AC 2008-1720: DESIGN AND SETUP OF A NETWORKING AND DISTRIBUTED PROCESSING LAB FOR RECRUITING, TEACHING, AND RESEARCH

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Abstract

In our continuous efforts to enhance the undergraduate curriculum in the Computer and Information Sciences department, we have created a new infrastructure networking and distributed processing lab (UTB/TSC-NDPL). The primary goal of this infrastructure is to enhance the existing curriculum in the undergraduate level by providing a state-of-the-art environment, isolated from the university campus network, in which Computer and Information Sciences (CIS) students can get hands on experience in areas such as Networking, Ad Hoc Computing, Wireless and Mobile Networking, Operating Systems, Image and Video Processing, Computer Vision and Distributed Processing.

The involved faculty, joined by top selected students, went through three distinct phases in creating the networking and distributed processing lab (NDPL): design and setup, specification and implementation, and integration into CIS curriculum. The design phase of the project relates to setting up the physical and logical topology of the network. We enclose a copy of the final design adopted as an appendix. The implementation phase relates to the choices of the equipment purchased and the different factors that influenced these choices as well as their overall role in the lab. As the design and implementation phases were completed, the CIS faculty created a new set of courses and lab modules to take advantage of the NDPL. Some new courses were created after the completion of the lab that include Internet/Intranet Server, Internet Communications, and Web Sever Support and Maintenance. Additionally, many lab modules were created to support current and existing courses and to improve research related to NDPL. These lab modules range from simple network setup and configuration to more advanced topics such as firewalls, streaming media, parallel computing, and distributed processing. The paper describes in detail the lab modules and how they relate to different competencies and course objectives set up by the department and based on accreditation authorities in the field.

Since its inception and based on enrollment figures NDPL has played a vital role as a catalyst in retaining students in CS/CIS by allowing them to create and work in realistic real-world environments. Such unprecedented exposure is facilitating certification and licensure and is increasing the students' competitiveness in the job market as well as preparing them for graduate studies in Science and Engineering should they choose to pursue that avenue.

Keywords:
Implementation of an Integrated Lab, Networking, Distributed and Parallel Processing, Operating Systems.

Introduction

Our university is the first "community university" in the nation and a unique partnership that joins a community college, and a university. This partnership combines the strengths of a community college and that of an upper-level university by increasing accessibility to students

and eliminating inter-institutional barriers while fulfilling the distinctive responsibilities of each type of institutions.

The University is relatively new as it was created in May 1991 as the newest component of its system. The institution currently enrolls over 14,500 students with more than 92% Hispanics. In an effort to meet regional demands in science and technology, a new Science, Mathematics and Technology College (SMT) complex was recently built to house computer science, engineering technology, physics, and mathematics course offerings.

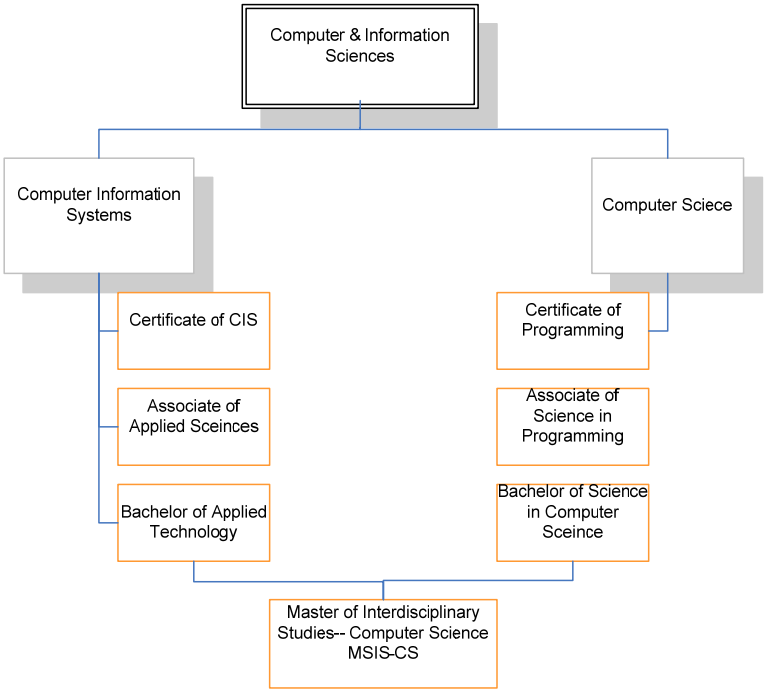


Fig. 1. CIS Programs

Part of the Science, Mathematics and Technology College (SMT), the CIS department has more than 652 students majoring in its technical and science (academic) disciplines. As figure 1 show, two disciplines have parallel degrees with the technical offering a Certificate of Computer Information Systems, Associate in Applied Science, and a Bachelor of Applied Technology in Computer Information Systems, while the Computer Science offers a Certificate of Computer Programming, Associate in Science in Computer Science, and a Bachelor of Computer Science. We have designed the MSIS-CS with different tracks (with a different set of courses) to allow graduates from both the BAT-CIST and the BSCS to enroll in the program. Table 1 shows our healthy and increasing numbers in all the degree we offer; our first MSIS-CS student is scheduled to graduate in fall 2008.

Table 1

UTB/TSC CIS Majors

Major	**Fall 2005**	**Spring 2006**	**Fall 2007**
One-Year Certificate	689	792	783

Two-Year Associate(AAS.CIS)	132	151	164
Four-Year BAT-CIST	54	57	65
Four-Year BSCS	164	158	174

As evident from the above table, the CIS enrollment has been increasing in the past three years. Consistent with the university's commitment to be the area's leader in Science and Technology, the NDPL is a cost-effective, inter-disciplinary vehicle for education and research within the department. NDPL can also serve the entire college by catering to a vast range of labs for courses offered in the different departments. In the coming years, we truly believe that the lab will bring forth a broad and positive change within the college (in terms of the degree programs offered) by providing a "technological rendezvous" for education, research, and inter-disciplinary cooperation. We also envision a myriad of research projects, for the students and faculty, springing out of this lab by our creation of research opportunities outside the scope of standard course work, and, as a positive side effect, promote the view of science, mathematics, and engineering as a cooperative enterprise.

Description

Computer networking and distributed processing have not only become a way for distributed resource sharing and remote communication but also have introduced new trends in education, information delivery, consumer patterns, business practices, and more. The vast amount of applications developed for the Internet, like the Web, make computer networking an integral part of our daily life. These new trends and applications, including concepts and disciplines encompassed, have introduced new research and educational requirements demanded by industry and/or society that are reflected in work force demands, employment figures, research grant opportunities, and enrollment in educational programs related to computer networking.

Tying in concepts and techniques from networking and distributed processing (NDP) into the curricula will better prepare students for future work force, and is therefore a major component of this application. The goal of the lab was to incorporate elements of NDP into existing curricula in science, mathematics, and engineering through the integration of carefully designed lab modules into our programs.

After its set up, NDPL has been utilized as a hands-on training lab which augments the classrooms by providing an environment for students to gain real-life experience in building, configuring, operating and troubleshooting complex hardware and software components. Eventually, it will also be a research facility for a wide range of areas: from Networking and Security, Streaming Media, Video Conferencing, Super and Grid Computing, Concurrent and Distributed Processing to Artificial Intelligence, to name a few. Additionally, it will serve as a recruiting tool for students interested in a science, mathematics, engineering, or even an inter-disciplinary career.

The research component is dynamic depending on the current interest of faculty and students. The teaching component of the lab, on the other hand, is more structured as it centered on a set of modules that span a wide range of topics. Each module is related to one or more courses identified as key-targeted courses. Table 2 shows the initial set of the key-targeted courses.

Table 2.	
Targeted Courses by Tracks	
Computer Science	**Computer Information Systems**
COSC 3330 Networking and DB Management	ITNW 2409 Network Administration for Intranet
COSC 4190 Senior Project	ITNW 2459 Web Sever Support and Maintenance
COSC 4310/5310 Operating Systems	CIST 3330 Networking and DB Management
COSC 4330 Computer Graphics	CIST 4310 Operating Systems Management
COSC 4335/5335 Computer Vision	
COSC 4342/5342 Database Management	
COSC 4349/5349 Computer Architecture	
COSC 4350/5350 Artificial Intelligence	
COSC 4355/5355 Expert Systems	
COSC 4333/5333 Digital Image Processing	
COSC 4360/5360 Numerical Methods	
COSC 4313 Computer Networking	

We selected the above courses carefully because they serve the whole range of degrees offered in the department from the associate all the way to the masters. This preliminary set of courses is by no means exhaustive and is expected to grow dynamically as new educational standards, recommendations, and research interests are identified and incorporated into the curricula. Additionally, we expect more active participation from the college faculty and students as (research/educational) results from deploying the initial lab modules are disseminated. The lab modules, their content and structures, are discussed in a later section.

In addition to regular courses, the NDPL was made available to students, faculty, and staff of the university to fulfill their senior project requirements, conduct independent research, and prepare for industrial and national certification (in areas such as Networking, Telecommunications, and Operating Systems Administration) respectively. Many of the senior projects will be an expansion of work started by the students in the key targeted courses.

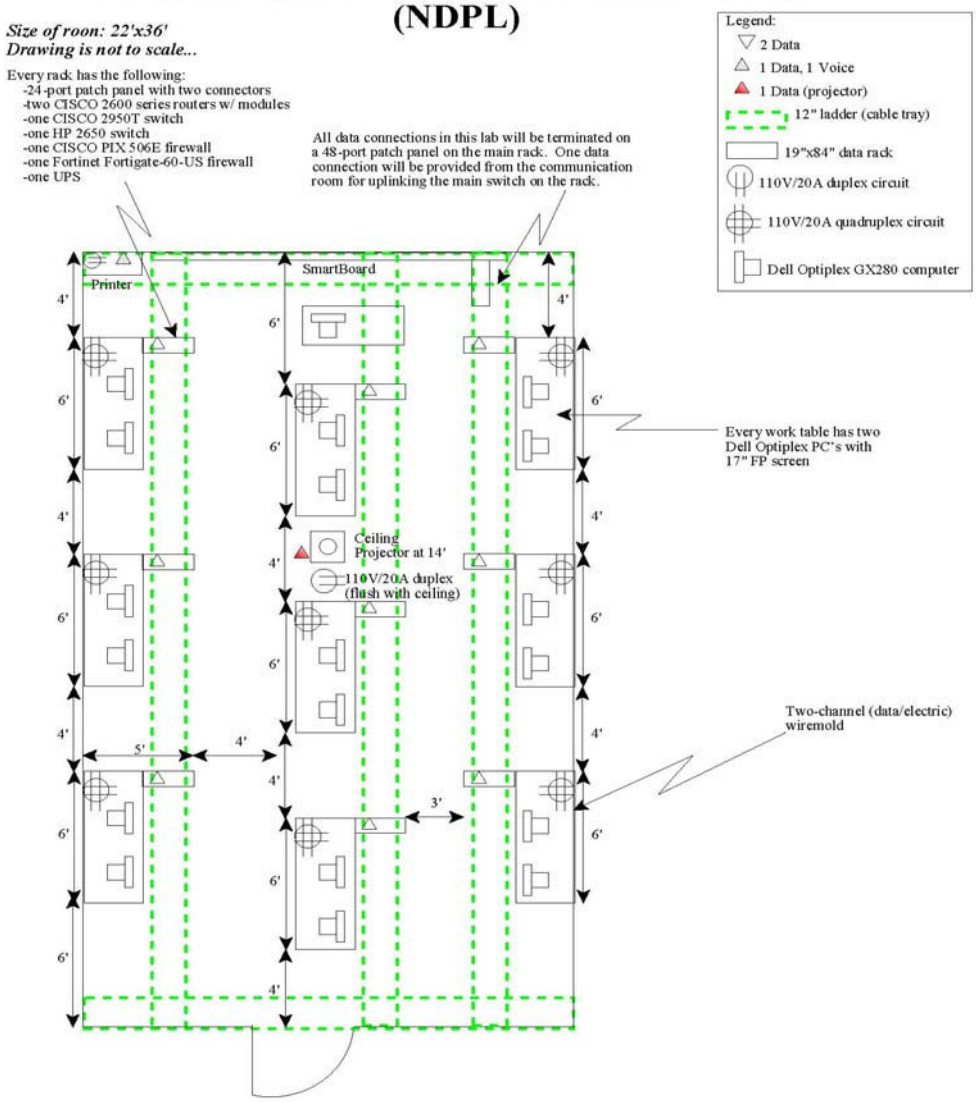
Engineering Plan & Layout
The lab uses a total of approximately 22’ x 36’ lab area. The infrastructure networking equipment was complemented by the existing in-house equipment from BCEIL. Currently, the existing equipment includes:

Image Capture Equipment
2 CCD Cameras 2 Image Capture Cards Flash Bus MX 332 with Flash Bus MX SDK
Video Codecs
2 Polycom Viewstation V.35 2 VFI 32" Videoconferencing cart 2 Sony KV-32S42 32" Video Monitor
Simulated PSN
2 Larscom Access T 211
Mini PBX (VoIP)
1 CALLMANAGER-3.3 1 CON-SNT-MCS7825H1 SERVE 1 SW-CCM-3.3-7825 CON-SAU-CCM33-25 CISCO 2651XM-V-SRST VWIC-1MFT-T1 CON-SNT-2651SRST WS-G5484 1000BASESX GBIC 4 CP-7940G/ 4 SW-CCM-UL-7940
24-node Beowulf cluster
24-node Beowulf cluster constructed from 24 Pentium computers, three Alpha workstations, and 10Mbps network switching matrix with an Asynchronous Transfer Mode (ATM) uplink

Details of the lab follow.

Lab Design
Based on current and projected enrollment figures for the targeted courses, we came up with the following design for the lab.

Networking and Distributed Processing Lab (NDPL)



Based on the above design, the seating capacity of the lab is 18 students and one professor. The lab consists of 9 independent student workstations to allow for customized operation, configurations and troubleshooting by a team of two students.

Each workstation simulates a Public Switch Network (PSN) with the help of two routers each with Wide Area Network (WAN) interfaces. Each router has a firewall and a switch connected to its Local Area Network (LAN) interface in order to simulate real world LAN environment. Each LAN has a computer attached to it. Each computer in a LAN is used to provide a computing resource as well as a tool to configure LAN/WAN devices.

In essence, each workstation simulates a real world PSN connecting two LANs in distant geographical locations. Also, the two routers, switches and firewalls are different in each workstation. In other words, the two routers in each workstation are of different models having different features. Similarly, the two firewalls and switches are of different models and brands. This is to expose the students of each team to different types of routers, firewalls and switches that are available in the real world. For example, one of the switches is a switch-router rather than being a switch only. There is a growing trend in networking where the switches and routers are merging in terms of switching and routing features.

Besides building a networking training environment, the lab also provides one for distributed computing. The flexible environment makes it possible for one to learn different aspects of networking, for example, cabling, configuring devices, and implementing routing protocols. The environment is ideal for learning distributed computing since all the workstations are networked to each other as well. The whole lab represents a Beowulf supercomputer with eighteen nodes. As an integrated component in the Science, the lab is accessible to all disabled students, faculty, and staff. Funding for the lab came from the Carl Perkins federal program.

Lab Installation

On of the faculty was in charge of the lab installation because of his extensive experience in the field. As the Director of Infrastructure, Telecommunications and Networks (ITNet) Operation at the university, the faculty has overseen and has been personally involved in the installation of Gigabit Ethernet fiber backbone for various UTB/TSC campuses. The faculty also designs the institution's computing labs. He is in charge of overseeing the design and implementation of the communications infrastructure for the new buildings and renovations of the existing buildings. The professor has started providing wireless networking in 1997 and under his watch, 80% of the campus has access to wireless networking at this time. His operation has a research wing where network security, trouble detection, and management software are developed. He has consistently involved students in all of these efforts in order to enhance their college experience. The new facility is allowing greater number of students to have similar enrichment experience.

The construction of the NDPL was completed in June 2005. The professor then taught the students the nuts and bolts of the development of the NDPL facility. Students then completed the installation under his supervision. This gave students immediate hands-on experience. Students who were interested in the initial installation were identified and asked to document the installation process for future students. The information gathered was then disseminated to faculty and staff.

Lab Management Plan
The following set of the NDPL modules will be eventually created as follows:

NDPL-151: LAN Setup & Administration

NDPL-156: Heterogeneous Network Administration

NDPL-161: Routing Algorithms

NDPL-166: Secure Communication

NDPL-201: Congestion Control and Quality of Service (QoS) in Streaming Media

NDPL-206: Real Time Protocols

NDLP-251: Asynchronous/Synchronous Replication

NDLP-256: Distributed Query Processing

NDLP-351: Remote Procedure Calls

NDLP-356: Multicomputer Scheduling

These lab modules will accompany the relevant targeted courses, but will also be used independently; such as in cases of independent research, senior projects, and preparation for certification.

Staffing
Due to its technical nature, the lab is administered by the CIS department and only qualified students from all departments within the college are eligible to work in the lab. As part of the sustainability of this lab, the Lab assistants' wages and maintenance and operation budget are allocated from incidental fees, charged by each of the key-targeted classes, which are currently in place. Beyond its instructional use, NDPL, with special arrangement with researchers and senior project mentors, is available for use 24-hours/day, seven days/week.

NDPL Modules
The NDPL modules are focused on maximizing the utilization of the new lab. However, the flexible design of the lab allows development of new lab modules over time. The following is a breakdown of the initial NDPL lab modules.

NDPL-151: LAN Setup & Administration
The students will learn how to setup Local Area Networks including configuring switches and routers to make it happen. They will be exposed to Virtual LANs for separating and securing traffics of different components of an organization. They will learn the basics of tools available for permitting or denying different types of network traffic.

NDPL-156: Heterogeneous Network Administration
The realities of real-world network traffic involving Wide Area Networks and Local Area Networks will be studied. By setting up a local Public Switched Network (PSN) and associated data/voice channels over simulated leased lines (e.g. T1's), they will learn how the real-world PSN and its components invariably affect network speed and integrity between two distant locations. They will learn programming of routers for end-to-end connectivity of LANs and

WANs over a PSN. They will learn the basic mechanisms of programming the routers via Access Control Lists for permitting or denying certain type of network traffic.

NDPL-161: Routing Algorithms

The students will learn different types of routing algorithms. They will start with static routing mechanism. They will be exposed to CISCO and non-CISCO routing algorithms such as EIGRP, RIP, OSPF and BGP. Each routing algorithm has its place in the networking world. Therefore, each selected algorithm will be studied and experimented with in detail.

NDPL-166: Secure Communication

Students will be made aware of different levels of security that can be implemented in a networking and computing environment. They will be started with programming of network firewalls including designing and implementing Access Control Lists. They will learn how to install and invoke host firewalls on a computer. Most of all they will be taught that the preferred method is to communicate using secured tunnels such as Virtual Private Network (VPN) because the network that a computer is connected to must always be assumed to be compromised. They will also be exposed to other network security features, e.g. MAC locking, RADIUS, MAC-IP pair discrepancies and 802.1x type of protocols. Biometrics methods to gain access to a computing resource will also be included.

NDPL-201: Congestion Control and Quality of Service (QoS) in Streaming Media

Congestion control and quality of service, especially for streaming media, are emerging as some of the most active areas of research. In this module, students will work on different algorithms for congestion control and QoS and the trade off between them. Techniques for congestion avoidance, packet scheduling, traffic shaping, admission control, and resource reservation will be exposed in great details.

NDPL-206: Real Time Protocols

Real time computing is important for time critical processes. Students will be taught how to prioritize traffic. For example, how voice packets can be given priority over non-critical type network traffic. Students will also be taught how to separate critical and non-critical network traffic into different Virtual LANs and apply priority at the LAN level. Students will learn bandwidth shaping and rate-limiting techniques to throttle certain type of network traffic depending on the bandwidth needed for critical network traffic.

NDLP-251: Asynchronous/Synchronous Replication

Replication is a technique to implement a distributed database by creating copies of a database relation or its fragment into different interconnected computers. Database replication has the advantages of a more reliable system, and a faster computation of local queries compared to a centralized database organization. Students will implement replication methods in order to measure and improve transmission costs of asynchronous and synchronous replication.

NDLP-256: Distributed Query Processing

Implementing query processing in a distributed database may be an involved process if the query requires the integration of information coming from several remote databases. In this lab module students will implement algorithms to improve distributed query processing, including caching, query optimization and pre-fetching.

NDLP-351: Remote Procedure Calls

Remote Procedure Calls (RPC) has become one of the most important frameworks in

multicomputer software. Students will implement RPC programs in order to deeply understand and practice the concepts of stubbing, marshaling, and the client/server architecture under RPC.

NDLP-356: Multicomputer Scheduling

In the multicomputer scheduling problem the operating system must decide not only what process should run next, but also what processor would execute the process. Elements that will be practiced in this lab module include time sharing, space sharing, and two traditional multiprocessing algorithms: co-scheduling and gang scheduling.

Computation and involve in projects like evolutionary computer graphics, evolutionary music, and evolutionary innovative design (e.g. circuits discovery).

NDLP Assessment

As an ongoing project, we have been collecting results and feedback on the modules for improvement. The following table gives an approximation of the number of students per year who were/will be directly affected by the NDPL lab.

Department	Course	Lab Modules	No. Students*
CIS	ITNW 2409: Network Administration for Intranet	NDPL-151, NDPL-156, NDPL-161, NDPL-166	25**
CIS	ITNW 2459 : Web Server Support and Maintenance	NDPL-151, NDPL-156, NDPL-161, NDPL-166	25**
CIS	CIST/COSC: 3330 Networking and DB Management	NDPL-151, NDPL-156, NDPL-161, NDPL-166, NDLP-251, NDLP-256	27
Engineering & CIS	COSC 4313/5313: Computer Networking	NDPL-151, NDPL-156, NDPL-161, NDPL-166, NDPL-201, NDPL-206	10
CIS	COSC 4330: Computer Graphics	NDPL-161, NDPL-166 NDPL-206, NDPL-211,	13
CIS	COSC 4333/5333: Digital Image Processing	NDPL-161, NDPL-166, NDPL-201, NDPL-206	13
CS/CIS	COSC 4335/5335: Computer Vision	NDPL-161, NDPL-166, NDPL-201, NDPL-206	15**
CIS	COSC 4342/5342 Database Management Systems	NDLP-251, NDLP-256	9
CIS	COSC 4349/5349: Computer Architecture	NDPL-156, NDPL-166, NDLP-251, NDLP-256, NDLP-351, NDLP-356	15**
CIS	COSC 4355/5355: Expert Systems	NDPL-301, NDPL-306, NDPL-311	15**
CIS	COSC 4360/5360 Numerical Methods	NDPL-106, NDPL-161, NDLP-351	13
CIS	COSC 4310/5310: Operating Systems	NDLP-351, NDLP-356	10
CIS	CIST 4310: Operating Systems Management	NDLP-156, NDPL-166	10**
CIS	COSC 4190 Senior Project	All Modules	15
Total Number of Students			**289**

*Based on student enrollment in the past offerings of the class
** Indicates new offerings with expected enrollment

Two of our future goals are to evaluate the effect of the lab modules on student enrollment and student retention, and to collect all the modules upon their creation in a manual and have it available on the web. This is expected as the courses go through their offering cycle (two-year cycle). The following sample testimonial from one of the classes is typical of the positive response we have been getting from the students. We are currently compiling all such evaluations to generate an annual improvement action plan.

Students Testimonials

In this section, we present a sample student testimonial that shows the type of hands-on knowledge that became available to the students through NDLP.

<table>
<tr><td colspan="5">Statistics for COSC-4313/5313, Computer Networking
Course offered every fall semester</td></tr>
<tr><td>No. Of Students</td><td colspan="4">19</td></tr>
<tr><td>Students overall Grade in the course</td><td>A
8</td><td>B
7</td><td>C
4</td><td>D
0</td></tr>
<tr><td rowspan="6">Comments from students</td><td colspan="4">I loved implementing my senior project using the camera and the TCP protocol.</td></tr>
<tr><td colspan="4">The labs cemented my understanding of class concepts</td></tr>
<tr><td colspan="4">The labs were fun to implement.</td></tr>
<tr><td colspan="4">I like hands on; easier to understand</td></tr>
<tr><td colspan="4">The distributed x-o game was fun to implement.</td></tr>
<tr><td colspan="4">I enjoyed the server and client side messaging application in java. Was not hard to do.</td></tr>
</table>

Impact on College and the Region

An ambitious, but realistic goal has been set to raise the level of education and research in the areas of Science, Mathematics and Engineering in a manner that shows them as integrated and related disciplines. By creating the NDPL, our students have been able to participate in hands-on learning as well as state-of-the-art research topics. The Advisory Board, which is a conglomerate of prominent and skilled professionals from the local industries, has repeatedly emphasized the need for our students to develop many of the skills that the NDPL addressed in practical ways. Recent surveys and reports confirmed this need; According to the U.S. Department of Labour, network systems and data communication analysts are the second occupation (only after medical assistants) with the highest growth rate which is estimated to grow at more than 50% during 2002 to 2012 (Source: U.S. Department of Labour, *Tomorrows Jobs*, June 2004).

An added benefit to the creation of NDPL was the facilitation of obtaining standard certification in the highly demanded networking and telecommunications arena. The U.S. Department of Labor estimates that 437,000 people were employed during 2004 as network administrators or network systems and data communications analysts (Source: U.S. Department of Labor, Occupational Outlook Handbook: Mathematical and Computer Occupations, June 2004). These numbers do not take into considerations software engineers, managers, and other computer science occupations that may involve computer networking training.

Conclusion

We have shown that integrated the NDPL can be an invaluable tool in implementing the educational goals set by the department to insure the delivery of top quality *education* and *research* to students in the CIS area. As the students graduate, they are bound to make important contribution as work force professionals. Our goal is to integrate gradually the lab into many key courses in CIS through a thought-out institutionalization and departmentalization process that has already started.

Appendix B

Sample Lab Session, Lab #1

Device Console

Physical Lab Setup:

The lab has several racks. Each rack has network gear to mimic two WAN nodes; the top WAN node is referred to as WAN Node 1 and the lower as WAN Node 2. Each rack is complemented with two computer workstations. Two participants need to be stationed at each rack. Each participant is expected to use one workstation. The participants need to work together to design and implement connectivity across the two WAN nodes. The workstation closer to the rack is for WAN Node 1 and the farther workstation is for WAN Node 2.

1. Examine the switch in your respective WAN node:

-brand:_____Cisco Catalist 2950_____

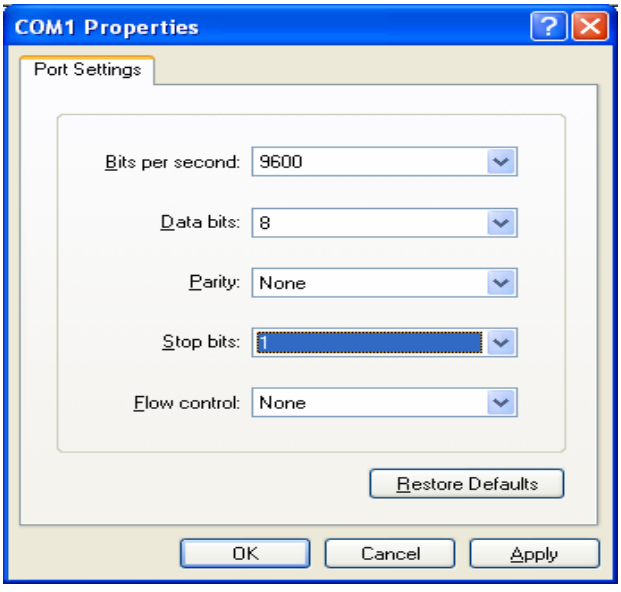
-number of ports:___28 ports 2G_____

-RS232 access:____no access ports_____

-Uplink ports:____two Gig T uplink ports_____

2. Connect to the switch's console port by using a straight-through patch cable to the available serial port on your workstation:

-Access the switch's console using hyperterminal session at 9600-8N1.



-Use ? in conjunction with SPACE-BAR and ENTER keys to browse through the available commands.

-Enter Privileged mode by entering ENABLE command.

-Browse through the available commands.

-Enter "show running-config" command to look at the existing configuration.

-Look at the state of the ports (find the relevant command by browsing through the available commands).

3. Enter the configuration mode (use "config t" command): (e.g. config t ENTER)

-Browse through the available commands by pressing the ? symbol and ENTER.

-Assign an IP address to VLAN 1 according to the following scheme:

10 . Rack# . Node# . 1/24

-First go into the interface mode of the switch (type in interface).

-Press the SPACE BAR and type in the ? symbol to see the available commands.

-Type in VLAN 1 and then ENTER. (e.g. vlan 1 ENTER)

-Type in ip address (10. Rack# . Node#.1 255.255.255.0) then press ENTER.

(e.g. 10.9.2.1 255.255.255.0)

-Type in no shutdown and press ENTER.

-Save the running configuration by:

-Type in exit then ENTER

-Type in exit then ENTER again

-Type in write mem

- You can check your modifications by typing show running config then ENTER

4. Assign an IP address to your workstation according to the following scheme:

10. Rack# . Node# . 17/24

-Access TCP/IP properties of your workstation and assign the above IP

1. Go into the Start Menu of your computer and click on the control panel option.
2. In the control panel menu click the Networking and Internet Connections.
3. Then click on the Networking Connections option.
4. This will bring up the Local Area Connection icon.
5. Left click on the icon with your mouse and choose the properties tab for the menu.
6. Highlight the Internet Protocol (TCP/IP) option and then choose the properties button.

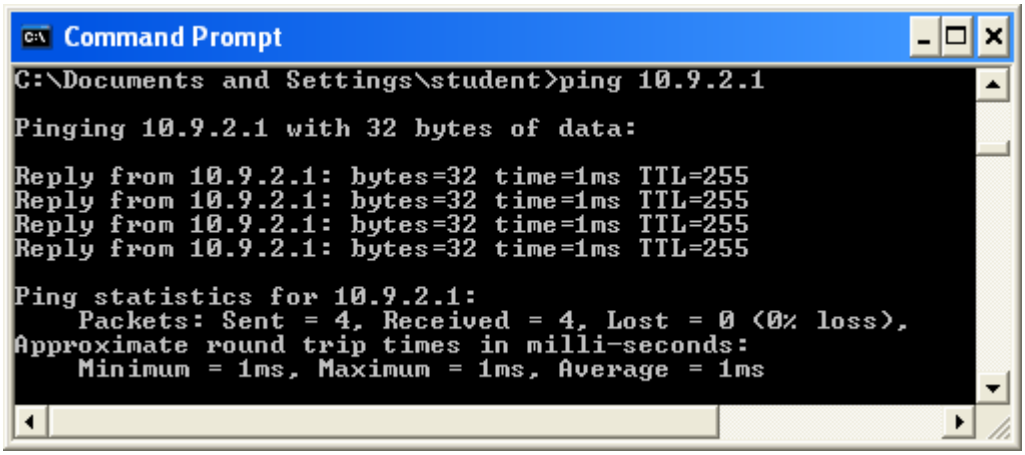
7. In the IP address text box type in: 10. Rack# . Node# . 17 (e.g. 10.9.2.17).

8. In the subnet mask text box type in: /24 (e.g. 255.255.255.0).

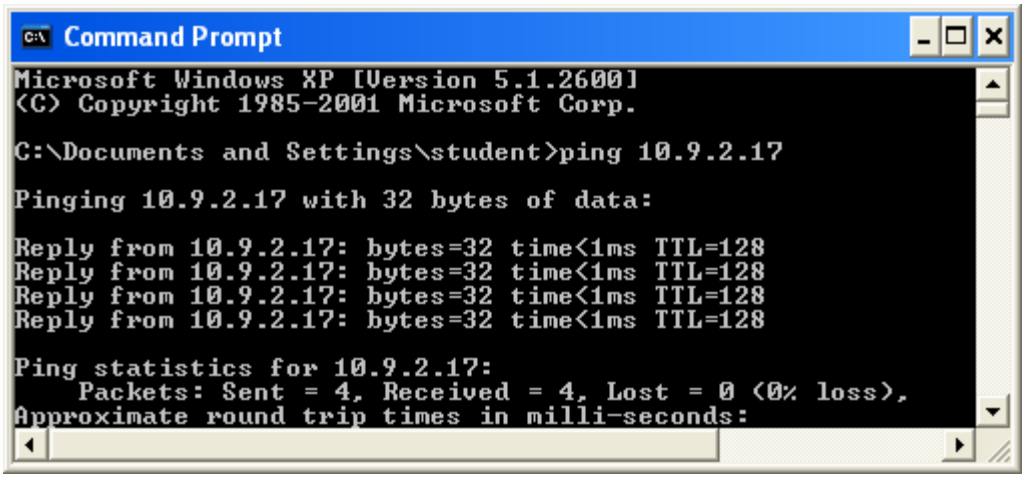
9. In the default gateway text box type in: the ip address of vlan 1 (e.g. 10.9.2.1).

-Connect your workstation to the switch in your node using Ethernet medium

-Using DOS Shell on your station, ping the switch.



-Similarly, using console of your switch, ping the workstation.



5. From the DOS Shell on your workstation, launch a telnet session into the switch on your WAN node.

-Confirm that telnet provides you with similar access to the switch as serial console did.

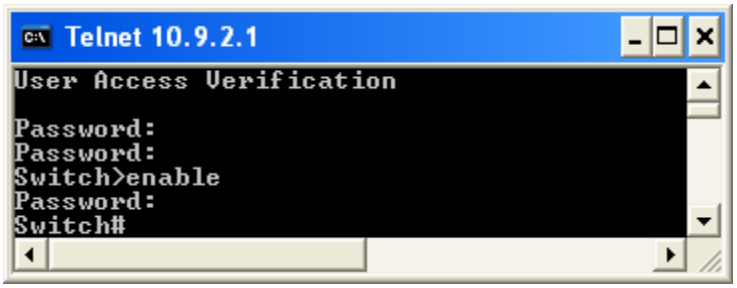
1. In the command prompt type in telnet.

2. Type in o for open then the ip address for the vlan.

3. Enter the password you set for enabling telnet.

4. Then it goes into the switch and you enter the password you set for the switch to enter into enable mode.

5. Type in enable and you are in your switch.



6. Using a browser on your workstation, try accessing it:

   -Make note of how different is the access if any.

   1. Open internet explorer or any other browser.

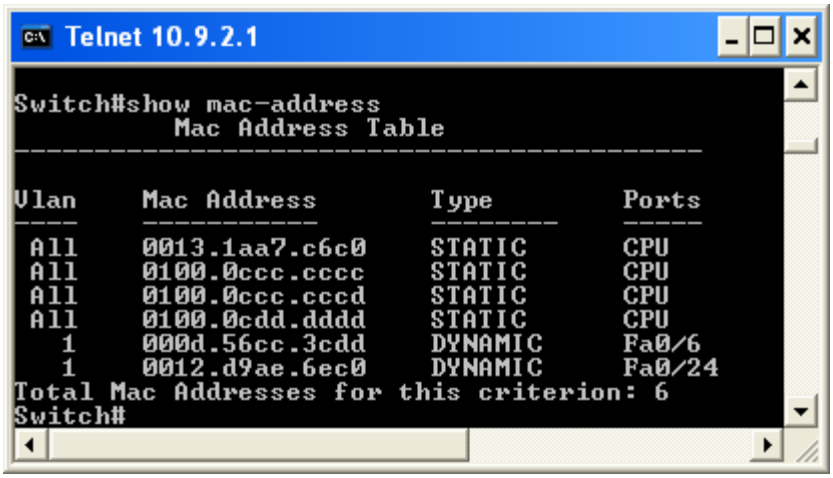
   2. In the address bar type in the ip address of vlan 1.

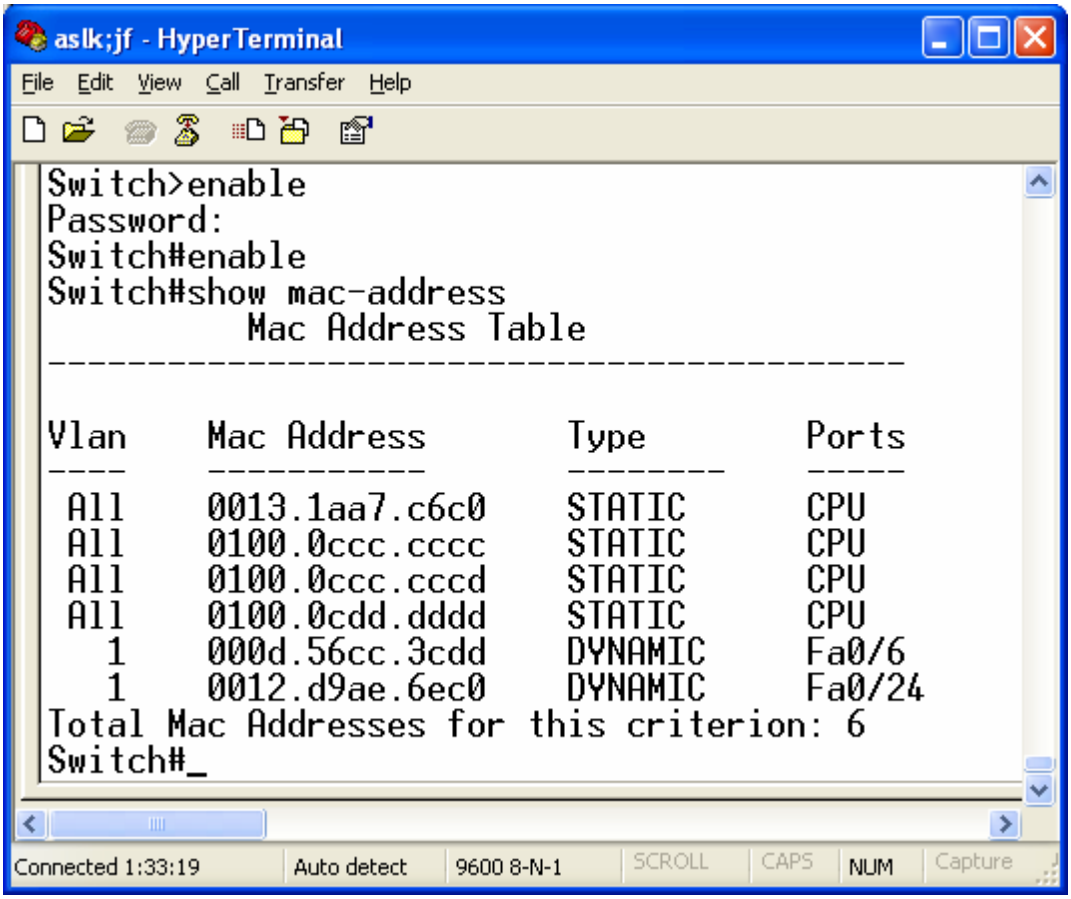
7. Display the MAC table on the switch:

   -Find the MAC of the NIC on your workstation and confirm that the MAC table on the switch has correctly associated the workstation's MAC with the respective port.

   -Connect your workstation on another port and check if MAC table is updated.

   -Observe how long it takes to remove an entry from the MAC table.




aslk;jf - HyperTerminal
File Edit View Call Transfer Help
Switch>enable
Password:
Switch#enable
Switch#show mac-address
Mac Address Table
Vlan Mac Address Type Ports
All 0013.1aa7.c6c0 STATIC CPU
All 0100.0ccc.cccc STATIC CPU
All 0100.0ccc.cccd STATIC CPU
All 0100.0cdd.dddd STATIC CPU
1 000d.56cc.3cdd DYNAMIC Fa0/6
1 0012.d9ae.6ec0 DYNAMIC Fa0/24
Total Mac Addresses for this criterion: 6
Switch#_
Connected 1:33:19
Auto detect
9600 8-N-1
SCROLL
CAPS
NUM
Capture