

AC 2007-1447: EXPLORING NEW ONLINE LABORATORY MODULES FOR THE ONLINE COMPUTER NETWORKING COURSE

Fanyu Zeng, Indiana Wesleyan University

F. FRANK ZENG is an Assistant Professor in Computer Information Systems at Indiana Wesleyan University, Marion, Indiana while still working in IT industry as an independent IT consultant and trainer. His research interests include data communication, networking, database, software development and software engineering.

Exploring New Online Laboratory Modules for the Online Computer Networking Course

Abstract

This paper presents a new set of learning laboratory modules for an online computer network course. These innovative laboratory modules are originally selected from existing computer network laboratory modules commonly used in a centralized laboratory. The goal to design these new laboratory modules is to provide online students with the same learning experience as students in a centralized laboratory. The philosophy for the new laboratory module design is to utilize simple networking devices, networking simulation software and Internet access from every online student's home to carry out all the laboratories defined in these laboratory modules. These new distributed laboratory modules overcome the constraints caused by the unavailability of a centralized laboratory for online students. Because of these specially designed laboratory modules, online students have gained the same learning experience as students in a centralized laboratory.

1. Introduction

Computer network courses are traditionally conceptual in nature with an emphasis on opportunities for students to apply networking theory in their practices in order to strengthen their knowledge in the theory and develop their practical problem solving skills. Therefore, a laboratory environment is a key component in any computer network course. The lab design for new online computer network courses first encounters a number of constraints that traditional networking courses do not have. The key issue is that there is no centralized laboratory for online students to physically attend, nor does any online course module clearly define any feasible practice in the laboratory [9]. There are many onsite computer network laboratory modules used in a centralized laboratory with clear standards and requirements [6] [7] [9] [10]. A few online computer network training courses offer guidelines for an online network laboratory [5] [8]. Most of them rely solely on software simulations on specific networking devices [8]. There has not been an existing laboratory module for an online computer network course to meet the same standards and requirements defined in an onsite computer network course and laboratory.

Needless to say it has been a challenge to design networking laboratory modules for a networking course in online or distance learning programs where a laboratory is essential [8] [9]. In order to address this issue, it is necessary to study and develop a new set of laboratory modules for online programs with availability of distributed resources. The key contribution in these new modules is to overcome the constraints of the unavailability of a single laboratory for the online students. Although it is impossible to offer a centralized laboratory in this situation, the solution is to offer students another type of laboratory module by taking full advantage of availability of simple and inexpensive networking devices in a student home. Every online student can run networking simulation software on their PCs. Also, every online student has their own Internet

access. By fully utilizing these resources, online students can gain a similar experience from their exercises at home and eventually achieve the goals that students can achieve in a centralized laboratory.

2. Design Philosophy of New Online Computer Network Laboratory Modules

There is no doubt that the computer network course is a practical course for Associate's degree program in Computer Information Technology. It introduces the basic concepts of networking and mainly focuses on developing a student's ability to solve practical networking problems. It is evident that there should not be any significant difference in its goals and course contents between onsite and online computer network courses. Therefore, it is determined that no compromise will be made for online computer network course and its laboratory as well.

Keeping all the core laboratory modules and their ultimate goals from the existing onsite computer network laboratory modules will enable students to carry out all the practical hands-on networking laboratories required in traditional networking laboratories in a distributed environment. As a result, online students will gain a similar experience in solving networking problems as the students in a centralized networking laboratory. The vital philosophy in online computer network laboratory module is determined to be emphasized based on onsite computer network laboratory and technology available at a typical online student's home [6]. It has a number of perspectives:

- Laboratory goals, requirements and standards in online learning environment – Although most of laboratory modules are self paced, self instructed, and self conducted; the goals, requirements, and standards in online learning environment are kept unchanged.
- Interaction – All the laboratories are designed to be highly interactive. Online students are able to communicate with their instructors and their classmates effectively via online learning environment.
- Mentorship – Online students can be mentored by their instructors via all communication resources between students and instructors.
- Help and feedbacks – Students are able to seek help from either their classmates or instructors in online learning environment. Instructors are able to send feedbacks to their students instantly.
- Simulation – Part of online laboratory activities can be simulated by specially designed software so that online students will work with the same user interfaces and gain the same experience that onsite students can have in a centralized lab.
- Compliance to onsite networking laboratories - Students learn only what they need to learn and what they should learn in an online networking laboratory. Same laboratory module designs, goals, files, exercises, and questions are included in those modules.
- Evaluation and assessment throughout laboratory exercises – All online laboratory modules ensure students will gain the same learning experience without any compromise. The requirements and outcomes are enforced and measured in every crucial laboratory module with the same standards. Instructors are able to test student's laboratory exercises and share their feedbacks with students instantly in an online networking laboratory.

With all of these principles the new distributed laboratory modules ensure that online students will gain the same experience as students in a centralized computer network laboratory. Students enrolled in the online computer network course will go through all the core laboratory modules. The same goals are going to be achieved in the online networking laboratory.

3. Contents of New Online Computer Network Laboratory Modules

In order for online students to succeed in the onsite computer network laboratories, the same standards and philosophy from onsite computer network laboratory modules are kept in new online computer network laboratory modules [4] [5] [8].

- Same laboratory goals, standards, guidelines and contents from online class and chapters in the textbook
- Same timelines with every checkpoint at a specific date
- Same outcome at every checkpoint
- Same grading matrix

In a centralized computer network laboratory instructors control the student's environment because they have monopoly on every single laboratory activity [5]. However, there seems to be a lack of this type of monopoly in a distributed laboratory environment. Students have their own control of pace, duration of their laboratories, and even control the outcomes of their laboratory exercises. Thus, additional guidelines and standards are crucial to the new online computer network laboratory modules. New means and resources are developed to ensure the same goals are achieved in the online computer network laboratory:

- Learning contracts – enhanced course syllabus and detailed lab manuals
- Online course and multiple dimensional instructional strategies – a variety of means for instruction and communication
- Interactive lecture – effective features in online teaching software Blackboard
- Tracking lab progress – instantly control and monitor students' laboratory progress and outcomes at every milestone in each laboratory module.

Another key contribution of this innovative approach is to explore a number of new design concepts. We intend to take full advantage of the availability of all crucial network devices, networking simulation software, and Internet access. After reviewing the required equipment in centralized computer network laboratories, particular network equipment and technology were integrated into online computer network laboratory modules [5] [9]. The technology and equipment include:

- A powerful PC with Windows XP
- A variety of affordable networking devices, such as, CAT-5 cable, hub, switch
- A Virtual Lab software
- Internet access from every student's home

Utilization of these resources available at every student's home makes it possible for students to conduct all computer network laboratories defined in the new online computer network laboratory modules. In addition to the previously stated thoughts, effective instructions and communications between instructors and students make most laboratories more centralized rather than distributed without any significant compromise. Besides newly adopted equipments and technology, other components below are added into the new online computer network laboratory modules to further improve the quality of the new computer network laboratories. These new components further enhance students' learning experience and guarantee the success of computer network laboratory modules with advantages over centralized laboratory modules:

- Interactions – Blackboard, email, group chat room and instant messenger via Blackboard makes multi-dimensional communications available to students and instructors that are uncommon in any centralized laboratory.
- Discussion Forum – A variety of discussion forums with specific topics are set up on Blackboard. As a result there are more interactions among students and instructors.
- Self-directed learning – Students are self motivated to make their plans, follow guidance and laboratory manuals, meet requirements, and achieve specified goals.
- Mentorship – Instructors use all communication channels for their teaching via Discussion Forums and Communication tools in Blackboard and email.
- Project collaboration and collaborative learning – Collaborations are emphasized on group assignments. More discussions and help happen via group forums in Blackboard.

Special accomplishments in the new online computer network laboratory modules include five computer network laboratory modules designed for distributed environment with compliance of all the goals and standards set up in typical onsite computer network laboratory modules [1] [2] [3]. These five networking modules from onsite computer network laboratory have been proved to be essential to providing students with opportunities to enhance their knowledge in networking, review difficult concepts, and obtain a better understanding of the concepts, something that is nearly unattainable from a normal classroom [8]. New online computer network laboratory modules also keep essential factors to enhance the students' learning and understanding of certain important and difficult networking concepts [5] [6]:

- Network basics and connectivity testing: Ethernet CAT-5 cable, hub, switch, network installation and network connectivity testing (ping and whois)
- Studying important network addresses
- Network management, TCP/IP protocols, and IP addressing - traceroute, nslookup, netstate, and arp
- Network standard studies: ISO/OSI 7 layer model
- Network implementation: SOHO network design and implementation and network security

The minimum requirements for those laboratories are identified as a powerful PC, Microsoft Windows 2000 or XP, CAT-5 cable, hub, switch simulation software, router

simulation software, and the Internet connection service [5]. Appendix A includes a list of computer network laboratory equipment for these five laboratory modules. Obviously computer and networking equipment at any online student's home can meet these minimum requirements. Therefore online students are able to conduct these computer network laboratories from their homes and accomplish all the tasks independently with proper plans and instructions.

3.1 Network Basics and Connectivity Testing

The physical linkages of a network continue to be the most neglected components in many computer network laboratories [9] [10]. However in reality many network-related problems result from poor cabling. In order to address this issue and train students' practical problem solving ability, students are first instructed to make a UTP cable before learning to build a reliable, efficient, and cost-effective network cabling infrastructure. After they master these techniques, they will learn to avoid common pitfalls and troubleshoot problems as quickly as they arise. In this laboratory module, students are required to make a UTP cable by using tools, such as, CAT-5 Cable, RJ45 connector and RJ45 Crimping Tool to make a UTP cable [3].

After the Ethernet UTP cable is made, a network connectivity test is their second task in this laboratory module because testing physical network connectivity is essential in any computer network troubleshooting. Students use their self-made UTP cable to connect their own PC to a switch/hub to learn how to test network physical connectivity. They are also instructed to try their PC's "Network Connection" to test any physical network connection exists. Because PING command is widely used to test network connectivity, students learn to use network command "PING 127.0.0.1" to check network connectivity between their PC and network. Lastly, after network connection to PC purposely gets disconnected students repeat the same PING test to see different results after a network connection is not available.

3.2 Studying Important Network Addresses

Students are instructed to follow the steps described in Appendix B to obtain key network address information of their PC and its network, such as, MAC Address, IP address, subnet Mask, DNS address, DHCP address. Students learn how IP addresses on a PC play their role for a network [1] [2]. This networking lab module also serves the purpose to conduct basic networking exercises at lower layers of OSI model later on.

3.3 Simulation Software to Learn Network Management, TCP/IP Protocols, and IP Addressing

With more and more routers and switches are widely used it is necessary for students to explore the interfaces of the network devices like router and switch. Virtual Lab software product for networking [4] is an effective tool used in this online computer network laboratory module considering that not every student has a switch or router. Students will benefit from this laboratory module and train their practical skills in performing essential network configuration tasks and gain insight into real-world implementation of Cisco internetworking technologies including network planning and designing, implementation

and operation; and LAN troubleshooting [1] [2] [4]. Typical router commands, such as, traceroute, nslookup, netstate, and arp are repeatedly used to perform those tasks part of which are recorded in Appendix C.

3.4 Understanding All The Layers in OSI 7 Layer Model

The OSI model is a 7 layer network protocol model in support of network communication. Each layer in the OSI model has its unique responsibilities and passes information to the layers above and below it. Eventually each layer virtually passes information to its corresponding layer on another host [1]. Students often have difficulties grasping this concept or are unable to obtain a dynamic picture of OSI working model in their mind.

Understanding all the layers in OSI model is what allows students to master the WAN networking technology, rather than someone who master a few commands on a router or to perform a configuration for a router. It further develops a student's ability in troubleshooting network so that they will be prepared to configure the most scalable or desirable solution used in today's large IP networks. Proper subject selection and preparation is a vital part in this module to fully understand OSI model. This network laboratory module includes planning, designing, testing and troubleshooting with a small network using a set of routers and switches. Therefore, commands to test network connectivity between devices, such as ping loopbacks, ping directly connected interfaces, IP routing (fix one protocol at a time)—show ip route, debug ip route are often used in this laboratory module.

The whole laboratory starts its work from the lowest layer. After it is complete, the protocol state of your connections should also be active. Students then check Layer 2 network connectivity by using the show cdp commands to see if the networking devices have discovered each other. This is a simple tool when students are pressed for time to ensure them to enable CDP globally and on the interface. Students still may not see any CDP.

The most crucial tool for this laboratory module is still the simple ping command. This simple command is a student's "best friend" in their computer network laboratory. In fact, when working on computer network laboratory, students will use the same command to verify network connectivity so they can quickly verify their own solutions as well.

To test Layer 1/2 connectivity between two routers over Frame Relay, for example, simply ping the remote router. If it does work, use debug ip packet or debug frame to decipher the problem. Keep using ping around all the IP network interfaces to ensure that full network connectivity is established. If students can ping over the WAN but not the remote network, students need to check their IP routing table. With a combination of the extended ping command and show ip route, students can quickly see where in their network routing is not occurring.

To use the traceroute command to verify no routing loops. This command quickly scrolls down to about 100 entries.

Finally, to ensure Layer 7 connectivity, students are instructed to use the telnet protocol to ensure full connectivity. If students cannot perform telnet, they probably have a problem within their network. Students who typically accomplish this task by the half-way mark of the lab generally succeed in passing the lab module. Their network should have full OSI connectivity from Layer 1 to 7.

In summary, some of the most useful tools in this laboratory module are below (not limited):

- ping
- arp
- netstat
- traceroute
- telnet
- trace
- debug ip packet
- debug frame

Appendix D compiles a recording of inputs and outputs from a student's exercise while this student tried to explore all the 7 layers of OSI model to enhance understanding of OSI 7 layer model and applications of OSI model.

3.5 Group Project – A New SOHO Network Design

The purpose of this laboratory module is for students to become familiar with the issues faced by network administrators and engineers while they are required to make decisions on a new network design and collaborate their works on implementation. The design for a SOHO Home Office Network Design is a group network concept design and it includes several important steps below.

- Download and install LanFlow Network Diagrammer (trial version) from <http://www.pacestar.com/lanflow/trial.htm>
- Using TigerDirect.com or a similar source, research the following items for newly designed network:
 - a. 2 PCs with Windows XP Professional Upgrade
 - b. 1 tower file server with Windows Server 2003 Standard (Full – 5 CALs)
 - c. 1 HP black & white laser printer
 - d. Uninterruptible power supply for server-related equipment
 - e. Surge suppressors (2 PCs, 1 printer)
 - f. Wireless router/switch combination unit
 - g. 50' patch cables to connect PCs and printer to hub
 - h. 5' patch cables to connect server-related equipment together
 - i. MS-Office 2003 Std Upgrade on each PC
- Designate a student within the group to use Microsoft Excel for the purpose of creating the purchase list above and provide Item Name, Cost, Quantity and Justification for each item mentioned. A detailed plan and timeline can also be created and recorded on the same Excel spreadsheet.

- Place the PCs, File Server, Printer, Wireless Router/Switch, DSL Modem, Internet Cloud, and appropriate connection lines within the network diagram. Be sure to assign a unique valid Class C IP address to each device as appropriate. Each student within the group will turn in their own diagram, though the group may discuss it.

4. Results and Analysis

Survey results obtained from students show that it is feasible for any online student to complete tasks specified in new online computer network laboratory modules for the online computer network course if they make full use of their home office computer, networking equipment, and the Internet access. It also proves that this new approach provides online students with the same quality of laboratory exercises and experience as that in a centralized computer network laboratory environment while the same goals are achieved. The new online networking laboratory modules prove considerably beneficial to enhance online students' learning and most of the students gained as much practical experience in networking as traditional students with access to a centralized networking laboratory.

In addition to that, it is found that there are some factors that particularly contribute students' achievements in this online course. Most of the online students enjoyed the flexibility to be able to conduct their computer network laboratory at their home at any time. Their independent laboratory practices have greatly enhanced their self learning ability and independent problem solving skills. Some of them went beyond the course requirements to explore other important parts of networking features, such as, VPN. Although students are not located in a centralized laboratory they seem to appreciate the opportunity to communicate with their instructors and work with other students by taking full advantage of communications in support of Blackboard and other means, more so than students in a centralized laboratory.

However the new online computer network laboratory modules have still encountered a few constraints that a centralized computer network laboratory would not have. There is no clear measurement on student's involvement in every lab exercise. It is hard to ensure every student will gain the same experience considering that they may have different brands of networking equipment or Internet services.

5. Summary

In summary, new computer network laboratory modules for the online computer network course have helped online students accomplish all of the critical tasks and reach goals in the online computer network course. Five laboratory modules have enhanced students' learning experience and developed their practical problem solving skills. This new approach has made a great example to other online courses without any centralized laboratory. Online students can still gain the same learning experience and achieve the same goals that are defined for a centralized laboratory. In addition to that, students will enjoy self-paced learning activities and gain interests in comprehending difficult concepts and solving practical problems independently that a centralized laboratory may not be able to offer to onsite students.

Bibliographic Information

1. Mike Meyer, *Mike Meyer's Network+ Guide To Managing and Troubleshooting Networks*, McGraw-Hill, ISBN : 0-07-225560-9
2. Mike Meyer, *Mike Meyer's Network+ Guide To Managing and Troubleshooting Networks Lab Manual* McGraw-Hill, ISBN : 0-07-225564-1
3. David Barnett, David Groth, Jim McBee, *Cabling: The Complete Guide to Network Wiring*, 3rd Edition (2004), Sybex.
4. Todd Lammle, *CCNA: Cisco Certified Network Associate Study Guide: Exam 640 – 801*, Deluxe, 4th Edition (2004), Sybex.
5. Illinois Online Network, “Instructional Strategies for Online Courses”, <http://www.ion.illinois.edu/resources/tutorials/pedagogy/instructionalstrategies.asp>, University of Illinois, 2006.
6. G. Bressan, M.V.S.O. Paula, T.C.M. Carvalho, and W.V. Ruggiero, “Infrastructure and Tools for a Computer Network and Data Communication Laboratory for a Computer Engineering Undergraduate Course,” Session T4C, in Proceedings of the 31st ASEE/IEEE Frontiers in Education Conference, Reno, NV, October 10-13, 2001.
7. D.E. Comer, *Hands-on Networking with Internet Technologies*, Prentice Hall, Upper Saddle River, NJ 07458, 2002.
8. WorlWideLearn, “Computer Network Training Online”, <http://www.worldwidelearn.com/online-training/network-training-course.htm>, 2006.
9. M. Aburdene, D. Hyde, X. Meng, J. Janzi, B. Hoyt, R. Droms, “An Undergraduate Networked Systems Laboratory”, in Proceedings of the 2002 American Society for Engineering Education Annual Conference and Exposition, Montreal, Quebec, Canada, June 2002.
10. Maurice F. Aburdene, Xiannong Meng and Gregory L. Mokodean, “Analysis of Computer Networks Courses in Undergraduate Computer Science, Electrical Engineering and Information Science Programs”, in *Proceedings of the 2004 American Society for Engineering Education Annual Conference and Exposition*, Salt Lake City, Utah, June 2004.

Appendix A: Online Computer Network Lab Equipment List

1. CAT5 UTP Cable (can be purchased at Staple, Best Buy, and Office Depot if needed)
2. RJ45 Connector (can be purchased at Staple, Best Buy, and Office Depot if needed)
3. RJ45 Crimping Tool
4. CAT5 Cables
5. Netgear 24 Port 10Base-T Ethernet Hub
6. Linksys 10/100 5-Port Workgroup Switch
7. Desktop PC Network Interface Card (NIC)

8. D-Link IEEE 802.11b Wireless LAN Adapter (NIC) for laptops (optional)
9. Linksys 2.4GHz Wireless-G Boardband Router (optional)

Appendix B: Studying Important Network Addresses

1. Click the Start menu button on the Windows taskbar
2. Click Run on this menu
3. Type cmd in the text box that appears. A command prompt window launches on the desktop
4. In this command window, type ipconfig /all. Details are shown for each of the computer's network adapters. Computers installed with VPN software or emulation software will possess one or more virtual adapters
5. The IP Address field states the current IP address for that network adapter
6. The Physical Address field states the MAC address for that adapter

```

C:\WINDOWS\system32\command.com
DNS Suffix Search List. . . . . : Belkin

Ethernet adapter Local Area Connection:

    Media State . . . . . : Media disconnected
    Description . . . . . : Realtek RTL8139/810x Family Fast Eth
Ethernet NIC
    Physical Address . . . . . : 00-0B-5D-06-0E-ED

Ethernet adapter Wireless Network Connection 3:

    Connection-specific DNS Suffix . : Belkin
    Description . . . . . : Intersil PRISM Wireless LAN PCI Card
    Physical Address . . . . . : 00-E0-00-89-3D-A9
    Dhcp Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . : Yes
    IP Address. . . . . : 192.168.2.98
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.2.1
    DHCP Server . . . . . : 192.168.2.1
    DNS Servers . . . . . : 192.168.2.1
    Lease Obtained. . . . . : Monday, January 08, 2007 5:48:24 AM
    Lease Expires . . . . . : Monday, January 18, 2008 10:14:07 PM

C:\DOCUMENTS\1\IMU>

```

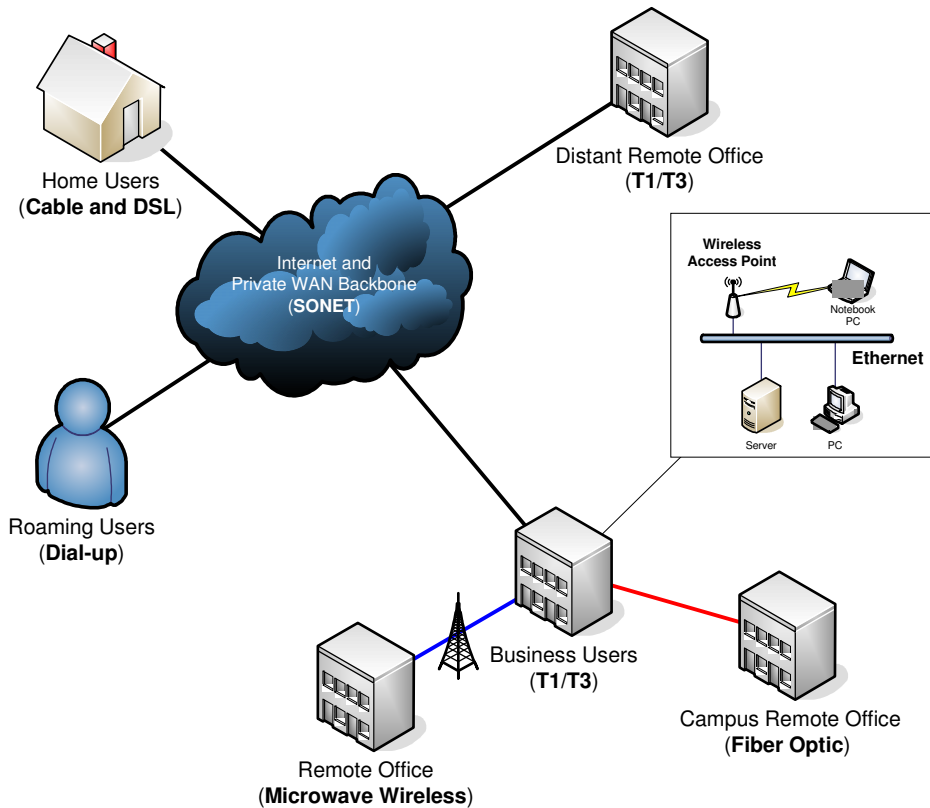
Appendix C: Simulation Laboratory - Network Management, TCP/IP Protocols, and IP Addressing

Perhaps this is a quick routing laboratory. Software used in this laboratory allows students to virtually set up network connections among multiple PCs, routers and switches. As far as routing is concerned Windows is a fine router for lower volume routing or a router simulation software can be a proper candidate. If students have a PC with two network cards installed they can easily discuss routing and build a router in XP.

Appendix D: Network standard and protocols: ISO/OSI 7 layer model laboratory

1. OSI Layer 1 – Physical Layer

It is appropriate to discuss the physical layers and the many ways that networks communicate. More than just Ethernet NIC, cables, hubs and switch there are many types of physical devices that facilitate networks as illustrated in Appendix A.



Physical Layer:

- Phone Lines – Individual WAN
- DSL / Cable – Personal/Corporate WAN
- T1 / T3 – Corporate WAN
- SONET – Telecommunications Provider WAN
- Fiber Optics – Long Haul Premise LAN (1000 Base SX)
- CAT5 – Premise LAN (1000 Base TX)
- Wireless – Premise LAN (802.11b/g) and Proximity WAN (Microwave)

2. OSI Layer 2 – Data Link Layer

The Data Link Layer is really the packaging of the bits on the physical layers into frames after expanding on the physical layer lab. This layer would be a proper place to explore PPP, Ethernet and ATM switches and MAC. Below is a portion of a MAC table from a switch which demonstrates an Ethernet switch by student when discovering how the switch builds a MAC table. Needless to say this is simple layer 2 switching. There are much more complex layer 2 stuff like VLAN, Spanning Tree Protocol and Port Trunks.

Status and Counters - Port Address Table

MAC Address	Located on Port
000039-4b2bd6	46
000039-feacd1	38
0000aa-872717	44
00023f-8b4748	33
000255-510715	50
0002a5-77f615	20

```

0002a5-796112 43
0003ff-923888 50
0003ff-933888 50
0003ff-943888 50
000423-94cc50 45
000476-7278dd 11
0004ac-3a28c8 50
000802-e56d92 49
00080d-776762 30
00096b-6522c3 50
000bdb-5b90d9 14
000d60-0f0a92 50

```

Data Link Layer:

Layer 1 – Physical Layer	Layer 2 – Data Link Layer	Notes
Phone Lines	HDLC / PPP	All WAN Data Links are ways to packaging bits into packages called frames. HDLC / PPP can create variable sized frames depending on the application.
DSL / Cable	HDLC / PPP, ATM	
T1 / T3	HDLC / PPP, ATM, Frame Relay	
SONET	ATM	ATM uses smaller fixed sized bid frames called cells. It creates pathways and then sends cells through those paths.
Fiber Optics	Ethernet	1000BASE-SX – Ethernet frames use MAC to know pathways of packets
CAT5	Ethernet	100/1000BASE-T
Wireless	Ethernet	WI-FI

3. OSI Layer 3 – Network Layer

The Network layer is the sorting layer where the data is addressed and told when to go. Students are required to extend the tables that they used in the previous examples. When connecting computer let them check their IP addresses. Students can try a ping which uses ICMP to send a packets looking for echoes. Students can also use the ARP –a command to show their ARP table which is a protocol used to cache IP addresses (layer 3) with MAC addresses (layer 2).

```

C:\>ping 172.22.4.1

Pinging 172.22.4.1 with 32 bytes of data:

Reply from 172.22.4.1: bytes=32 time<1ms TTL=255
Reply from 172.22.4.1: bytes=32 time<1ms TTL=255
Reply from 172.22.4.1: bytes=32 time<1ms TTL=255
Reply from 172.22.4.1: bytes=32 time<1ms TTL=255

Ping statistics for 172.22.4.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

```

```

C:\>arp -a

Interface: 172.22.5.112 --- 0x10003
    Internet Address      Physical Address      Type
172.22.4.1              00-11-20-6c-5b-70    dynamic
172.22.5.101           00-0f-20-97-f1-31    dynamic
172.22.5.102           00-0f-20-97-92-c5    dynamic
172.22.5.115           00-0f-20-97-23-f4    dynamic
172.22.5.116           00-0f-20-97-03-c9    dynamic
172.22.6.48            00-08-02-e5-6d-92    dynamic

```

Students then try to configure a P2P network using only IPX as an example of another layer 3 protocol. IPX uses SPX as the layer 4 protocol. Microsoft also has done away with NetBEUI of students are asked to try that.

Network Layer:

Layer 1 – Physical Layer	Layer 3 – Network Layer	Notes
Phone Lines	IP, IPv6, ICMP	Since phone lines are typically going to be used for a single user they will probably only use IP and ICMP. Routing protocols are probably not used much on phone lines because of speed a reliability of lines.
DSL / Cable	IP, IPv6, ICMP	DSL / Cable at the user level will probably not use routing protocols because a cable and DSL service unit is more of Layer 2 switched device.
T1 / T3	IP, IPv6, ICMP, IPsec, OSPF, BGP	Corporations will use IP and IPsec mostly but often for larger networks they will use routing protocols like OSPF and BGP for building dynamic routing tables.
SONET	IP, IPv6, ICMP, IPsec, ARP, BGP	The internet backbones are all built on IP and use BGP for creating global routing tables. Each router must know where to send data outside of its local network and since thousands of routers might be connected to one OC-12 they need a protocol to communicate routing information; BGP is that layer 3 protocol.
Fiber Optics	IP, IPv6, IPX, NetBEUI	Local networks typically use IP but older networks used IPX with was similar to IP and NetBEUI from Microsoft for local network connections.
CAT5	IP, IPv6, IPX, NetBEUI	
Wireless	IP, IPv6, IPX, NetBEUI	

4. OSI Layer 4 – Transport Layer

The Transport layer is where the data is actually moved over the network. For the laboratory students would look at open TCP/UDP ports using the netstat –a command. Try to browse to a web site and then look at the netstat –a again. They will see the IP address and the TCP port used to make the connection. The example output below is that a PC is running a web server on TCP port 80 and it establishes its access on 216.109.117.206 to TCP port 80. It is also using the connectionless UDP protocol for directory services requests on UDP port 445.

```
C:\>netstat -a
```

```
Active Connections
```

```

Proto Local Address           Foreign Address         State
TCP    0.0.0.0:80               0.0.0.0:0              LISTENING  Web Server Waiting for
Clients
TCP    0.0.0.0:135              0.0.0.0:0              LISTENING
TCP    0.0.0.0:1494             0.0.0.0:0              LISTENING
TCP    127.0.0.1:1494           127.0.0.1:1561        ESTABLISHED
TCP    127.0.0.1:2285           127.0.0.1:1494        ESTABLISHED
TCP    127.0.0.1:9742           127.0.0.1:1168        ESTABLISHED
TCP    172.22.5.112:3935        216.109.117.206:80    ESTABLISHED  Web Browser Access
TCP    172.22.5.112:4347        172.22.5.104:1152     ESTABLISHED
TCP    172.22.5.112:4530        172.22.5.102:445     TIME_WAIT
UDP    0.0.0.0:161              *:*
UDP    0.0.0.0:445              *:*  UDP ports accepting/sending directory services
packets.
```

Transport Layer:

Layer 1 – Physical Layer	Layer 4 – Transport Layer	Notes
Phone Lines	TCP, UDP, SPX	There are many layer 4 protocols that work with IP, TCP and UDP are the most popular. SPX is the transport protocol for IPX. All devices that use IP or IPX will use TCP/UDP or SPX on layer 4. Layer 3 and 4 is where the physical or application has little meaning.
DSL / Cable	TCP, UDP, SPX	

T1 / T3	TCP, UDP, SPX	
SONET	TCP, UDP, SPX	
Fiber Optics	TCP, UDP, SPX	
CAT5	TCP, UDP, SPX	
Wireless	TCP, UDP, SPX	

5. OSI Layer 5, 6 , and 7

The session, presentation and application layers are all very closely related. There are very blurry lines among these in reality. Named Pipes and NetBIOS over TCP/IP are a few popular layer 5 entities, ASCII and Unicode tend to show up in layer 6 and HTTP, SMTP, FTP and Telnet are the majors in layer 7(L7). A good layer 5, 6 and 7 laboratory is for students to create an http server on students' XP boxes. Students can install IIS5 in their XP systems and build a simple web page. IIS5 is also capable of creating an FTP server. Have students open sessions to the http server. From there, students start to think about the process HTTP request (L7), Unicode Web Page (L6), TCP Session (L5), TCP transfer (L4), IP control and addressing (L3), Switching and Ethernet framing (L2) and 100 Base T bits transfer in and out of the NIC (L1) in order to gain a complete picture of OSI 7 layer model.