PDHonline Course E175 (8 PDH)

Introduction to Computer Networking

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2020

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Introduction to Computer Networking

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MODULE 4: Extending to the WAN

4.1 Introduction

As discussed in Module 2, a WAN spans a wide area, hence the name Wide Area Network. Given that these distances are involved, a WAN often makes use of local LANs and carrier transmission facilities provided by telephone carriers.

WAN technologies typically perform functions related to the first three layers of the OSI model. As you should remember from module 2, these major functions provide the physical media and provide routes for data.

4.2 WAN Connections

WANs can be interconnected in a variety of methods.

4.2.1 Point to Point

The simplest type of WAN is a point-to-point network. It is often used when we simply need to interconnect two geographically separated facilities. In Figure 15 below, two facilities LANs are interconnected through a WAN. The WAN cloud is usually a leased line from a carrier, which creates a private and permanent circuit between the facilities. The circular box in the figure indicates a router, which will be discussed later. The computers in the figure indicate devices on the other side of the router, of which there could be one or many. In either case, the computer is indicating a LAN.

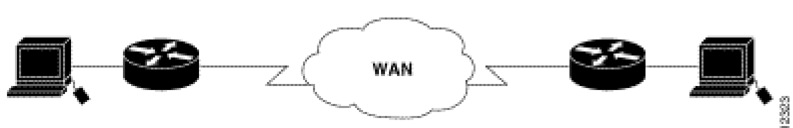

Figure 15. Point to Point WAN
Courtesy of Cisco [5]

4.2.2 Circuit Switched

A circuit switched network acts like a telephone call. When you make a call, and the other party answers the phone, a dedicated circuit is established between you and the person you called. Yet, before the call is made, you have the potential to dial any number in the world and establish a circuit. In Figure 16 below, we see that two circuits have been established by the carrier's network switching, by the connections made in the cloud. By changing the switching arrangement, we can interconnect the networks with many other networks. However, circuit switched networks are somewhat static. In other words, the circuit remains up until it is removed. The term DCE in this figure just refers to Data Communication Equipment.

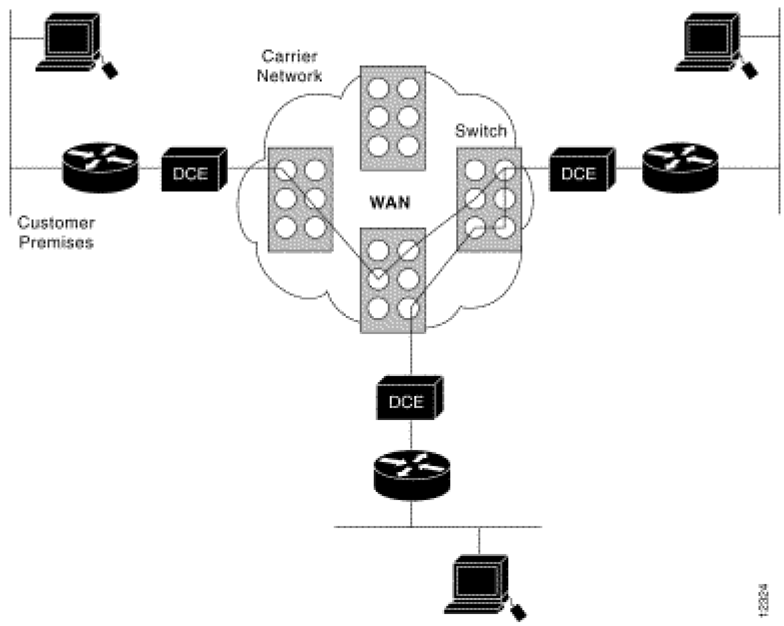

Figure 16. Circuit Switched WAN
Courtesy of Cisco [5]

4.2.3 Packet Switched

A packet switched network, shown in Figure 17, is what we have in the Internet or even in most companies where there are usually multiple interconnected LANs. In packet switched networks, data is put together in pieces all on one circuit, much as if you put various pieces of mail into one mailbox to be picked up by one mail truck, but each goes different places. The method of putting unrelated data together on a single circuit is called multiplexing. Figure 18 shows this process. As each terminal generates packets, they are put together on a larger packet, much like multiple trailers being stacked onto a train car for shipping. The carrier network ships all of the packets together until they are de-multiplexed at the other end and then sent their various ways.

The Internet has one slightly different arrangement from that of the Figure 17, however. The Internet may de-multiplex the data in route and send the various packets to their respective locations, instead of a single end location.

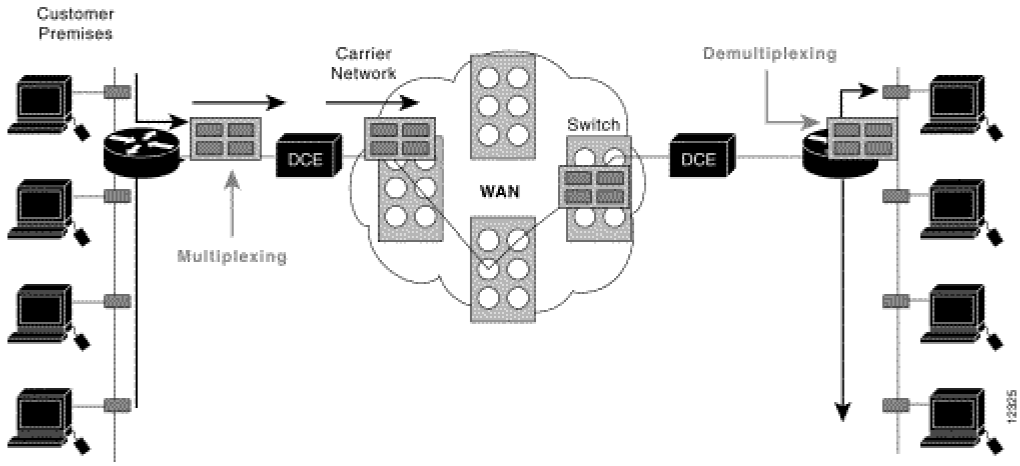

Figure 17. Packet Switched WAN
Courtesy of Cisco [5]

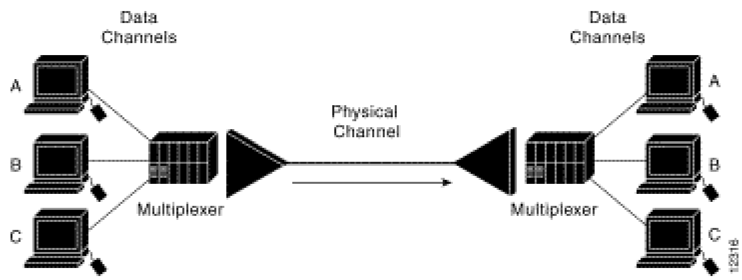

Figure 18. Multiplexing
Courtesy of Cisco [5]

4.3 Routers

A key element of the LAN to WAN interconnection is the router. In the figures that we cover in this section, the circular devices represent routers.

Routers serve as a switchboard for traffic going into and out of a LAN. When data packets arrive at a router, the router decides which way the packets are to go. Usually the key indicator for this decision is the IP address. Network routing actually works much like the zip code on mail. For instance, mail from Atlanta to Anchorage might first route to Denver, then to Seattle, then to Anchorage. In Atlanta, the postal service is not concerned with the final destination; they just know the mail with this zip code go to Denver. Then in Denver they make a similar decision to send the mail to Seattle.

This example of mail routing scheme is very similar to how routing in networks operate. Data packets with a certain range of IP addresses are routed to the appropriate next destination. The goal is to hand packets from router to router until the final destination is reached.

A simple example of this routing can be used via a single router connected to your office LAN. As packets hit the router, the router decides whether they go to the Internet (the cloud) or to the internal LAN. Only one decision is made.

In more complex schemes, the router might have several interconnections to other routers. In this case the router must decide which path to take.

Therefore, the router has two main functions.

1. Determining the optimum path. This task is accomplished through a routing table (database) or routing algorithm. These tables and algorithms contain information such as the next hop of the path. The algorithms might be optimized to provide the fastest route, the shortest route, the most economical route, the most stable and reliable route, etc. To serve this purpose, there are numerous routing protocols and algorithms that may be implemented.

2. Switching. When the destination is multiple hops away, the router will replace the physical address, or the MAC address, of the packet with the physical address of the next router in the path. (The MAC address is a lower layer address than the IP address. We can think of the MAC address as the zip code, since it does not route you to the final destination as does the street address or P.O. Box number, but only routes you to the final post office, which acts like a router.) In most instances packets go through many routers to reach their final destination. Switching is shown in Figure 19 below.

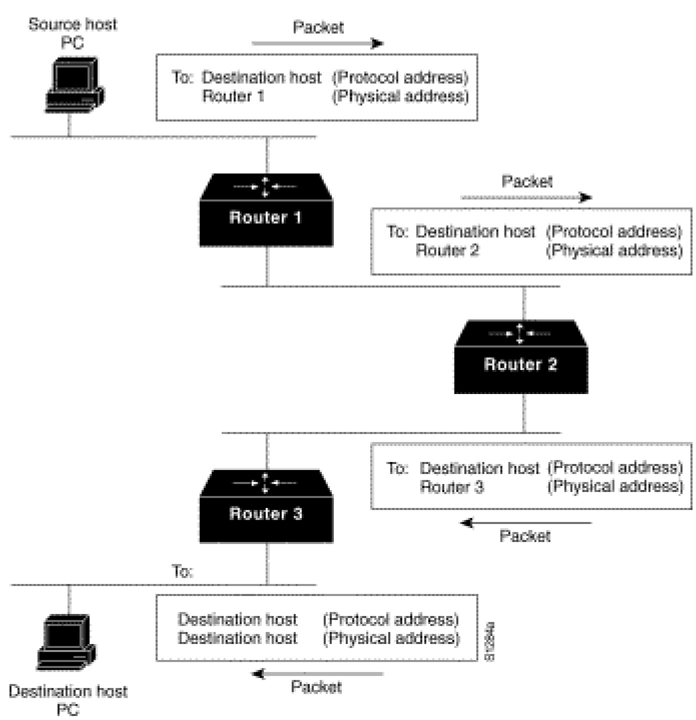

Figure 19. Routing through multiple Routers
Courtesy of Cisco [5]

Here are a few common routers. In Figure 20 we have the Linksys Etherfast router. It is a router with a built in four port hub, which allows you to connect to the outside world with one port and then connect up to four computers. This popular router is used with cable or Asymmetric Digital Subscriber Line (ADSL) modems.

Figure 20. Linksys Etherfast Router
Courtesy of Linksys [2]

Figure 21 shows the ports of the Linksys router. The port to the far left is the WAN port, which is coming from our connection to the world. The cable in the middle is coming out of the port 2 location to a PC.

Figure 21. Back of the Linksys Etherfast Router
Courtesy of Linksys [2]

Shown in Figure 22 below is the back of the Cisco 2621 router.

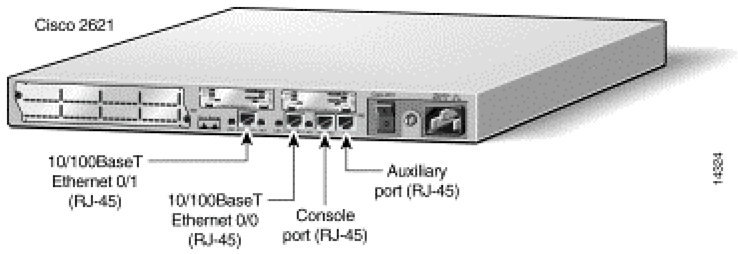

Figure 22. Back of the Cisco 2621 Router
Courtesy of Cisco [5]

When all is said and done, we often have stacks of equipment made up of switches, routers, and cabled together, such as shown in Figure 23.

Figure 23. Center for Telecommunications Education and Research Lab (CTER)

4.4 Routing – How it Works

Every device that is connected to the Internet has at least a physical address. The physical address is unique for every piece of equipment that connects to the Internet. For example, inside your PC, the NIC is used to connect your PC to the network. The NIC actually contains a coded address. Each manufacturer has a series of addresses that they can use, and every device they make must have a unique address. Therefore, given the physical address of a device, we can determine the manufacturer. This address is the MAC address. The MAC has 6 bytes, the first 3 identify the manufacturer, and the second three identify the individual device with its serial number.

Another type of address we have is logical or our IP address. The IP address can be changed - such as when we move the computer to another LAN or the LAN administrator changes the IP address for the machine. Changing the IP address is done via software. If you are a Windows user and have a network card installed, run WINIPCFG. This command will show you your current IP address for your different adapters.

When you send an email, your PC software breaks up the email message into packets. Each packet is labeled with both the origination and destination address. These addresses are used to get your email through the Internet in much the same way the combination of zip code and street address gets your mail through the postal system.

To get some idea of the many routers you might go through in a typical Internet function, go to a DOS or command prompt and type

tracert www.cisco.com

This command runs the trace route program, tracert, which shows the routes you are taking to go from you computer to the final destination. Shown in Figure 24 is a trace route from one of our systems. We will cover these commands in more detail in a later module.

```
route to www.cisco.com [198.133.219.25]
over a maximum of 30 hops:

 1   13 ms   13 ms   12 ms  CMTS1-Montevallo-AL.hsacorp.net [24.216.185.129]
 2   13 ms   15 ms   12 ms  GW1-Montevallo-AL.hsacorp.net [24.216.185.1]
 3   25 ms   21 ms   38 ms  84.ATM1-0.GW6.ATL1.ALTER.NET [157.130.77.97]
 4   50 ms   19 ms   25 ms  174.at-2-1-0.XR1.ATL1.ALTER.NET [152.63.82.42]
 5   23 ms   19 ms   19 ms  0.so-3-0-0.TR1.ATL1.ALTER.NET [152.63.10.69]
 6  118 ms  154 ms  134 ms  109.at-5-0-0.TR1.SAC1.ALTER.NET [146.188.140.250]
 7  146 ms   99 ms  111 ms  297.ATM7-0.XR1.SFO4.ALTER.NET [152.63.51.5]
 8  109 ms  101 ms  108 ms  191.ATM7-0.GW8.SJC2.ALTER.NET [152.63.49.245]
 9  109 ms  111 ms  102 ms  cisco.customer.alter.net [157.130.200.30]
10  189 ms  116 ms  105 ms  sjc-k-dirty-gw1.cisco.com [128.107.240.189]
11   97 ms  179 ms  119 ms  sty.cisco.com [128.107.240.78]
12  261 ms  197 ms  213 ms  www.cisco.com [198.133.219.25]
```

Table 4. Trace Route