Improving the Performance of Coast Guard TCP/IP Applications Over SATCOM

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Abstract

The primary purpose of this project is to reduce cost and increase efficiency of satellite usage by underway cutters. Building on two years of work, the focus of this project is to evaluate the software that was created by Architecture Technology Corporation. The Dial-On-Demand router establishes and maintains a connection over a satellite link; the Web Proxy provides header caching and data batching and compression, and the Email Proxy stores, batches and compresses emails until a connection is established.

Test beds were created to simulate the cutters in the Coast Guard fleet. The software was evaluated through rigorous testing under various conditions. The software was corrected and evolved to meet criteria and circumstances. The results proved that the software is a viable option in the ongoing battle to cut spending because of its ability to drastically decrease connection time.

Introduction

In an effort to bring the aging Coast Guard technology up to speed with the civilian sector, the United States Coast Guard has upgraded its computer and network assets. After the five-year migration, the Coast Guard has completed the transition from CTOS systems to Microsoft Windows NT-based Standard Workstations. These new computers have allowed the Coast Guard to take advantage of software that is currently available to improve efficiency and productivity. In addition, the land-based network has been upgraded from X.25 lines to a high speed TCP/IP wide area network known as the Coast Guard Data Network Plus. CGDN+ takes advantage of web browsing and email applications as the front ends [1].

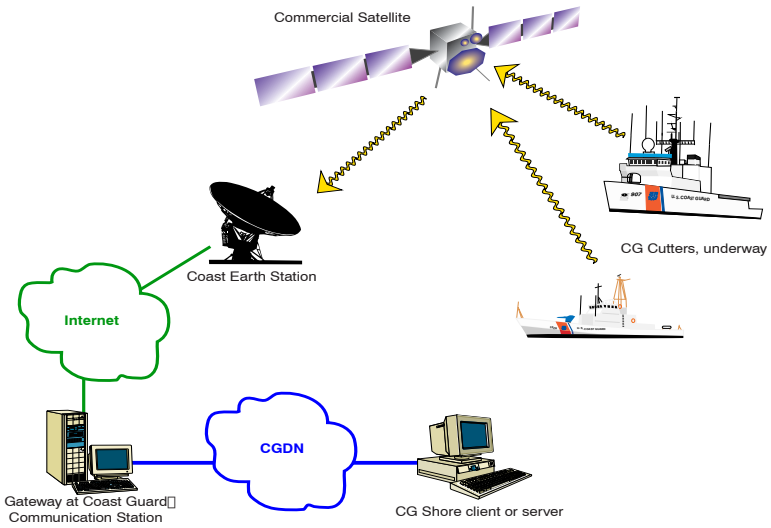


Figure 1: Overview of the Coast Guard Communication Flow

The next step with this technology migration is that the Coast Guard fleet of cutters and airplanes are still in need of more effective means of communicating with the Coast Guard's land-based resources and each other. In order to correct this problem, several initiatives are in progress to bridge this gap. The large cutters (210 feet and longer in length) of the fleet have been equipped with Inmarsat-B terminals with a high-speed data option. The small cutters (below 210 feet in length) have been equipped with Inmarsat Mini-M terminals and HF email capabilities. This project is also one of the initiatives, which was conceived and sponsored by both the Telecommunications and Information Systems Command and the Coast Guard Research and Development Center [2]. In an effort to correct the dilemma of poor communication, the Coast Guard has begun optimizing usage of satellites for more reliable and effective lines of communication. Due to limited allocation of resources, the Coast Guard cannot adequately fund extensive usage of this valuable resource. Therefore by optimizing TCP/IP, the Coast Guard improves link utilization and efficiency. This reduction of data transmission in return reduces the amount of transmission time needed. The reduction of time equates to greatly needed funding saved for operational needs.

Background

The Coast Guard has only in recent memory started to work with the full technology available through the usage of satellites. The problem still exists that satellite connectivity is very costly and this makes usage a dilemma for the Coast Guard due to budgeting constraints. Therefore, this project was created in an effort to maximize satellite usage while efficiently using United States tax dollars.

Two years ago, LTJG Tobias Reid (2000) worked on improving connectivity for small cutters by testing web surfing and simple email over a 2400-baud asynchronous connection. The results revealed that a reduction in Maximum Transmission Unit from 1500 bytes to 500 bytes was the most efficient size for packets. LTJG Reid also came to the conclusion that by increasing the Initial Retransmission Time Out to 3 seconds from 5000 milliseconds increased efficiency [3]. LTJG Reid determined that these two alterations improved efficiency because they eliminated time-outs, which resulted in unnecessary retransmissions [1].

One year ago, ENS Robin Kawamoto (2001) and ENS David Bauer (2001) continued the work of LTJG Reid. The focus of their project was expanded to a large cutter test bed and a small cutter test bed. The large cutter testing included the simulation using a 64 kbps link over an Inmarsat B terminal. The small cutter testing included the simulation using 2400-baud on an Inmarsat Mini-M and Dial-On-Demand router software. The Dial-On-Demand router was created through a contract with Architecture Technology Corporation [4,5]. Finally, a SkyX Gateway XR10, commercial product, was tested to see if improved the results [6]. The conclusion that ENS Bauer came upon was that the SkyX Gateway greatly improved TCP/IP transmissions but ultimately there was no improvement for web browsing [7]. ENS Kawamoto came to the conclusion that the Dial-On-Demand router software improved performance of the connections for the small cutter test bed. Performance improvement of the email proxy could not be established because the program was released too late for adequate testing [8].

Objective

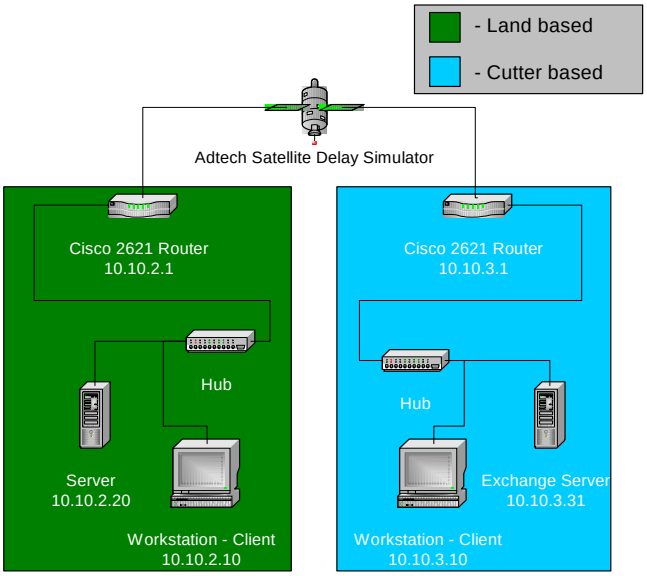
The objectives for this year were to continue testing on both simulations of the large cutter and the small cutter test beds using both the Dial-On-Demand router and the newly acquired web proxy and email proxy software. These two new programs were created by ATC through the contract with the USCG Research and Development Center.

The purpose of the Dial-On-Demand router is to provide establishment of a ship to shore connection via satellite. The DDR would also provide link management for the reduction of connection time and streamlining of Point-to-Point Protocol (PPP) [9]. The web proxy was created with the intent of providing "intelligent caching" that would compress the header data from a web page and prevent the shipment of that header after the initial transmission. The web proxy would also provide data compression of the contents of the web page so that fewer packets were required to browse the web. The email proxy was created with the intent of batching emails and then compressing the data before transmission. The email proxy would also streamline the Simple Mail Transfer Protocol (SMTP) and disconnect after shipment was complete [10].

Technical Approach

Before the actual simulations were commenced, the networks had to be in working order. The two test beds were revamped to meet future criteria by integrating new computers. The server onboard the large cutter was upgraded to Windows 2000 Professional Server with Exchange 2000. Several other computers were replaced with computers using Windows 2000 Professional.

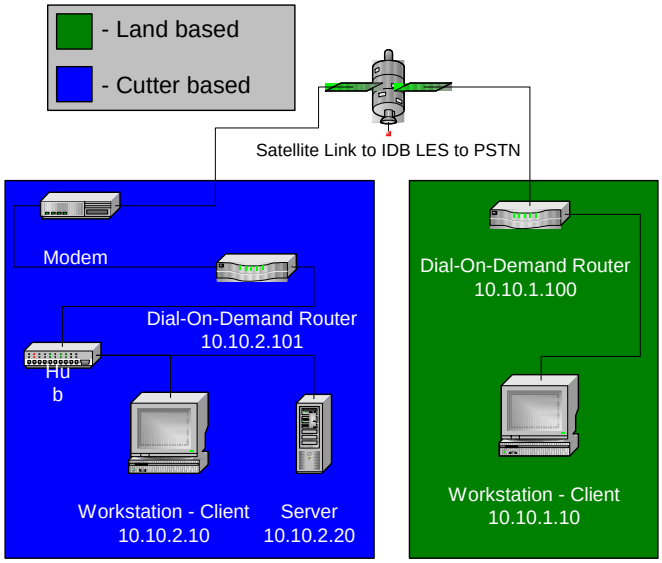
On the large cutter test bed, optimization of the simulated satellite connection was examined using the Dial-On-Demand router and both the web and email proxies. The large cutter was established as shown below in Figure 2.



Large Cutter Testbed

Figure 2

On the small cutter test bed, the efficiency of the connection was studied using 56 kbps modems. The Dial-On-Demand router and proxies were used to optimize this already slow connection. The small cutter test bed was established as shown below in Figure 3.



Small Cutter Testbed
Figure 3

The recently obtained web proxy software and newest versions of the Dial-On-Demand router and email proxy were installed and configured to their specific test beds. Once the networks were complete, they were documented using Visio. Testing commenced with the compatibility of all software for errors or inconstancies with either the hardware or software.

After compatibility was determined, simulations commenced to more efficiently share data over the simulated satellite links. The simulations included the transfer of packets using different sizes and such to find the most effective rate and size to save the Coast Guard funding.

Email was sent from both shore side and shipside and packets were viewed through Ether Peek to determine if the software is making the communications more efficient. Several web pages were established on the shore side. These pages were downloaded by the shipside and transfers were viewed over Ether Peek also.

Results

This project has met some tough stepping-stones throughout the progression of this academic year. The first hurdle for the project was the establishment of the test beds. The large cutter connection operationally simulated the 64 kbps satellite link. There were issues with the original version of Microsoft Exchange 2000 Server that made it impossible to configure properly. The second hurdle of this project was the usage of the Microsoft Windows 2000 Professional operating system on the Dial-On-Demand router computers, because the ATC software could not access the Host file that was needed. This problem was solved by installation of Windows NT

on the DDR computers. These were the issues faced during the first semester. The second semester saw continued struggles but finally both test beds were finally operational.

A visit to TISCOM revealed another factor about the usage of satellites by large cutters. The new connectivity policy for the fleet provided that each large cutter was reserved time blocks during each day to use the Internet and transmit email. The current setup for large cutter's email in the fleet had also been altered. Each large cutter had an Exchange server that would store onboard email until the connection was established.

The small cutter test bed was removed from simulation because results from last year were sufficient and the web proxy could be studied on the large cutter. In reaction to this visit and small cutter removal, focus was placed on development of the web proxy software on the large cutter test bed. The web proxy had many bugs that had to be worked out through intensive testing on the test bed and packet viewing by Ether Peek. Daily communication with ATC became a way of existence for progression of the project.

In order to use the Dial-On-Demand router on the large cutter test bed, the satellite simulator had to be removed and replaced. Two 56 kbps modems were used to simulate the satellite connection with a delay emulator in between the ship and shore. The final version of the large cutter test bed is shown below in Figure 4.

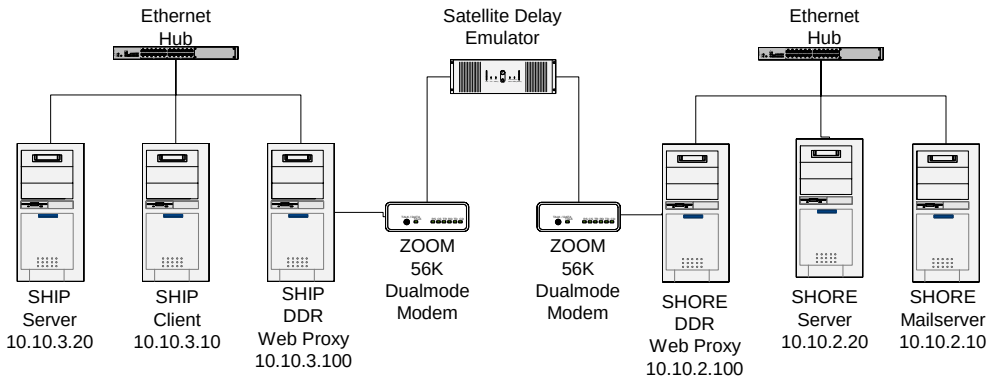


Figure 4: Final Large Cutter Test Bed

Multiple problems were found with the initial versions of the web proxy. The web proxy did not correctly communicate with the Dial-On-Demand router. The web proxy would not download the web page once the connection was established. Once the web proxy began downloading the page, there was an error in the code that told the proxy not to send the page to the cutter because it did not receive a finished acknowledgement. The web proxy also had issues with handling certain size packets.

After all these problems, on a bright day in April, the connection was established and a web page appeared on the shipside. The web proxy became operational and testing of its abilities commenced immediately. It requests the connection from the Dial-On-Demand router. The web proxy was taken through a series of testing situations. The web page was downloaded several times without the web proxy using simply a web browser. The web page was then downloaded several times using the web proxy and web browser. The intent of these tests was to establish if

the web proxy appropriately used the “intelligent caching” and if the batching and compression was effective.

The first test web page was a four-page text document. The average results are shown below in Figure 5 and the individual test results are shown in appendices A compare the usage of the web browser with and without the web proxy software. In the first test, the web proxy downloaded the page about seven times faster than the test without the proxy. The second test web page was a 350-page text document. The average results are shown below in Figure 5 and the individual test results are shown in appendices B. In the second test, the web proxy downloaded the page about nine times faster than the test without the proxy. The third test web page was a graphically intensive page. The average results are shown below in Figure 5 and the individual test results are shown in appendices C. In the third test, the web proxy downloaded the page at almost the same rate as the web browser without the proxy.

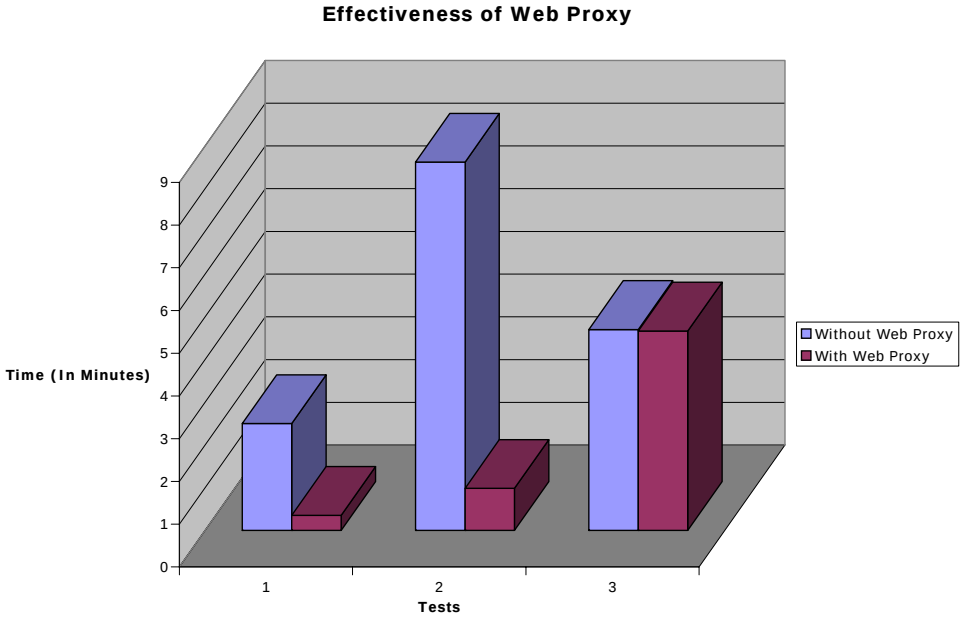


Figure 5: Web Proxy Results

Conclusions

Testing proved that the web proxy is a very effective means of downloading text-based web pages. The intelligent cache effectively saves and compressed the headers for the web pages. The web proxy also did an excellent job of batching the data from the web page and then compressing it. Testing proved that the web proxy provides no increase in efficiency while viewing graphically intensive web pages. This is due to the fact that graphic files are already compressed data.

The web proxy in combination with the Dial-On-Demand router has been successfully proven as valuable assets to the Coast Guard in the ongoing battle to save funding. The next step is believed to be the usage of the web proxy software on an operation cutter for the determination of ultimate viability.

While the email proxy was not tested, the possibility of incorporation of the abilities is still a viable option. The current MTA for Exchange Server onboard the cutters could be modified using the email proxy technology to improved efficiency and functionality.

References

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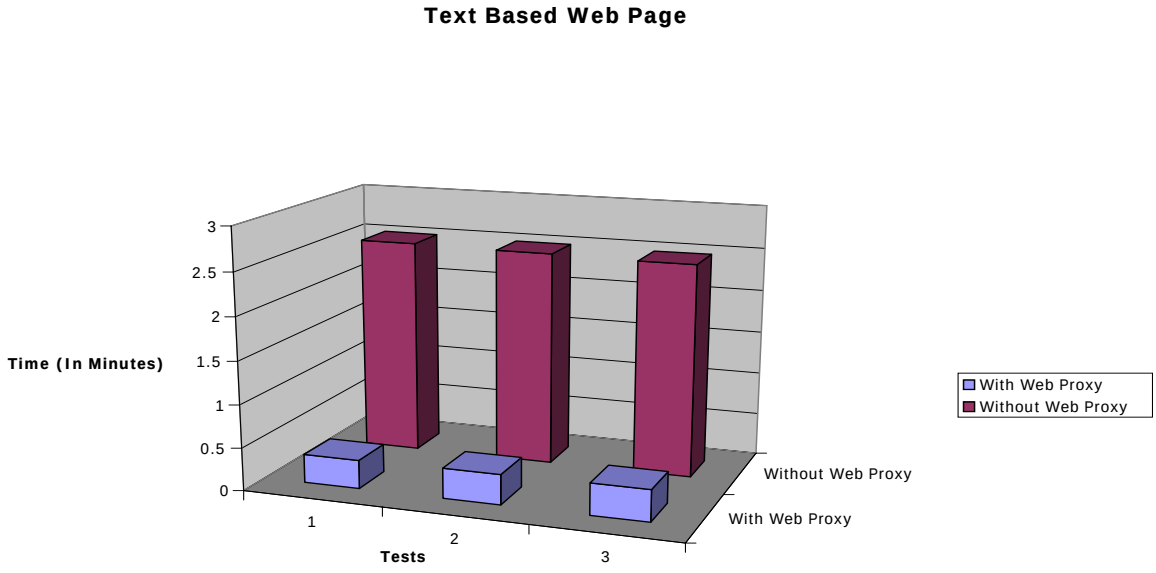
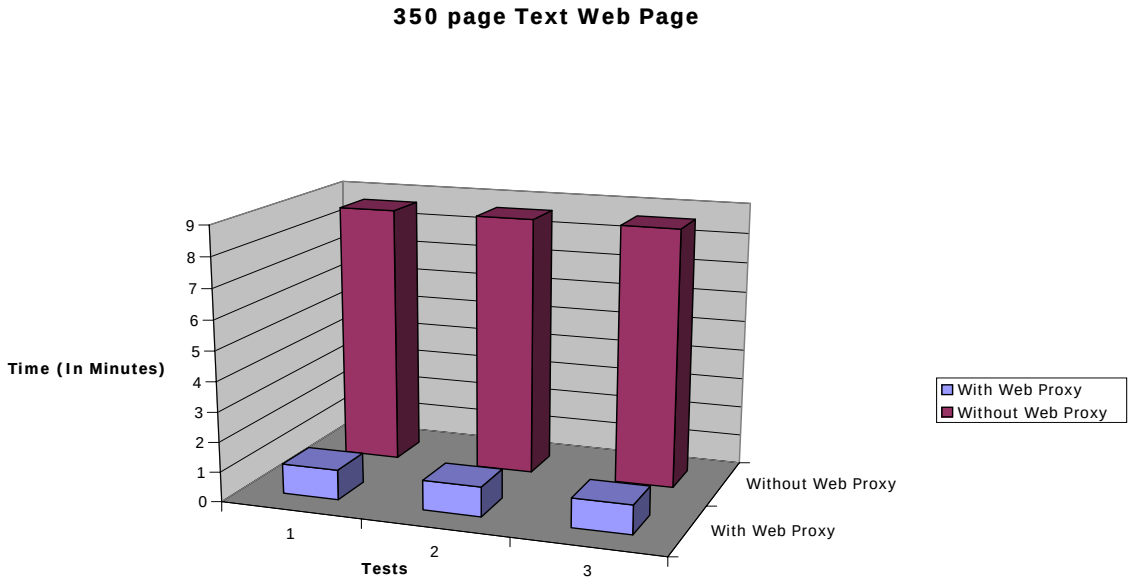
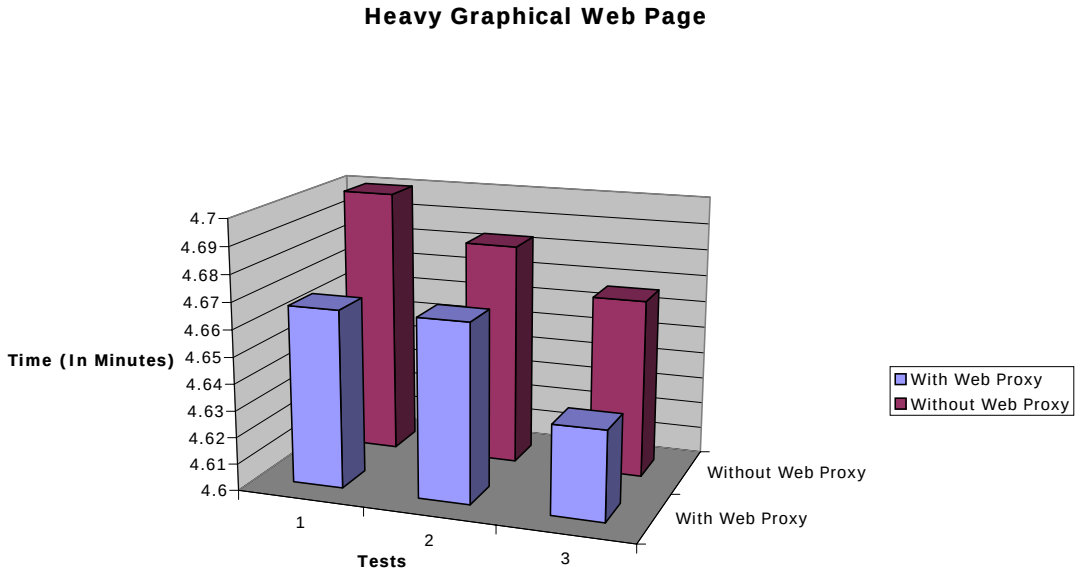
Appendices



Appendices A



Appendices B



Appendices C