# A VENDOR NEUTRAL WIDE AREA NETWORKING LABORATORY COURSE

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## ABSTRACT

Within information technology the course presentation is often implemented as lecture and laboratory. At the senior level of undergraduate studies options exist to allow for a collaborative laboratory learning environment. The course delivery model may still be split between lecture and laboratory class assignments, but the laboratory exercises are delivered as a collaborative phased strategy.

One of the primary requirements of the course is to develop vendor neutral curriculum that could be taught on any set of laboratory equipment meeting basic requirements. The design of the curriculum is not based on a single lab model, but it is based on standard project management concepts. Utilizing a customized project management model, the delivery of courses occurs over five phases. Phase 1 is assessment of student skills and base lining of students' skills. Phase 2 is a top down network design of a scenario utilizing either case studies or a known infrastructure. Phase 3 is the actual implementation of some large component of the previous phases design. Within phase 3, a large part of the design process is expected to be refined and derived requirements examined. Phase 4 is the testing and analysis of the design as implemented by students. While tracking requirements, students can create test models of the network based on their requirements from previous phases. The final phase is phase 5 and the students will assess their work and present their findings. The environment of collaborative investigation at the student level is extensive. The cross communication requirements between student laboratory groups is further expanded if the overall design is implemented in partial content by each group requiring communication between groups. The phased approach allows for several points to assess student achievement and provide feedback. More importantly the phased approach more closely aligns to the standard industry model of implementations.

## 1. INTRODUCTION

When defining the knowledge area of wide area networking, the specifics are often explained that wide area networking is a geographic discipline. Since campus, and metropolitan area networks exist and utilize the same technologies as a wide area network there must be a specific difference in a course named such. Explaining to the students the paradigm of wide area

networking and that geographic dislocation is an important part of the concept students then begin to wonder why the course is named such.

The specific reason for having a wide area networking course is in the management of the tasks and goals. A wide area network has specific needs that may not be apparent in the other models of network topologies and types. Wide area networks have to meet specific business goals, are expensive to maintain, and are often not controlled by a company and have vendor influences. Modeling a wide area network in the classroom and laboratory environment is a fairly trivial exercise. Modeling the processes of "how difficult" it is to manage a wide area network in the classroom or laboratory is very difficult.

It becomes a matter of perspective in how the instructor allows access to the equipment and specifically the design paradigm. The design of a network of large scale should be a top down network design [Oppenheimer]. There are four phases to a network design: analyze requirements; develop a logical design; develop the physical design; and test, optimize and document the design [Oppenheimer]. Within this course we will attempt to encapsulate those concepts into the phases that students will experience during a lab course.

## 2. LAB ENVIRONMENT

The lab environment consists of a variety of X86 based PC's, two racks of equipment containing Cisco, 3COM, Fast Iron, and a variety of hub vendors' equipment. Several smaller hardware firewalls from different vendors are available to the students. The equipment racks each contain one Digi CM 16 port Serial Port Concentrator. This allows many students to work on the equipment from anywhere in the class environment or even remotely. The port concentrators allow for web access to the equipment and that means any vendors access method is going to work.

The students are divided into at least two teams. The students have a variety of operating systems to choose from, server technologies, and equipment to link these into a network as they design it. Students are required to write a laboratory report as a team, with the caveat, that each team member writes a separate conclusion [McKeachie].

### *2.1 Lab Phase 1*

Students are given a scenario. The scenario is detailed enough and based on a real world entity that they can look at and draw some conclusions from it. Each student is given the scenario and asked to develop a set of questions for the customer and as much of the solution as they can determine at the time. Sufficient detail is given in the scenario for the students to think that they have a significant conceptualization of the network. When the students have been divided into just two largish teams (5 to 9) it becomes apparent that this is one of the few times large teams work well together. Students begin to facilitate and feed off of each other brainstorming solution as well as desired information.

Working with the students they may be given two or three lab sessions to begin the process of design and working on their skills. Through the laboratory process the instructor is observing and providing remedial skills enhancement as required. Students are busily designing and acquainting themselves with the equipment. This process concludes with the (for this example) two teams presenting the current solution to the professor and the other team. Their questions are answered by the professor, and both teams keep notes on what the answers are for the continuing build process. Often students realize that the process has not even begun and following lecture discussions the concept begins to evolve that the design process is iterative. The lecture and laboratory environment has not precluded or required the use of any specific vendors equipment within the design

*2.2 Lab Phase 2*

Students are given the tool Cisco ConfigMaker [Cisco] to design the network and begin the process of implementation. Students begin the process of developing the network, and in general based on a Cisco centric vendor methodology. The scenario chosen is ignorantly resource intensive and requires a topology/design that can not be met with the amount of current Cisco equipment. Students are encouraged to adapt and work the process. In general, students self-report that the choice of tool led to their decision of how to use the resources in their inventory for the solution. Often, the numbers problem will lead to discussion and debate. An objective of the course is to teach troubleshooting or more specifically critical thinking skills.

The process of design continues and the students implement the changes that were part of the Phase 1 question and answer period with the customer/instructor. Students are required to work through problems as a team. Strategies are in place that allow students to work together but make sure that individual student success is assessable [McKeachie]. At this point the students have pretty much finished the logical design. Their ability to implement the physical design thereby reaching the goals of wide area networking is about to occur. Students will discover that the relationship to their original design does have specific and certain consequences.

*2.3 Lab Phase 3*

Students have had two chances to evaluate their design. With the third phase of the laboratory course they begin implementing the local area network portions of the design and building the routing gateways of the network. More importantly even the faster groups will start building test plans based on the requirements gathered in lab phase 1. Those teams that had significant work to do on their documentation packages will have some extra work to do on this portion of the exercise.

Students start utilizing applications like Traffic Generators [Traffic] to create and saturate the network. Servers are specified for segments of the network and clients who can generate HTTP traffic. It is interesting to note that students spend a significant amount of time on the inter-domain routing and often leave the server and client configuration for last. This challenges their testing capabilities and design constraints requiring them to rethink the process. Though lecture topics cover these same issues and design constraints, the students seem to make the same mistakes semester to semester. From the error of trying to build a network top down versus top

down network design, bottom up network building, students seem to receive a significant value in troubleshooting skills.

Utilizing packet sniffers like Ethereal [Ethereal] students can watch and manipulate factors within the network. Once a test plan has been developed the students execute the plan and audit each others results. The original network design is adapted to the current equipment availability and the design documents, updated requirements documents, and test plan for the network with results is presented to the instructor and other student work groups.

*2.4 Lab Phase 4*

At this point the students have been working in separate groups on the same problem. It is interesting to note that industry may be a similar situation with differing groups working to fix the same problem for a single customer. The students are brought into a meeting and asked to now fix a small problem with the network.

The students are to link and recreate the distinct networks so that they can talk to each other and route traffic between the two groups. Depending on the design decisions of the two groups as to IP schemas [Comer] and choices on routing protocols this can cause significant design changes. Literally, within the course, groups have had to completely rebuild their networks with new decisions. Similar to industry experience students who have listened to lecture materials explaining the concepts of flexibility and scalability groups may have little or no issue with this phase of the laboratory. Otherwise groups have significant work. Once again groups build a significant documentation package as it relates to their network. Each group will gather the previously mentioned documentation as well as the configuration of the routers, and the switching devices.

Testing of this network is added to include a client at the leaf nodes from one group must be able to reach any other groups web server on the leaf node of their network. Similarly and with equal interest DHCP server scope and services must remain within the particular groups' network and not be broadcast. Students gain extensive experience and may spend some real time configuring firewall services to achieve these goals.

*2.5 Lab Phase 5*

When building an assessment strategy for this course, it was determined that the choice and design work should be primarily student decisions. The students should be in a vendor neutral environment where they could determine the best tool from a set of resources for a particular task in the design. Earlier it was noted that the use of tools would drive the first phase of design and students rapidly understood that fact. Later in the course students would be wary of that trap.

There is some feeling that students do not appreciate the totality of the documentation package they have produced with the specific provision that somebody should be able to build the network from the package and implement their test plan. Because the groups will design to similar requirements, but will choose different methodologies of implementing those requirements a simple plan of assessment was initiated.

Students are asked to present their design to the class as a whole at the end of Lab Phase 4 and explain their design directions. Then the lab packages are given to a different group and the new group is asked to implement the design. This provides a clean set of eyes on the documentation and further experience for the students to evaluate a different view of the design process. Students expand their knowledge significantly while providing a simple assessment strategy for the instructor.

## 3. SUMMARY AND CONCLUSION

This course has been run with these constraints for three semesters. The vendor neutral aspects of providing the students with several proprietary and open systems has expanded the attractiveness of the course. As an interesting note to the course students as a group have eschewed the use of hardware firewalls instead choosing to build PC based Linux or Windows based software firewalls. The characterization of the students to this course is that it draws their interest further into the networking paradigm. Further, having had significant choice in the design process, the students tend to evaluate technologies rather than just implement them.

Students in this course are usually junior or senior level attending a bachelor degree. The students involved in this program have already had significant networking and operating system theory and laboratory courses. In conclusion, the course is sought after by students, and provides for an evaluative and critical understanding of networking.

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