SUPPORTING SHIPBOARD NETWORK OPERATIONS THROUGH ELECTRONIC PERFORMANCE SUPPORT SYSTEMS

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Abstract

The Navy's IT-21 program (Information Technology for the 21st Century) will modernize fleet operations by integrating advanced information technology capabilities into ships, battle groups, and shore facilities. A primary goal of IT-21 is to provide a smooth flow of information between operational units, allowing warfighters to instantly exchange tactical or non-tactical information, thereby improving warfighting capability, combat support, and quality of life.

IT-21 presents a considerable training challenge in preparing the shipboard Network Administrators who will be responsible for maintaining smooth network operations and preventing system failures. Currently, training is not standardized and is not consistently available. Even when training has been provided, the IT personnel on these newly outfitted ships have been overwhelmed by the sheer volume of what they need to *know* in order to *do*. As knowledge decay statistics show, the rate at which we forget means that only 10 to 15 percent of what sailors are taught in preparatory training is retained as they transition to performing their jobs (Lippincott, 1997)

To counter this problem, the Navy is moving to modernize its training approach along with its IT infrastructure. Future training design and delivery efforts will be directed toward the goal of *performing* rather than *learning how to perform*. To demonstrate an implementation of this approach, a prototype electronic performance support system (EPSS) has been developed for the DDG-51 ship platform. This EPSS provides an intuitive, task- and goal-based user interface to focus and filter access to a knowledge base. The DDG EPSS supports troubleshooting and analytical decision making, displays and explains networking configurations, houses critical policies and guidance, allows platform-specific customization, and provides "just in time" learning for networking concepts and procedures. The fully developed EPSS will provide a continuum of support, being used initially to facilitate and enhance instructor-led training, and then becoming available to administrators as part of the standard shipboard software load.

This paper will present an overview of electronic performance support, how it can be applied to complex work processes, and the benefits that can be achieved through this approach. The paper will also discuss the specifics of the DDG EPSS project, and will discuss how the prototype will be leveraged across remaining ship classes to reduce subsequent EPSS development costs and shorten its implementation.

Biographical Sketch:

Ms. Janet Cichelli has spent the past eight years at SI International, Inc., building one of the industry's premiere electronic performance support practices. Under Ms. Cichelli's direction, her award-winning group develops embedded learning and performance support solutions for a wide range of government organizations worldwide, including the U.S. Air Force, U.S. Navy, National Security Agency, Defense Intelligence Agency, Federal Deposit Insurance Corporation, U.S. Department of Education, Department of Veterans Affairs, the U.S. Immigration and Naturalization Service and others.

Ms. Cichelli brings a unique insight and extensive experience in the human performance and learning areas. She is a pioneer of and recognized leader in the field of electronic performance support systems, and is frequently invited to speak at national industry conferences on user interface design, EPSS and performance technology.

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SCENARIO

Seaman Thompson has a problem. It's 2200 hours aboard the USS Underway, and the Captain can't log on to his computer. As the new shipboard network administrator, Thompson needs to think and act quickly. He urgently tries to recall the troubleshooting procedure he learned during training. Unfortunately, that was more than three months ago. Following Basic Training and Information Technology Class "A" School, Seaman Thompson spent the first 100 days at his new command as a compartment cleaner.

Four days ago, he began this new assignment as Network Administrator. And tonight, while the ship conducts battlegroup operations, the call comes in from the Captain. Using his best memory and limited experience, the seaman tries the Unix "ping" command, which turns out to be a very inappropriate first action. He sees that the Captain is connected to the network, so he guesses it's a network problem. The network server seems to be operational, so he decides it is best to reboot the server, using Ctrl-Alt-Delete, to clear the problem.

A young, inexperienced sailor rebooting the system at the wrong time can have catastrophic results, not to mention the effect on blood pressure levels. His actions have shut down everyone else. It also happens that this server contains the ship's Microsoft Exchange Server where all e-mail comes in. Not surprisingly, his phone starts ringing off the hook.

UNDERSTANDING THE PROBLEM

An unlikely scenario? Unfortunately not. Even with prior training, problems often occur when an inexperienced worker relies entirely on the knowledge that resides in his head to make a decision or solve a problem. Why is this? There are many reasons, but the primary one is *knowledge decay*. As humans, the rate at which we forget is high. Seaman Thompson may have been ranked first in his classes during technical training, but statistics show that he'll walk out of the classroom with less than 50 percent of what he learned. Two weeks following training, he will have forgotten up to 85 percent (Lippincott, 1997). Add to this the fact that Thompson's *actual* work situations will almost always differ significantly from those he encountered during training, since it's simply not possible to cover all of the possible scenarios that students will face.

The U.S. Department of the Navy, like many other organizations at the dawn of the 21st Century, is pressured to continuously improve its performance. The National Performance Review (1993), the Government Performance Results Act (1994), Clinger-Cohen (1996), Executive Order 13111 (1999), and other statutes have helped define and mandate how the Department of Defense and other federal agencies can adopt a results-oriented approach to performance improvement and become an adaptive, agile organization (Weidner, 1999). While maintaining warfighter readiness, the Navy must also reduce costs and improve efficiencies. The Navy's IT-21 program (Information Technology for the 21st Century) is a complex mix of highly sophisticated network and electronic devices that promises considerable operational improvement aboard ships and ashore. The Naval Sea Systems Command (NAVSEA) and Space and Naval Warfare Systems Command (SPAWAR) are providing the Navy fleet with the absolute best equipment and operating systems available. However, the success of IT-21 ultimately relies on the competency of operators that have varied and often very limited experience.

To prepare sailors to harness the power of these modernized systems, shipboard training groups have added targeted classes to train sailors on the use of Microsoft Windows NT, systems administration and local area network (LAN) maintenance. Most ships also have access to extensive libraries of interactive courseware from commercial vendors that provide CD-ROM and network-based courses on topics ranging from Unix, routers, MS Exchange, and NT.

Unfortunately, these efforts often fail for two reasons:

1) ***Sailors are unable to take time away from work for formal learning activities***—Sailors typically work 12 to 14 hours while underway. At times, they will work in excess of 24 hours at a time. While they may be encouraged to take courses, dedicated time for formal training is rarely allocated.

2) ***Training events are conducted far in advance of the need to perform***—Learning takes place most effectively in the context of *doing*. Not only do sailors forget what they have learned, but they are also required to know *when* and *how* to apply training concepts and skills in a real work situation.

In the shipboard work environment, information abounds. Network schematics, vendor specifications, technical knowledge bases, procedures, protocol, tools, and best practices for managing and maintaining shipboard systems all exist. The problem is not a lack of information and knowledge assets. The problem is sailors are besieged with too much out-of-context *stuff*, and spend precious time looking for what's useful. Each network administrator bears the burden of sifting through all that is available to quickly find the right information to help solve a problem, make a decision, or perform a task.

So, then, what's the solution? For Seaman Thompson, and countless others, what's needed is a way to get exactly the most meaningful and appropriate information, tools, and expertise at the moment needed. EPSS are quickly gaining a foothold as an effective way to provide *just-in-time* support.

WHAT IS AN EPSS?

An EPSS is an electronic infrastructure that provides a supportive context in which work is done. Everything needed to do the job—information, software, expert advice, guidance, and learning experiences—is integrated and available, enabling a desired level of worker performance in the fastest possible time and with minimal support or intervention by others. For Seaman Thompson, it would mean the difference between quickly and confidently solving the Captain's problem, or spending the next several hours pouring through the NT Troubleshooting Guide and the Network Administrator's Guide—assuming they could be found—searching for answers.

The goal of an EPSS is to provide whatever is necessary to generate performance and encourage learning at the moment of need. This kind of support has always required human beings in the past. But we now have the means to model, represent, structure and implement it electronically. (Gery, 1991)

A number of companies have claimed large gains from the implementation of EPSS within their organizations. Among them is the American Express customer service department, which claims that the training period for their employees was reduced from 12 hours to 2 hours, that productivity improved from 17 minutes per request to 4 minutes per request, and the data entry error rate decreased from 20% to 2% (As reported in EPSS case studies at http://www.epss.com).

Electronic performance support systems are emerging as a vital element in the Department of Navy's knowledge management and distance learning initiatives. The reason is simple: an EPSS can deliver the expert *know-how*, regardless of a sailor's location, prior experience, or type of work. In the Navy's vision of a knowledge-centric organization (KCO), an EPSS becomes the delivery mechanism for filtering and focusing access to enterprise knowledge. In a distance learning initiative, EPSS excels as a way to convey just-in-time learning and coaching.

EPSS FOR COMPLEX WORK

Many of the job tasks that Seaman Thompson will perform in his role as network administrator are repetitive, procedural-oriented activities (e.g., setting up new user accounts, creating shared directories, performing backups). EPSS supports these well-defined and structured tasks, as well as more infrequent or unfamiliar tasks. For example, Thompson may have formally learned the emergency procedure for handling hardware problems following water or fire damage, but if he only performs it once or twice during his deployment, he will likely forget and require support to handle this situation effectively.

But a network administrator's job is not comprised entirely of recurring tasks. Troubleshooting problems with an unknown origin and other complex decision-making and cognitive tasks can require considerable support, especially for the novice. How can sailors gain access to decision-

making rules, volumes of resources, and have them available, in context, at their fingertips?

This type of dynamic, complex *knowledge work* tends to be much less routine and linear than other kinds of work tasks. Because boundaries around decision-making and other knowledge work processes are unclear, complex tasks are more difficult to support through traditional help and reference systems (Mohrman, et al., 1995). But an EPSS, which is designed to visually and organizationally represent the performer's mental model of the work, can provide the right framework for supporting good decision-making and problem solving.

EPSS FOR THE DDG PLATFORM

The Navy is embarking on pilot programs to demonstrate implementation of EPSS as a just-in-time approach to training and support. In one of these efforts, a proof-of-concept EPSS has been developed for the DDG-51 destroyer platform. The DDG EPSS supports a broad range of troubleshooting and analytical decision making, houses critical policies and guidance, allows platform-specific customization, and provides "just in time" learning for networking concepts and procedures.

The EPSS supports Navy personnel assigned the duties of managing, maintaining, and administering DDG-51 shipboard digital networks. The goals of the DDG EPSS are to *reduce* time and lead to *better* performance by helping sailors to quickly achieve consistently high levels of performance regardless of their varied or limited prior knowledge and skills.

The EPSS is organized around a main interface screen that provides context-appropriate access to tools for decision support, troubleshooting, step-by-step assistance, and access to learning and reference resources. The main interface of the EPSS application, shown in Figure 1 below, uses an innovative visual browsing metaphor to focus and filter access to the EPSS components.

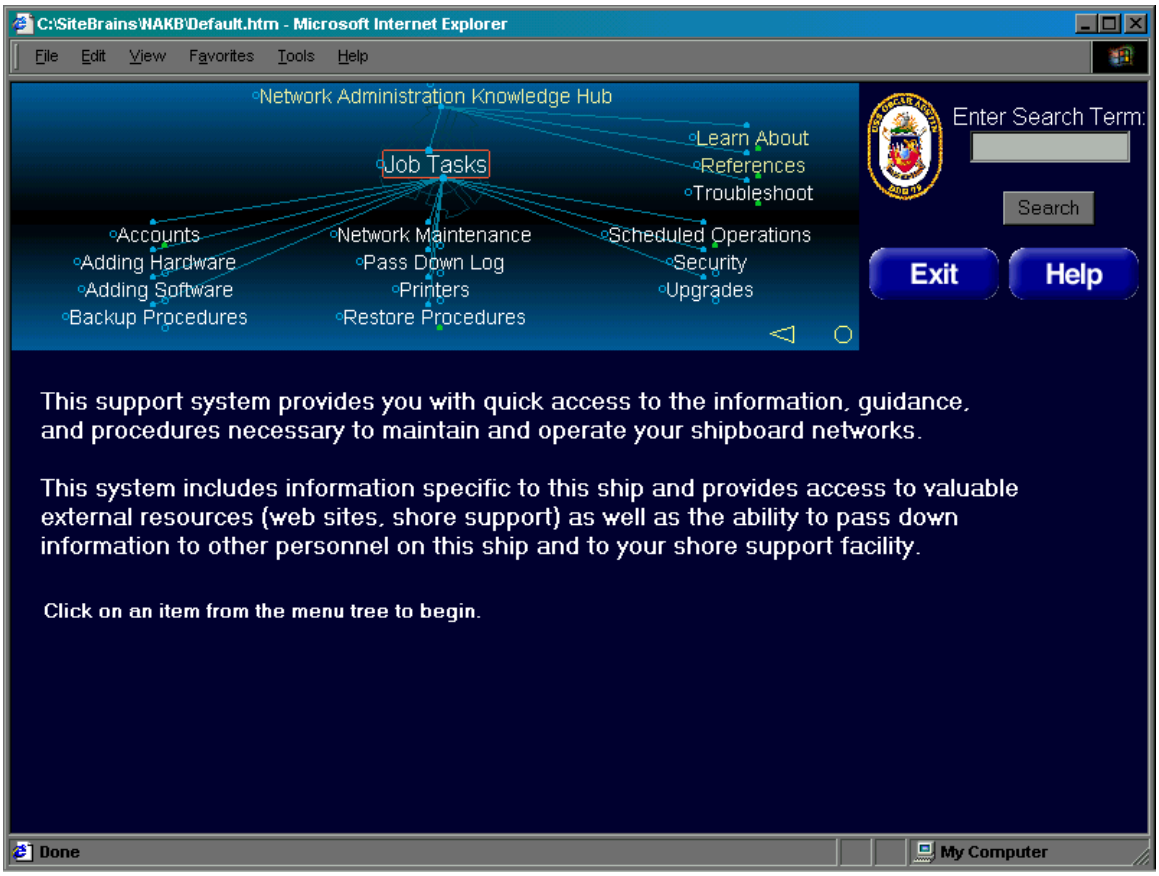

Figure 1: Main EPSS Screen

This visualization technique is known as a *hyperbolic browser* and is utilized in the DDG EPSS for navigation and menu structuring. A hyperbolic browser is one of a class of browsers using a *focus + contex*t (fisheye) technique. The hyperbolic browser replaces conventional methods of cascading or expanding menu trees and has been shown to be particularly effective for visualizing and navigating large hierarchies of information. Conversely, static tree-based menu structures, which are more commonly used in EPSS and reference systems, constrain a performer's navigation path and have a tendency to confuse users (Lamping, et al., 1995). As shown in Figure 1, the 3-dimensional hyperbolic browser initially displays a topic at the center of the display (i.e., *Job Tasks*), with related topics shown visually as "branches."

By clicking on one of the "branches," the animated display moves that topic to the center of the display, and shows the new related topics surrounding it. For shipboard network administrators, the hyperbolic navigation method has several advantages:

- ***Provides a "big picture" view***—Hyperbolic navigation provides network administrators with an "overview diagram" of the entire EPSS support structure which is a very effective method for orientation (*Where am I?*) and navigation (*Where can I go?*) in hypermedia. This view is organized to represent the sailors' mental model of their job tasks and goals.
- ***Supports performer diversity***—This method of navigation is well suited to a broad range of competency levels comprising the network administrator audience. The hyperbolic browser makes it much easier for novice network administrators to navigate without getting lost, but also effectively supports experts without imposing excessive screen displays or forcing a navigation structure.
- ***Faster searching***—Network administrators will be able to perform searches faster and more thoroughly using this type of browser than conventional navigation techniques, especially given the large amount of information integrated with the EPSS. In a recent study, the hyperbolic browser proved to be 62 percent faster than Internet Explorer for retrieval tasks similar to those in the DDG EPSS (Pirolli, et al., 1999).
- ***Maintains context***—Most "pop-up" help displays take a user away from the context, focus on the current task activity, and require the user to focus elsewhere, if only momentarily. The hyperbolic navigation method allows the user to navigate within a single space, with minimal screen redraw, which maintains their focus and context to the task at hand. Additionally, the hyperbolic approach provides users with the relationship of the detail to the entire structure.

The DDG EPSS supports two primary goals: learning and *doing*. When a sailor's goal is to get a job done, and make sure it's right the first time, the DDG EPSS conserves the number of things he needs to learn in order to perform. This supports the EPSS notion that *learning* is not always a pre-condition to *doing*.

When a network administrator is newly assigned to a ship, perhaps filling an empty billet where no crossover training is available to him, he needs to quickly learn about his role and areas of responsibility. He can use the EPSS to view a job description, read about his primary job tasks, access *how-to* information, and review performance criteria and self-assessment checklists. As an ongoing learning aid, or to support continuing education requirements and goals, he can use the portal capabilities of the EPSS to access seminars, interactive courseware, and other job-related formal learning.

EPSS COMPONENTS

All of the DDG EPSS functionality is accessible from the main browser interface. Each core EPSS component is described in the following sections.

Configuration Displays

Previously, the network administrator had access to a limited number of configuration displays. Some were available through network monitoring utilities; others, in paper format from training materials. But no centralized, comprehensive set was available to provide a big picture view of the network. The EPSS consolidates a set of visual network displays that includes a thread through the DDG-51 class NIPRNET components and allows for drill-down to view a specific workstation (see Figure 2).

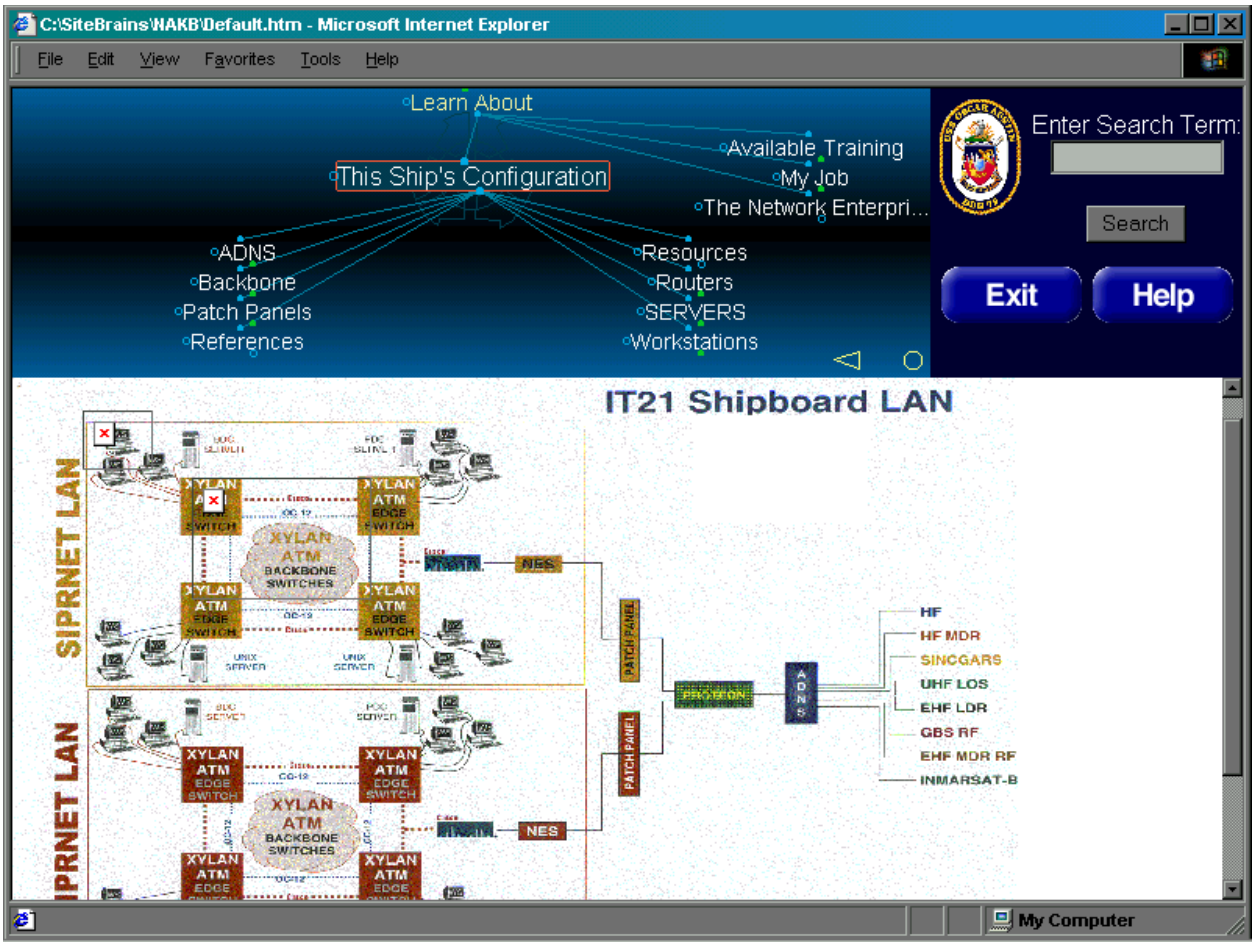

Figure 2: Configuration Display

Using this EPSS component, a sailor can view configurations, annotate displays, and gain detailed information for use in completing routine tasks, maintenance, and troubleshooting. Configuration elements are integrated with various databases to enable real-time updates as changes occur. Notes can be added by the administrator for later viewing, or for inclusion in the pass-down log (PDL).

Troubleshooting

A network administrator's daily shift involves solving problems related to connectivity, hardware/software failures, and user errors. After only a short time on the job, an administrator becomes familiar with a small set of common, recurring problems and their resolution.
But for the brand new administrator, or for those outside-the-ordinary problems, a systematic approach is a must to ensure smooth network operations, minimize downtime, and ensure that administrator's adhere to policy and best practices. The EPSS troubleshooting component is a highly interactive system, both for "known problems" and "unknown problems." When a network administrator knows the nature of a problem, he/she can quickly access its resolution procedure through a categorized index.

For unknown problems, the EPSS uses a specialized filtering and baysian logic system to narrow the solution set based on the operator's entry of symptoms (see Figure 3). Once the probable cause is identified, the EPSS displays the procedure for stepping the network administrator through resolving the problem.

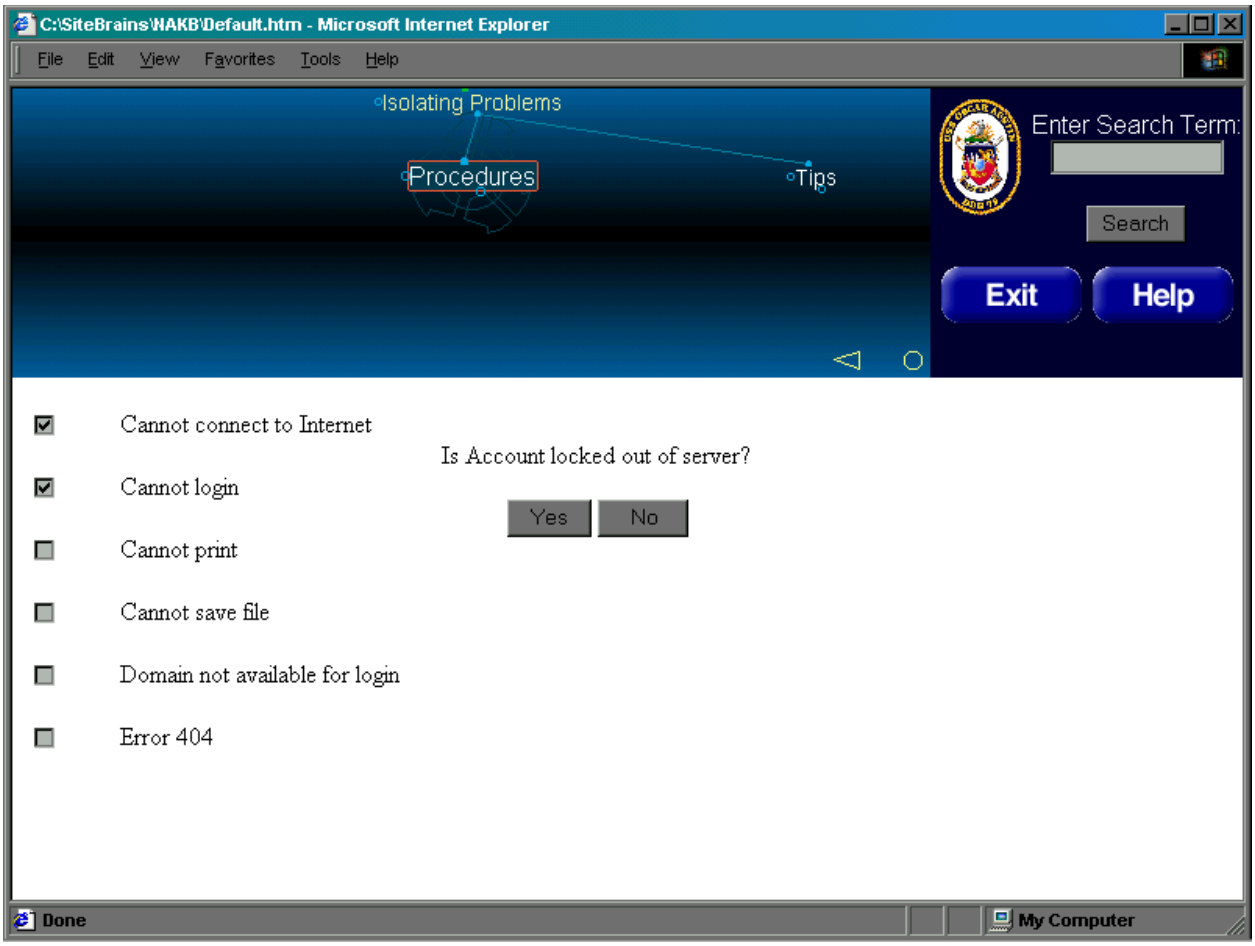

Figure 3: Troubleshooting Component

Pass-Down Log (PDL)

When network updates are not communicated, incorrect assumptions can adversely impact networking activities. The pass-down log feature of the EPSS enables operators to pass critical items to the next watch, maintain a permanent record of changes made that impact day-to-day operations, and have a vehicle for extracting this data and making updates to configuration, as required.

Learn About—My Job

This EPSS component can be used as a learning tool or as a guide for performing job tasks. For the network administrator, this section includes:

- A clear outline of job responsibilities.
- Procedures and examples for performing job tasks, with links to available resources on the network or on the Intranet.
- Access to good examples of completed work products, such as forms and reports.

Learn About—Other Training

This EPSS component acts as a portal to shipboard and enterprise learning opportunities. For shipboard resources, this includes integration with libraries of CD-ROM courses and other self-paced instructional materials. It also includes integration with the Navy Learning Network (NLN) and the hundreds of continuing education courses available through this newly launched initiative. Through the NLN and other emerging tele-training capabilities, sailors will be able to *reach back* to universities, specialized technical training, and vendor courses (see Figure 4).

Figure 4: Available Training Component

DDG EPSS BENEFITS

With the DDG EPSS, the Navy anticipates a decrease in the time it takes a new network administrator to achieve basic competency, thereby narrowing the performance gap between the novice and expert. In addition, it will give network administrators easy access to relevant information, independent of platform or source.

Additionally, it is anticipated that:

The EPSS will overcome knowledge decay problems—The EPSS was designed to anticipate network administrators' questions, such as, "How do I…?" "What if…?" "When should this be done?" "What does this mean?" By developing this understanding of what sailors need to *know* in order to *do*, the most targeted combination of EPSS components were developed. Routine tasks, infrequent tasks, and complex problem solving no longer rely entirely on what may (or may not be) reside in the heads of sailors.

The EPSS will standardize best practices—The EPSS will ensure success in each situation by institutionalizing proven approaches and methodologies for troubleshooting, job roles and responsibilities, conducting testing and maintenance procedures, and recurring processes.

The EPSS will facilitate and enhance instructor-led training—The DDG EPSS will provide a continuum of support, initially to facilitate and enhance instructor-led training, and then becoming available to network administrators as part of the standard shipboard software load. Several factors make the EPSS well suited to integration with instructor-led training: 1) The situational learning context matches the operational context, 2) it represents an engaging

learning mode in which the student has to actively seek the information needed to solve problems, and 3) the on-the-job availability of the EPSS reduces the number of skills needed to be taught. (Desmarais, et al., 1997)

The EPSS will capture experiential knowledge—The EPSS is much more than a static collection of documents and tools. It is a dynamic, living support framework that encourages the ongoing capture and update of content. Designed as a "shell" application, all of the EPSS content resides separately—in a database—from the application program structure. This structure allows for fast update by staff without specialized programming knowledge. Additionally, the Pass-down Log provides a way for capturing new technical and configuration data, and providing feedback and comments.

The EPSS will improve efficiency and quality of life—With the DDG EPSS, sailors no longer need to worry that their technical manuals are locked in the EMO office. Getting support on specialized equipment, such as a Proteon router, no longer suffers when the technical expert at Fleet Technical Support is on leave. An EPSS increases performer confidence—and the confidence of those they work and interact with. The EPSS supports the work to be done today, while supporting the sailor to move to new levels of expertise.

THE NAVY'S *THINK BIG, START SMALL* APPROACH

Preliminary audience and job task analysis indicates that the job duties of a DDG shipboard network administrator are comparable to that of an administrator on a CVN or an LPD class of ship. Specific network and system configurations may differ, but general roles and responsibilities are parallel. With this in mind, the DDG EPSS has been approached with a "think big, start small" mindset. By focusing on the "big picture," up-front consideration is given to eventual local and wide area network (LAN/WAN) operations support across all ship classes. Design and implementation strategies have been employed that will reduce subsequent development costs and shorten implementation. For example, during initial development of the DDG EPSS, a standard architecture and program "shell" is being developed. This shell will address core EPSS components, basic look-and-feel, navigation, and baseline functionality.

WITH EPSS—A VERY DIFFERENT SCENARIO

Seaman McCormick was introduced to the EPSS in Class "A" School. During training, he used the EPSS to assist him in completing the practical exercises and became familiar with how it could assist him in his upcoming duty assignment. McCormick reported onboard the USS Underway with this initial training, but no previous network administrator experience. On his first day as network administrator, McCormick accesses the EPSS to review his new job role and responsibilities. He views the recurring tasks that he will be responsible for performing, reviews the Pass-Down Log to note any changes to the configuration, and checks to see what training is available for the new ATM networks that have been implemented since he completed training. Periodically over the next few days, McCormick uses the EPSS to guide him through new and unfamiliar situations.

When the Captain's call comes in three days later at 2200 hours, McCormick is fully prepared. He accesses the Troubleshooting section, and selects "Known Problem." From the list of known problems, he selects "User Cannot Log On." A series of questions are displayed, "Did the user enter their user name and password correctly? Is the domain server down? Is there an IP conflict?" McCormick isn't sure. He clicks on "View Configuration," drills down to display the Captain's workstation and gets the MAC and IP Addresses. He checks the server for conflicts and finds that there is one. The EPSS guides him to determine the exact cause, based on the symptoms: User Account Locked Out. McCormick launches the procedures to resolve the problem: *Unlock Account and Reset Password.*

Following the step-by-step procedures in the EPSS, Seaman McCormick takes immediate action to have the Captain reboot his workstation and walk him through logging on with his user name and a new password. Within twenty minutes, the Captain is back online. The EPSS reminds McCormick to update the Pass-Down Log with this new information. The next morning, both the EMO and Division Chief review the Pass-Down Log before attending the morning meeting and become aware of the problem that had occurred. There was no operational impact, and McCormick gets an approving nod from the EMO. He settles in, knowing this will be a good day.

CONCLUSION

Organizations like the U.S. Navy realize it is not enough to invest in the technology alone. Support and a work environment must be in place in which people learn while working in day-to-day job situations. This type of performance support in the actual work context is so much more effective than performance resulting from the distance between training events and work performance. When an organization can institutionalize its best practices and provide workers with a master teacher, an expert advisor, and a knowledge base of process and policy, the result is the transfer of more knowledge, faster and more efficiently.

Electronic performance support systems help get the right knowledge to workers at the right time. The DDG EPSS provides shipboard network administrators with a low learning threshold for novice network administrators, while providing the flexibility for experienced administrators to do the things they need to do.

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