tolerate a core system failure during a war game. To address this the CMI team did several hundred hours of testing in a simulated condition that was far more taxing than the one present at the war game. Simulated network and server loads were placed on CommandNet to ensure that the application would not fail. Additionally, the team loaded CommandNet on a high-end multiprocessor server with RAID drives. It was hoped that such preparations would make the application less vulnerable to crashes and would also aid in quick recovery.

Six weeks before the wargame was scheduled to start the lead CMI programmer shipped the CommandNet server to the Naval War College and later installed it on the network. Another researcher secured a list of users and built the CommandNet access control lists for each log. These pre-wargame measures afforded the CMI team the ability to avoid last minute preparations and guarantee that CommandNet was running well prior to the hectic days just prior to the wargame.

8. FILM Logs

In support of the weapons platforms and the warfighters at Global, the staff at the Naval War College had worked diligently to develop a suite of collaborative tools known as the Wargaming Information Grid System (WIGS). WIGS was intended to provide NCW collaboration capabilities to the wargame participants. Among the collaboration tools were chat, desktop teleconferencing, shared files, collaborative editing and a number of other shared resources. CommandNet was integrated into WIGS under a hyperlink labeled “Log Books”. This caused the integration to be seamless to the users.

At the mid-term planning conference for the Global 2001 Wargame the CMI researcher present and the head of the

development staff for the WIGS project met to discuss how CommandNet could be integrated into WIGS. The WIGS initiative had made great strides in developing a full range of tools to support the staffs and commanders during Global. They did, however, have certain constraints and the inclusion of CommandNet would allow them to focus their limited resources on perfecting the rest of WIGS.

Originally, there were to be five operational logs. The top-level log would be the Commander's Battle Watch log. Under this would be four logs that would support the cross-functional network arrangement known as the FILM concept. They were labeled FILM logs for the four areas: (1) Fires, (2) ISR – Intelligence, Surveillance and Reconnaissance, (3) Logistics, and (4) Maneuver. The goal of this organization was to break the players out of their traditional roles and force them to work within a true NCW framework.

9. Global 2001 Wargame Start

After meeting several more times with the NCW staff, the CMI researchers brought the standalone server to the wargame site. User accounts were created and the participants were given permissions based upon their roles. In July 2001 the two-week wargame started.

CMI fielded three researchers and one developer to the Global Wargame. One of the developers was working on a related project and would have limited responsibilities for CommandNet. The other three team members were primarily focused on supporting CommandNet and ensuring that users were trained and aware of the system.

This effort to train and advise users of CommandNet was difficult at times. The application was not included in the standard WIGS training, so the researchers were forced to enact a training program on the fly. The research team split the different user groups up and did ad hoc training as opportunities became available. Though this was not an optimal solution, it did allow the team to work with key personnel that would later drive the adoption of CommandNet.

10. Failure of FILM Concept

In spite of the extensive technology efforts, the FILM concept was not implemented smoothly in the Global wargame. The users were not comprehensively trained in NCW doctrine or operations. It was not natural for them to suddenly shift gears and perform their duties in a new way and with new tools. They tended to revert to their traditional ways of communicating and working.

The War College staff put a significant energy into training players to use WIGS and the associated collaborative toolset. At first there were high expectations for testing the tenets of NCW as users readily took to WIGS to gather information for their missions and commanders. Soon, however, WIGS became a victim of its own success. While there were still training problems, the major fault was that the collaborative tools were too processor and bandwidth intensive for the network. Several days into the event the main server crashed and could not be brought back on line for over a day.

Without extensive indoctrination and training in the concepts of NCW, the staffs were unable to transition successfully to networked operations. Though the FILM concept was thoughtfully conceived, it was never successfully transitioned into a way of working. Staff officers knew how to organize themselves within functional groups, but the idea of cross-functional organization eluded them.

11. Return to Established Procedures

While this network failure at first seemed catastrophic, the staff and players simply innovated and adapted to carry on with the experiment. It was at this time that CommandNet became a major focus of the wargame. Since users could not utilize the core collaborative tools that had been developed in WIGS they were anxious to try CommandNet as a coordination and decision support tool. Since CommandNet was developed in the bandwidth-limited sea environment and was running on a separate server it was not heir to the hardware problems encountered by the rest of WIGS.

Soon CommandNet was a centerpiece application for sharing and updating situation awareness throughout the wargame. Because the users were not accustomed to the FILM concept, these logs were abandoned in favor of a functional set with which they were more accustomed. There were separate logs for Air, Land, Sea, Special Operations, Logistics, and the CJTF Battle Watch. Though these logs were not directly aligned with NCW concepts, they more importantly supported the established work processes and training of the staffs and commanders as dictated by the ubiquitous computing theory. This afforded them the opportunity to get beyond the technology to focus on the battle and coordinating with other forces.

At the conclusion of Global 2001, the CommandNet logs were fully integrated into the work processes of the staffs. Midway through the wargame, CommandNet was even adopted by the CJTF's superior, the theater commander-in-chief (CINC), as a way to monitor the progress of the operation. The logs also became a key component in the

evaluation of the wargame. The control group was using the entries to track action and reaction throughout the wargame.

12. Findings and Applications

The work with CommandNet at the Global wargame was only a first tentative step towards making an investigation of the tenets of ubiquitous computing in support of NCW. It was, nonetheless, a revealing research effort.

Weiser states "Ubiquitous computing is roughly the opposite of virtual reality. Where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people. Virtual reality is primarily a horse power problem; ubiquitous computing is a very difficult integration of human factors, computer science, engineering, and social sciences."[18]

CommandNet seeks to be one of the tools in such an environment. Although it misses the ubiquitous computing mark for technological invisibility, it does begin to address the idea of pervasive computing systems that support the natural work processes that people have developed. Log keeping is a task that all navy personnel are indoctrinated in from the beginnings of their careers. Thus, CommandNet fits very readily into the work schemes that already exist.

When WIGS experienced its technical difficulties the various wargaming staffs were forced to abandon many of the new technologies that were the focus of much of their energy. Though many of the tools within WIGS were quite useful, they did not meet the requisite requirements of simplicity and reliability. By transitioning to a ubiquitous computing environment, one assumes a level of reliability and usefulness that will make the system suitable for high-reliability, mission-critical work.

Users reverted to the processes and practices that they had relied on throughout their careers when the new collaborative capabilities broke down. Though these tasks weren't directly aligned with the NCW concepts laid out during the wargame inception, they were ultimately those tasks and practices that were required to concert forces, prioritize targets and attack the enemy in a coordinated fashion. These are directly aligned with marshalling and employing military forces.

CommandNet was successful not because it provided a quantum leap in capability. At the end of the day, CommandNet is a text-based tool that is deceptively simple. Instead, the users embraced CommandNet because it readily and unobtrusively supported the very real and uncontrived tasks that were required by the scenario.

The value of shared SA throughout the Global wargame cannot be discounted. NCW demands a higher level of awareness on the part of players at all levels of the military organization. Experienced military officers maintain a vast corpus of experiences and knowledge that they apply readily [12]. Collaborative tools like CommandNet are powerful because they can be seamlessly integrated into the working environment. Such information systems provide tangible support while requiring little in the way of training or accommodation.

13. Future Directions

CommandNet was created as a result of direct contact between a research team and warfighters. Requirements identification and elicitation are often difficult without such direct contact and observation. Current operational procedures within the U.S. Navy demand specific requirements before an information system can be designed and created. There are, however, few parties methodically assessing needs for collaborative technologies. More often, these requirements are arrived at in a haphazard fashion. In fact, when the research team attempted to get approval to use the original prototype for CommandNet the researchers were told the software was a solution looking for a problem.

Collaboration between researchers and warfighters surfaced unknown requirements for a collaborative tool that supports critical command functions. The success of CommandNet as a tool to sustain situation awareness provides a number of opportunities for future research and changes in business practices.

First, with complex concepts such as collaboration there is a need for researchers and end users to work together. Only by striving to understand each other's requirements and constraints can effective tools be created with available resources. If one were to go on board any given ship to talk with warfighters to ask them what their collaboration requirements are, the responses would be either vague or very narrow. Allowing researchers to understand firsthand the job of warfighters while providing service members with an understanding of collaboration takes considerable resources. The investment can, nevertheless, return phenomenal results if the relationship is given time to develop.

Second, the concepts of ubiquitous computing need to be extrapolated to exploit the power of collaboration. Effective coordination between team members in an organization is critical to success. Human communication supported with information systems are proven as a successful combination [6, 14]. Ubiquitous computing concepts are tremendously

powerful and naturally enhance the advantages of effective collaboration.

Third, there are immediate needs to expand the capabilities of CommandNet. Exploration into the use of handheld devices for data entry and review is required. Incorporating voice recognition technology into a collaborative situational awareness tool demands study, as keyboarding can be distracting in crisis situations. Finally, work needs to be done to understand interaction processes across distributed battle groups and commands. Often in the rush to develop technology to support collaboration the understanding of human interaction is overlooked. Human communication and group interaction processes are critical to developing effective collaborative information systems.

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