

WIDE AREA NETWORKS: A COMPARISON OF DIFFERENT APPROACHES FOR HANDS-ON LABS

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ABSTRACT

Teaching a course in the area of computer networks is challenging. Teaching a course in Wide Area Networks is even more challenging. A Wide Area network (WAN) is a network that provides services to a very large geographic area. A WAN uses devices, systems and media that may not be used in a Local Area Network. The main challenge in teaching a course in WAN is getting across many of the WAN concepts to the students. We have learned from teaching other computer courses such as introduction to programming, that using hands-on labs has been very effective in providing better learning experience for the students and enabling them to understand these concepts more effectively. Providing hands-on labs in a WAN course will also enhance the students learning experience. There are two main approaches in providing a hands-on experience to the students. The first approach, implementing a Wide Area Network in a lab designated for the WAN class. This lab will include a number of routers, switches and gateways. The second approach, using simulation software that simulates a Wide Area Network. The simulation software simulates a WAN that includes a number of routers, switches and gateways. This paper provides a comparative analysis for these two approaches and makes recommendations with respect to these approaches.

Keywords: Wide Area Networks; Network Simulation; Hands-on Labs; routers

INTRODUCTION

Computer Networks

A computer network is a combination of hardware and software technology that allows computers to share a variety of resources. These resources include data, software applications, printers, scanners and storage devices. Networks are categorized into a number of categories. The main two network types are: local area networks (LAN) and wide area networks (WAN).

A LAN is a single collection of machines and peripherals as shown in Figure 1. A LAN enables these computers to share resources within a small geographic area. A LAN is considered the basic building block for larger networks. A LAN is usually located within one room or one floor.

Wide Area Networks

A WAN is a collection of networks as shown in Figure 1. A WAN enables two users or systems on different LANs to communicate or exchange data. A WAN spans miles of distance and provides services to a very large geographic area. A WAN uses devices, systems and media that may not be used in a LAN. A WAN is different from a LAN with respect to protocols, devices, technologies and media.

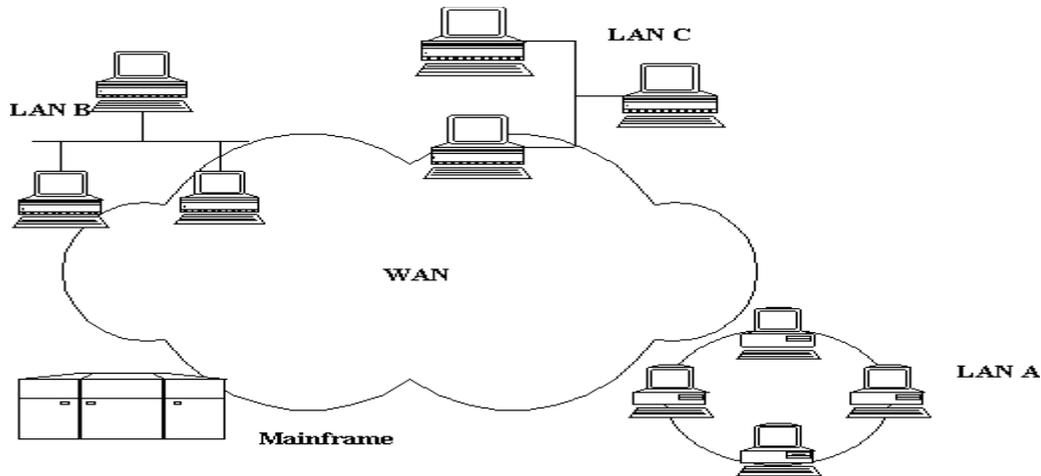


Figure 1: A WAN

A course in WAN should discuss the following topics [2]: the network and transport layer of the OSI model, Transmission control protocol (TCP), Information Protocol (IP), routing protocols such as routing information protocol (RIP), interior gateway routing protocol (IGRP), open shortest path first protocol (OSPF) and exterior gateway protocol (EGP), routers, switches, WAN connection types, Frame relay, integrated services digital network (ISDN), High-level Data Link Control (HDLC), link access procedure balanced (LAPB), Asynchronous Transfer Mode (ATM) and point-to-point protocol (PPP). The major components in a WAN are the routers, switches and the links.

This paper compares two approaches of providing hands-on labs for students taking a course in wide area networks or internetworking. The first approach, implementing a Wide Area Network in a lab designated for the WAN class. This lab will include a number of routers, switches and gateways. The second approach, using simulation software that simulates a Wide Area Network. The simulation software simulates a WAN that includes a number of routers, switches and gateways.

The paper starts by introducing the different types of networks, it describes a wide area network, presents the concepts that should be covered in a WAN course, presents the two models for teaching a course in networking, discusses the two approaches for providing a hands-on labs, provides a comparative analysis of both approaches and makes recommendations.

WAN TEACHING MODELS

Teaching a course in the area of computer networks is challenging. Teaching a course in Wide Area Networks is even more challenging. The main challenge in teaching a course in WAN is getting across many of the WAN concepts to the students. We have learned from teaching other computer courses such as programming course and database development, that using hands-on labs has been very effective in providing better learning experience for the students and enabling them to understand these concepts more effectively [6]. Providing hands-on labs in a WAN course will also enhance the students learning experience.

There are mainly two models for teaching a course in wide area networks or internetworking:

- The traditional model: The course covers the theoretical concepts in internetworking. This model will not include any hands-on components. This model might include a TCP/IP programming project that simulates a portion of one of the WAN components.
- The Hands-on model: The course covers the theoretical concepts in internetworking. This model will also include a hands-on component that will familiarize students with routers, switches, and protocols. The objective of the hands-on model is to provide the students with practical experience in the configuration and administration of the different devices used in a wide area network. We will focus our discussion on the hands-on model.

THE HANDS-ON MODEL

The objective of the hands-on model is to provide the students with practical experience in the configuration and administration of the different devices used in a wide area network. Some examples of these functions are specifying the IP address for the different ports on the device, Identifying the routing protocol used for the router, specifying the subnet mask, setting up the device name, getting statistics of the data passing through the device.

There are two approaches of providing hands-on labs for students taking a course in wide area networks or internetworking. The first approach: implementing a Wide Area Network in a lab designated for the WAN class. This lab will include a number of routers, switches and gateways. The second approach: using simulation software that simulates a Wide Area Network. The simulation software simulates a WAN that includes a number of routers, switches and gateways.

There are hundreds of devices that might be used in a WAN. For educational purposes we are going to select a small number of these devices. These few devices will provide a general idea about the rest of the device used in a WAN.

Implementing a WAN Lab

We are going to use the least number of devices that will provide the students with the needed skills that are specified earlier. A WAN lab should include at least three routers and two low-end switches as shown in Figure 2. We are going to use UTP cables to connect workstations to each

switch and fiber optics cables to connect the routers. We need to use at least three routers for the following reason: One of the concepts that we need to demonstrate for students is routing. Therefore, users on different LANs should have more than one path/route for sending their data over the internetwork. If we use only two routers then there is only one direct route from one workstation to another and routers don't need to carry out any routing functions.

Using three routers enables us to interconnect three local area networks. Each local area network needs a switch to connect the local workstations. So we need three switches in order to have three LANs. For educational purposes we can use two switches, which will provide us with two LANs.

Using A Software Simulator

There are a number of simulation packages in the market that simulates a wide area network. These packages include Sybex CCNP Virtual Lab and Boson Router Simulator. For this paper we will focus our discussion on Sybex CCNP Virtual Lab. Most of our discussion of the Sybex Simulator will be applicable to Boson Router Simulator.

The Sybex Simulator provides hands-on experience with routers and switches. It enables students to practice with the --equipment-- on their own, or follow suggested labs that cover a wide range of WAN issues. It provides a Realistic, Interactive Simulation of several Router and Switch Functionality.

The following is a list of functions and activities that can be performed using the Sybex simulator [4]:

- Routing: which includes IS-IS, IP addressing, and Interconnecting OSPF areas.
- Switching: which includes connecting the switch block and Configuring 1900.
- Remote Access: which includes working with asynchronous connections.
- Support: which includes troubleshooting Cisco routers and switches.

COMPARATIVE ANALYSIS

We are going to provide a comparative analysis between the two hands-on approaches. The first thing we need to do is to select a criteria for comparison that ensures an objective and fair comparison of both approaches. The following is a list of our

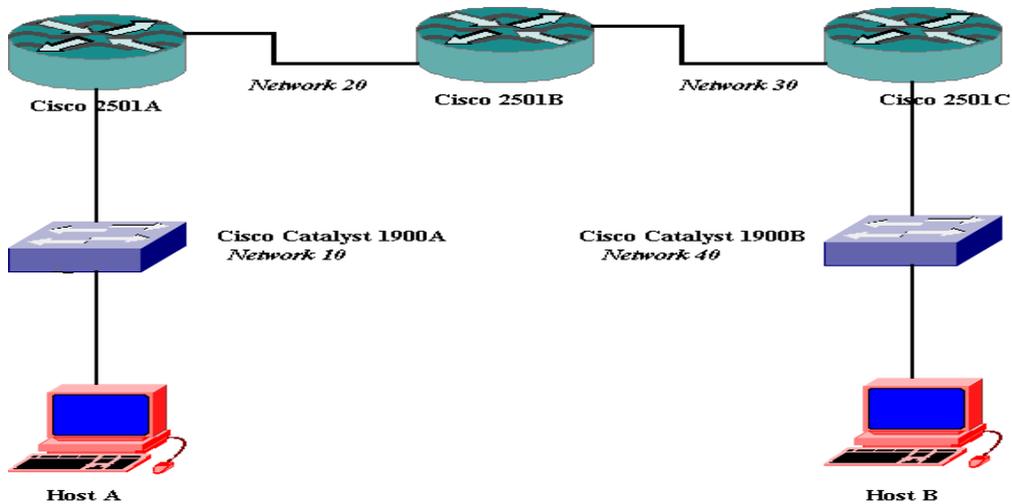


Figure 2: Network Configuration

criteria elements: Product Cost, Product Capability, Physical Facilities Needed, and Product Administration & Maintenance

Product Cost

We need to identify the total cost of implementing both approaches. The total cost includes the cost of both software and hardware components needed for the implementation.

Approach #1: The Sybex simulation software is priced \$119.00 for educational institutions for a single user [7]. We are going to assume a class size of twenty students working in groups of two. Group work adds a lot of value to the group members [1]. So we need to purchase ten licenses of the software. The total cost is $\$119 * 10$, which equals \$1190. We are not going to consider the cost of installing the software since a member of the IT staff usually performs the installation at no charge to the department. The other issue that we need to consider with respect to cost is the computer system that is going to host this software. The computer system needed is determined by the system requirements specified for this software [7]: Web browser and Internet connection, Windows 95 or higher, 133 MHz or faster Pentium, 32MB RAM, 2MB video card, 7MB HD space.

These requirements indicate that we don't need any special hardware or software for the simulator. The software simulator could be installed on almost any computer machine that is found in the computer lab.

Approach #2, The WAN lab includes three routers, two low-end switches and cables. The total cost of the lab is the cost of the three routers, the two switches, and the cables. We are going to use three Cisco 2521 routers and two 1900 series switches in building our WAN lab.

These devices can be purchased from many sources. There are some web sites that will provide you with a comparative pricing for different resellers. One of these sites is nextag. The pricing offered for the routers and the switches is different depending on the condition of the device: new, used, and refurbished, the modules that are included, the number of ports, and the type of ports. We are going to find the lowest price for a new device. We found that Cisco 2501 costs

\$1935.16 [5], Catalyst 1900 costs \$799.99 [5], six UTP cables cost \$119.00 [6] and two fiber optics cables cost \$59.00 [5]. The total cost for building this lab is \$7583.46

This WAN lab does not allow all students to have hands-on labs simultaneously. In order to enable the ten student-groups to perform configuration and administration functions simultaneously, we need to have a set of these devices, which is very expensive.

Product Capability

We need to compare both approaches with respect to the operations that they support.

Approach #1: The Router simulator supports a large number of instructions and operations that are supported by the physical router. We are able to use the same set of commands that are used on the router with the same parameters. However, it does not support all operations. This does not mean that the simulator capability is insufficient. We are using the simulator for educational purposes, and so only the major operations are needed. Even though routers and switches support a large number of operations and scenarios, but when they are operational only a small subset of these operations is performed. The Sybex simulator provides built-in internetworks and also allows the students to design their own networks.

The simulator provides a flexible environment for the student to practice and design different networks easily. The simulator does not provide a graphical view of the routers and the switches. Students are not able to see how these devices look like or to see the different ports and modules in that device.

Approach #2: Supports a larger number of commands. Students are able to design their own network Device do not come preconfigured with other devices or internetworks in mind. Students are not able to configure the different devices in the lab simultaneously. One group is able to configure any device at a certain time.

Physical Facilities

We need to identify the type of facilities that is needed to host both products.

Approach #1: We need to install the simulation software on a server. The system requirements for the software are very minimal as indicated previously. There is no special hardware required for this software.

Approach #2: We need to install our network in a secure place. We need to have a space to hold five different devices. These devices are small in size and so they don't require huge physical facilities. They could be placed in the same room where we have our servers. Students will have access to the WAN network from a remote location. They will use Telnet in order to configure these routers and switches.

Product Administration and Maintenance

We need to identify the amount of time and effort needed to administrate and maintain software and/or hardware used in each approach.

Approach #1: We need to ensure that the students have access to the software by providing a login account. The Sybex simulator includes several built-in labs that the students can carry out in order to practice in configuring and administrating the different devices.

Approach #2: we need to ensure that the students have access to the different routers and switches in this lab. The routers do not come with built-in labs. We need to develop labs that the students are able to carry out.

CONCLUSIONS

Using a WAN simulator has many advantages over building a WAN lab. It costs \$1190 to purchase the software compared to \$7583.46 to build the WAN lab. The simulator is easy to install, configure and administrate. The simulator comes with built-in labs, which enables the students to start practicing as soon as the software is installed. Also students are able to use the software simultaneously.

The only drawbacks of the simulator are that it does not support all commands that are supported by the physical devices and it does not provide a graphical view of the devices and its modules.

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