INTERNET ACCESS FOR INSTRUMENT CONTROL AND DATA VIEWING AT BEAR LAKE OBSERVATORY

Kerry M. Nelson
Space Dynamics Laboratory and
Department of Electrical and Computer Engineering
Utah State University
Logan, Utah

Abstract

Two departments at Utah State University have collaborated to operate an observatory near Bear Lake, Utah. The purpose of the observatory is to study various phenomena in the upper atmosphere, and houses such instruments as high-power CCD cameras, a radar system, and others. Until recently, only one instrument has had the capability of being controlled and monitored remotely. Since the other instruments do not have this capability, they must be set up and left running, only to have a person drive up to the observatory to check their operation after a given amount of time. This monitoring system is not only costly in terms of research time, but has been the cause of data loss in the past. The system reviewed in this paper was designed to provide a low cost, short-term solution to the problem of remote access. A computer system located on the USU campus communicates to a gateway computer at the observatory, which, in turn, is connected to the various observatory instruments. The communication takes place over an existing telephone line using a standard serial line protocol (PPP). This communication is then routed through World Wide Web servers on the two computers to provide a simple user interface.

Background

As part of the goal of researching the upper atmosphere, Space Dynamics Laboratory (SDL) and the Center for Atmospheric and Space Sciences (CASS) at Utah State University (USU) operate an observatory near Bear Lake, Utah (shown in Figure 1). Data is collected at Bear Lake Observatory (BLO) from a variety of instruments, including high-power CCD cameras, a radar system, and others. Each of the various instruments at the observatory is controlled by its own computer, but, until recently, only one instrument (an FPI) was almost fully automated with a dedicated telephone line for data downloading to the USU campus. Thus, although the observatory was operational, there were a few concerns pertaining to instrument operation that needed to be addressed. For example, to make sure that the instruments were functioning correctly, someone had to regularly drive up to BLO to check their operation. This was particularly important for the CCD cameras operated by Mike Taylor that require large amounts of data storage capacity. Also, once a system was set up and running, there was no way to control how much data was taken (e.g., camera data was taken even when it was cloudy). Because of this, automatic operation had proven difficult and data had been lost on some occasions.

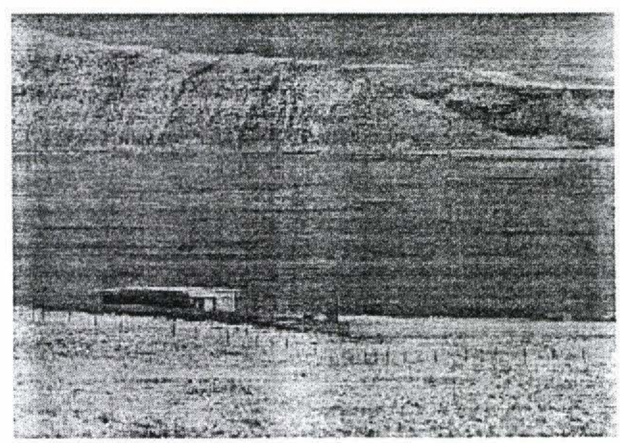

Figure 1: Bear Lake Observatory

Various solutions were considered when this problem became apparent. The driving force behind the solution was that it had to be as low-cost as possible. Also, because each of the different instruments at BLO is controlled by its own computer system, the solution had to have the capability to interface to a variety of computer platforms. Since there were other telephone lines already in place at the observatory, most of the solutions focused on some sort of serial line communication. Further, the solution had to provide some reasonable level of security for the data and instruments and BLO. Finally, the solution did not need to be a permanent fixture, but should provide a temporary answer to the problem.

Eventually, a novel solution was proposed to connect BLO to the Internet via the World Wide Web (WWW) to alleviate this problem. This Internet solution turned out to best meet the solution criteria. First, computers that already existed on campus could be used to do the communication so that no new hardware had to be purchased. One of the reasons for the growing popularity of the WWW is its ability to allow data to be viewed independent of platform. Therefore, using a WWW browser as the front-end software package would allow the various computer platforms to be interfaced easily. Next, because the Internet can be used over a telephone line, no new communication wire needed to be laid. Also, interfacing the WWW system to a secure computer platform would allow for a reasonable measure of system security. Using a Web-based system would be a helpful temporary fix, yet would provide other benefits as well. For example, the instruments at BLO could be monitored from any campus computer connected to the Internet. Even better, researchers could check on their systems from their home computers or their portable computers when away from USU. Also, other scientists throughout the world could more easily collaborate with those in Logan by easily being able to view very current data at USU. Finally, once the communication system at the observatory is eventually upgraded, little or no changes would have to be made to the remote access system.

System Design

The system was originally designed to have two IBM-compatible computers running a version of the Linux operating system. (See Figure 2 on page 3 for a system diagram.) One of these computers would be located on the USU campus, would be permanently connected to the Internet through the campus network, and would have the capability to dial out to the observatory. The second computer would also be running Linux, would be located at the observatory, and would permanently be connected to the BLO phone line. Both of these computers would be running a WWW server program to provide the user-friendly interface. The campus computer would function as the gateway between the Internet and the observatory; the BLO computer would function as the gateway between campus and the instruments' computer systems. As is shown in the figure, the observatory gateway computer would have the capability of interfacing to many different computer platforms including DOS and Windows 3.1, Windows 95 and Windows NT, a standard UNIX platform, and any computer using Novell's IPX system.

Many decisions had to be made about the tools needed to build this communication system. These decisions included which computers to use to do the communicating, which operating system the computers would be running, what type of communication would take place over the phone line, and which type of Web server software should be used.

Linux

The UNIX operating system has been around for years, and is the widely accepted platform in which to network computers. Linux is an operating system that tries to mimic UNIX, except it runs on a personal computer instead of a workstation. Since UNIX and Linux inherently provide network support, it seemed wisest to use one of these operating systems for the BLO system. Because of the goal of keeping this communications system very low cost, it was planned to use older IBM-type PCs that were collecting dust in the ECE department of USU or SDL. This made Linux the logical choice, as it can be installed even on older PC systems.

There are many versions of Linux, most of which are in the public domain (freeware). After some research, it was determined that the best version of Linux to use would be the one distributed by Red Hat. The Red Hat version of Linux provides one of the easiest install methods and supports most standard UNIX programs. It also has extremely helpful documentation, both with the software itself, and on the Web with the Linux Documentation Project. Red Hat Linux also makes it easier to set up PPP and Web servers than most other Linux versions. Also, Red Hat Linux provides interfaces to DOS and Windows-based systems, UNIX systems, and Novell's IPX. For these reasons, Red Hat Linux was chosen as the operating system for the two communication system computers.

PPP

For many years, the standard method to communicate over a telephone line was using the Serial Line Interface Protocol, or SLIP. Recently, though, a

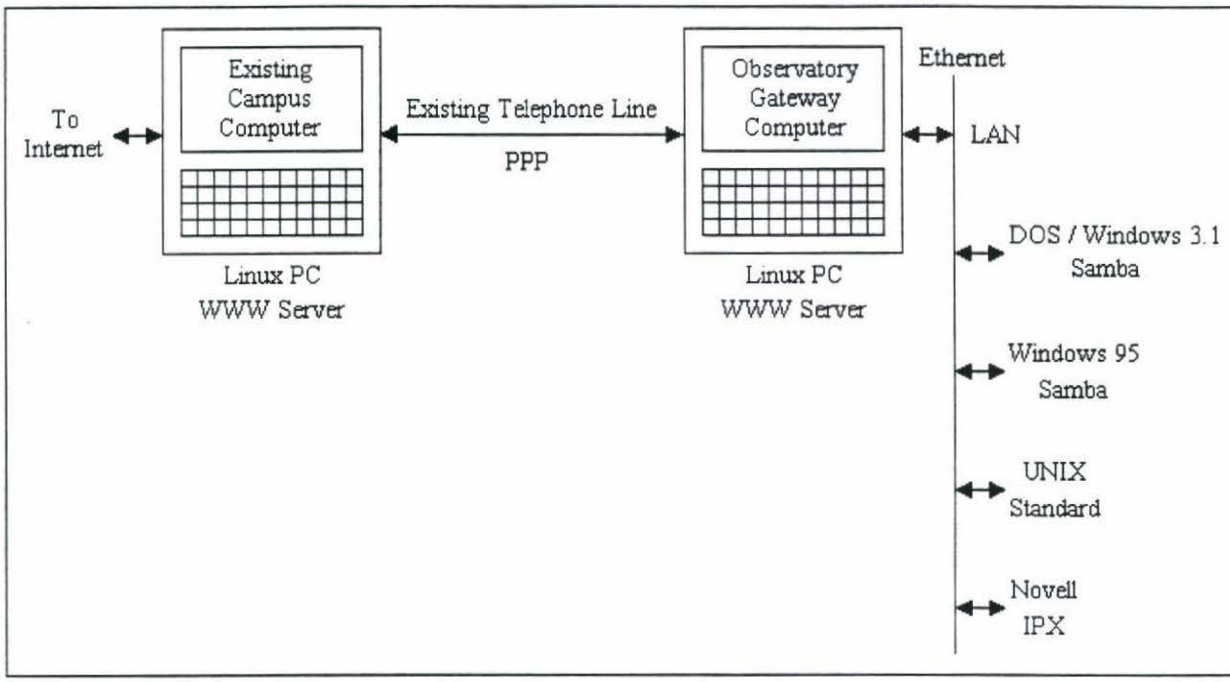

Figure 2: System Diagram

new method was developed called PPP, or Point-to-Point Protocol. PPP offers many benefits over the more traditional SLIP method. First, it lets the two communicating devices negotiate options such as IP (Internet Protocol) address and the maximum datagram size at startup time. Next, it provides for authorization on both the client and server side, making the whole system a lot more secure. Also, PPP provides support for Van-Jacobson header (or VJ-header) compression of IP datagrams, allowing a faster communication rate. Finally, a PPP frame is capable of holding packets from protocols other than IP, such as Novell's IPX or Apple's AppleTalk. Because of these benefits when compared to SLIP, PPP is almost universally accepted as being the superior serial communication protocol. For this reason, PPP was chosen as the way to implement the communication over the telephone line to BLO.

Apache

There are also a wide variety of World Wide Web server software packages available in the public domain. The Web server that was chosen for this project was Apache, which has a few advantages over other servers. First, Apache not only follows all of the HTTP guidelines set by NCSA, but also fixes numerous bugs and security holes in some of the original (NCSA) server versions. Apache is also faster and, in some ways, more efficient than any of the other servers. Finally, the documentation that comes with Apache is far better than with most other Web servers.

System Implementation

Once all of these tools were assembled, there was still quite a bit of work involved to get the whole system to work together. First of all, computers were located to use for the communication. Because a lot of the initial testing was to be done with Dr. Mike Taylor's CCD cameras, he donated the use of one of the fast Pentium machines in his Imaging Lab. This computer was used as the campus computer with the permanent Internet connection. Dr. Dyke Stiles of the ECE department graciously donated another PC (a 386) to be used as the observatory gateway computer. Next, Linux had to be installed on the two communication computers. Red Hat has made it quite easy to first install the operating system and to get the computer up and running. But, to streamline the system and to choose which packages are running, the Linux kernel must be re-compiled. This task required a lot of work, partially because each of the two computers required a different kernel. Both kernels required the PPP interface to be installed, which took a lot of "tweaking". Once both computers were running a stable kernel, the Apache Web server was installed. Because of the good Apache documentation, this was a fairly easy process. A WWW site was then created on the campus computer

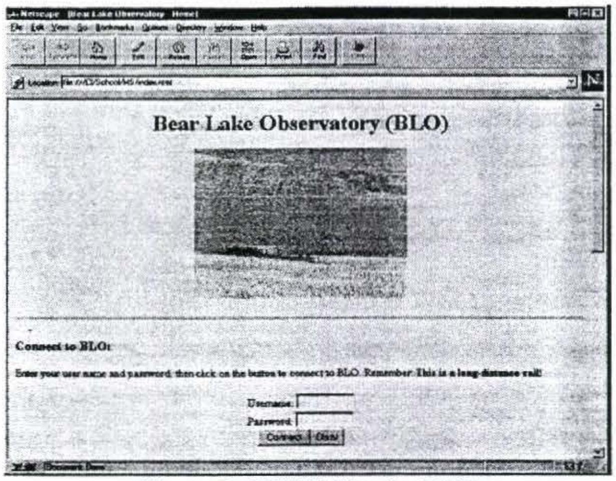

Figure 3: WWW Site for BLO

for interfacing the system to the Internet. (This site can be reached at the address given in the summary, and is shown in Figure 3 above.) The home page for the observatory communication system allows users to enter a username and password, and then to connect to the observatory. This was implemented with a "Guest" username to allow other researchers the opportunity to view Bear Lake data. Once a user logs in through the Web page, he or she may then upload commands to the different instruments, check their operation, and download data samples. After a certain time-out period, the BLO gateway computer shuts down the connection, as the telephone call to the observatory is long-distance. The programs to log in to BLO, shut down the connection, and interface to the various platforms were written in C and then interfaced to the Web page through the Common Gateway Interface (CGI) ability of the WWW server.

System Testing and Verification

As of this writing, the Internet communication system is still in the implementation phase. Once completed, the system will be tested on the USU campus before installing it at BLO. These tests are being done using a Phone Line Emulator wired between the two computers with normal telephone cables. The final interface tests will be done using one of Dr. Mike Taylor's CCD cameras. After these final tests, the system will be made available for all the instruments at BLO.

Summary

In summary, this communication system offers many benefits.

- The cost was low because many of the components were made from existing parts.
- No new communication line had to be laid to BLO, though this system allows for a faster connection to be implemented in the future.
- The data at BLO is accessible for viewing from anywhere in the world, yet is secure.
- Fewer trips have to be made to BLO (i.e., for data retrieval only), cutting down on travel expenses and wasted time.
- Verifying data and functionality of the systems is straightforward, and may be done while sitting at any campus or home computer.
- Other parties interested in the systems at BLO can access information from their respective locations.
- A range of data displays for viewing over the Internet will be expanded upon at a later date.

The communication system can be reached at http://soton.sci.sdl.usu.edu. To log in anonymously, use the username "Guest" and the password "BLOGuest".

References

[1] Apache WWW Server documentation: http://www.apache.org

[2] Red Hat Linux installation documentation: http://www.redhat.com

[3] Red Hat Linux, Linux Documentation Project: http://www.redhat.com/ldp/LDP, (PPP, WWW servers, platform interfaces)