Fundamentals of WAN

Wide Area Networks

Basics

LAN standards and protocols define how to network between devices that are relatively close together, hence the term local-area in the acronym LAN.

WAN standards and protocols define how to network between devices that are relatively far apart.

LANs and WANs both implement the same OSI Layer 1 and Layer 2 functions, but with different mechanisms and details.

WANs and LANs match OSI Layers 1 and 2, they have many similarities: Both define cabling details, transmission speeds, encoding, and how to send data over physical links, as well as data link frames and forwarding logic.

Positioning Leased Lines with LANs and Routers

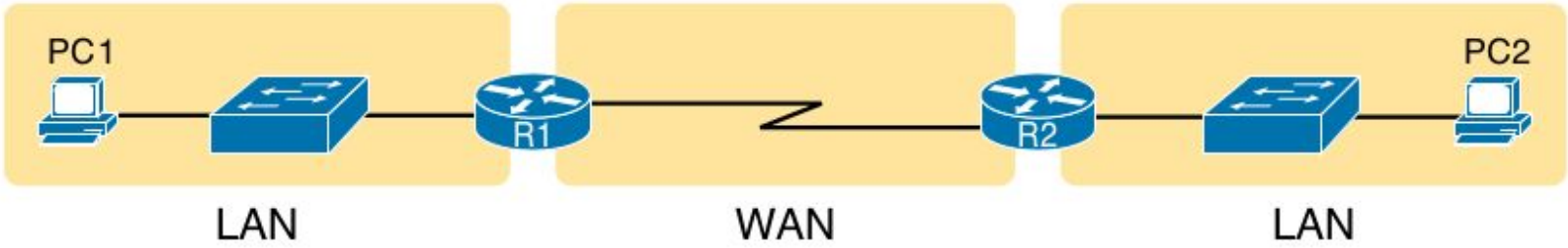

Figure 3-1 *Small Enterprise Network with One Leased Line*

Physical Details of Leased Lines

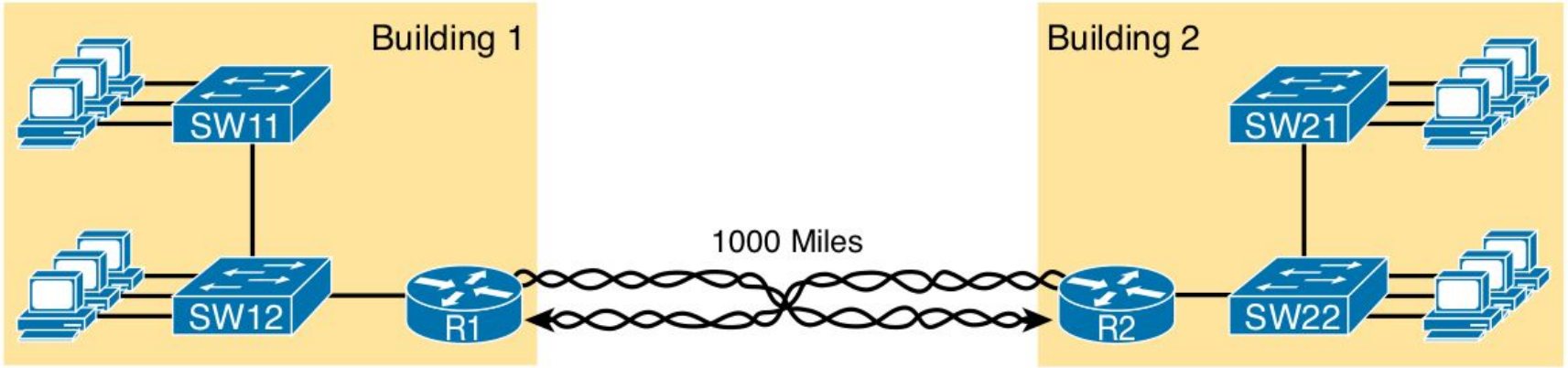

Figure 3-2 *Conceptual View of the Leased Line Service*

Table 3-1 Different Names for a Leased Line

Name	Meaning or Reference
Leased circuit, Circuit	The words *line* and *circuit* are often used as synonyms in telco terminology; *circuit* makes reference to the electrical circuit between the two endpoints.
Serial link, Serial line	The words *link* and *line* are also often used as synonyms. *Serial* in this case refers to the fact that the bits flow serially, and that routers use serial interfaces.
Point-to-point link, Point-to-point line	Refers to the fact that the topology stretches between two points, and two points only. (Some older leased lines allowed more than two devices.)
T1	A specific type of leased line that transmits data at 1.544 megabits per second (1.544 Mbps).
WAN link, Link	Both these terms are very general, with no reference to any specific technology.
Private line	Refers to the fact that the data sent over the line cannot be copied by other telco customers, so the data is private.

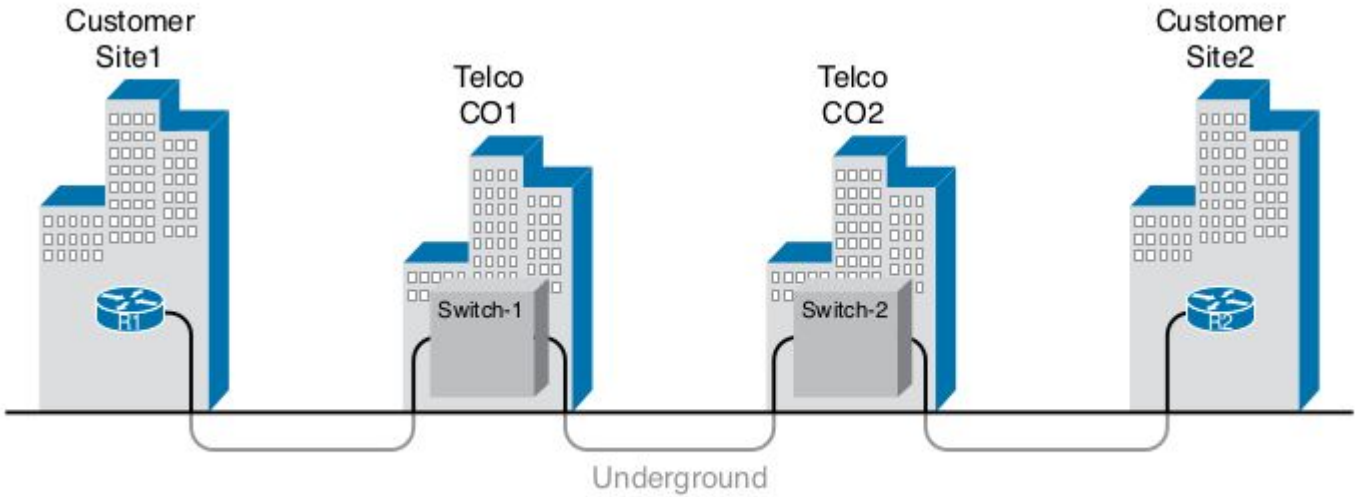

Figure 3-3 *Possible Cabling Inside a Telco for a Short Leased Line*

First, each site has *customer premises equipment (CPE)*, which includes the router, serial interface card, and CSU/DSU. Each router uses a serial interface card that acts somewhat like an Ethernet NIC, sending and receiving data over the physical link. The physical link requires a function called a channel service unit/data service unit (CSU/DSU). The CSU/DSU can either be integrated into the serial interface card in the router or sit outside the router as an external device. Figure 3-4 shows the CPE devices, along with the cabling.

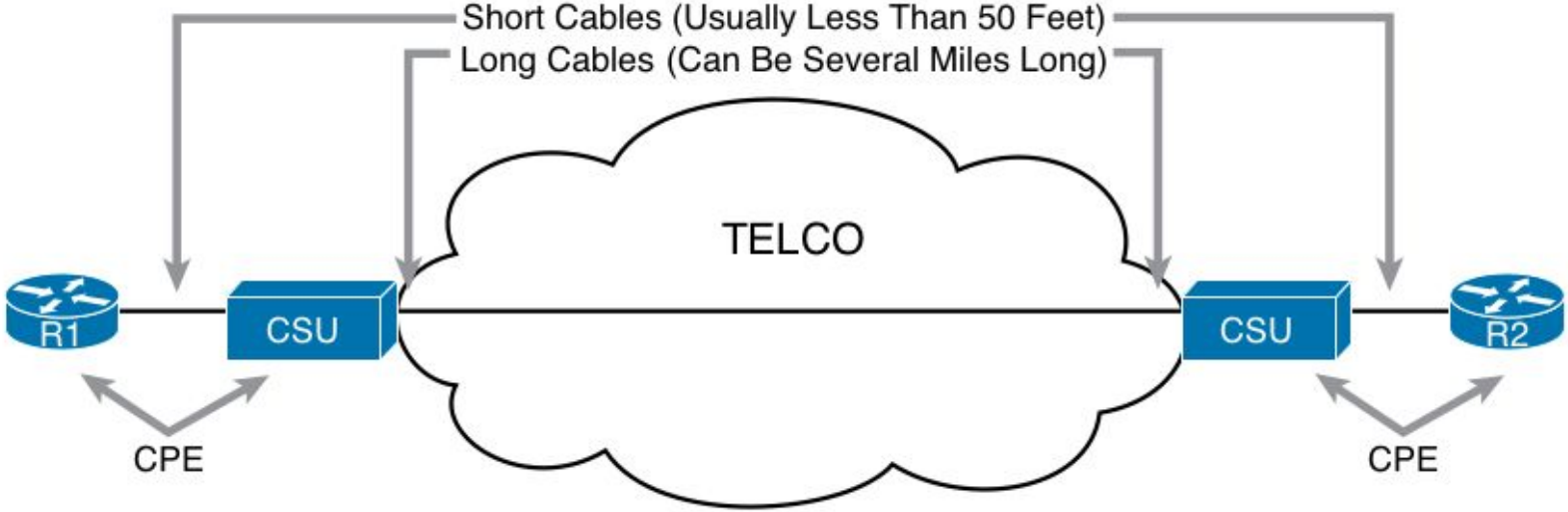

Figure 3-4 *Point-to-Point Leased Line: Components and Terminology*

First, the serial cables normally used between a router and an external CSU/DSU are called *data terminal equipment (DTE) cables*. To create a physical WAN link in a lab, you need two serial cables: one serial DTE cable, plus a similar but slightly different matching *data communications equipment (DCE) cable*. The DCE cable has a female connector, while the DTE cable has a male connector, which allows the two cables to be attached directly. The DCE cable also does the equivalent task of an Ethernet crossover cable by swapping the transmit and receive wire pairs, as shown in Figure 3-5.

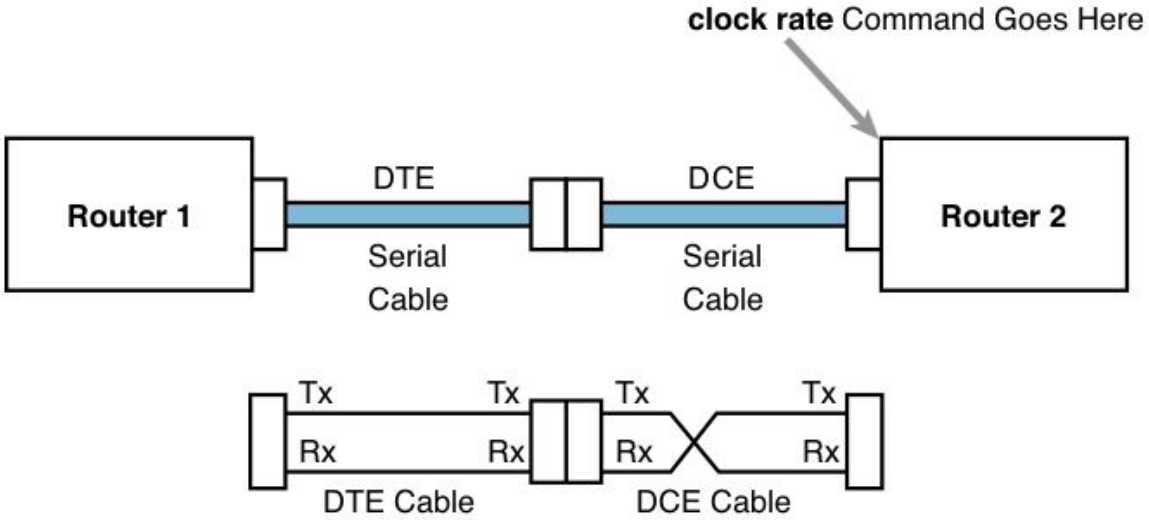

Figure 3-5 *Serial Cabling Uses a DTE Cable and a DCE Cable*

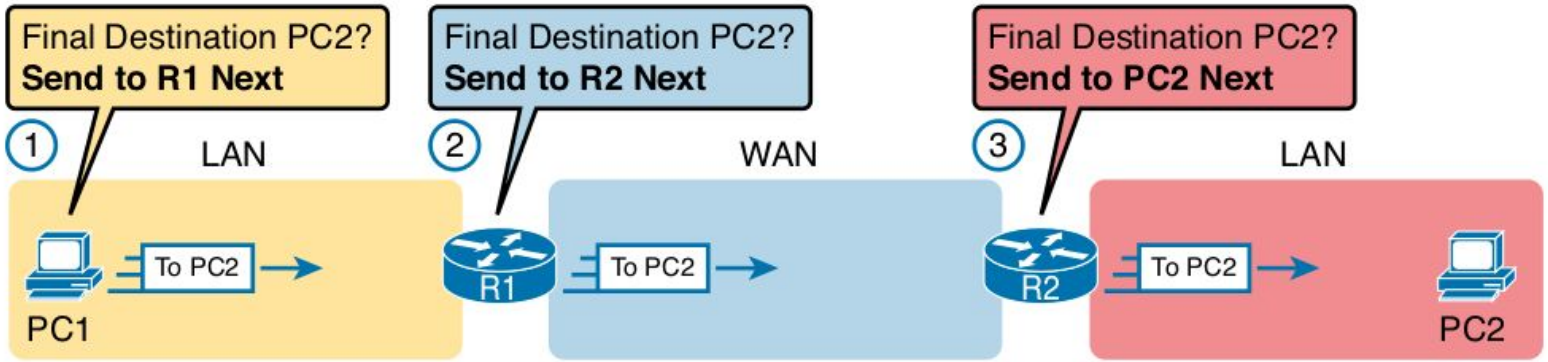

Figure 3-7 *IP Routing Logic over LANs and WANs*

Following the steps in the figure, for a packet sent by PC1 to PC2's IP address:

1. PC1's network layer (IP) logic tells it to send the packet to a nearby router (R1).
2. Router R1's network layer logic tells it to forward (route) the packet out the leased line to router R2 next.
3. Router R2's network layer logic tells it to forward (route) the packet out the LAN link to PC2 next.

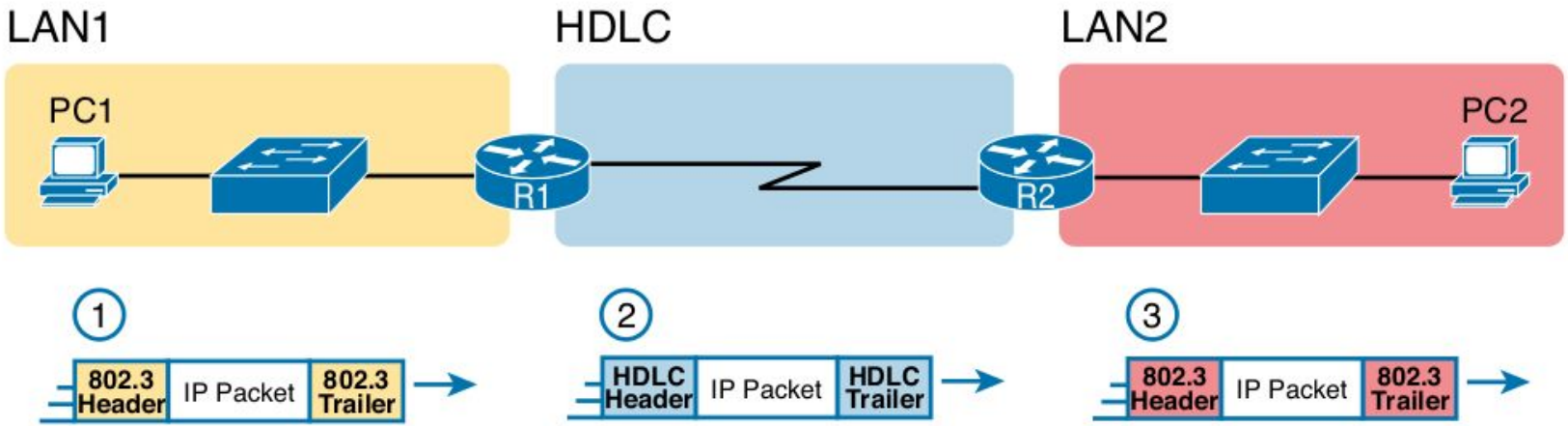

Figure 3-8 *General Concept of Routers Deencapsulating and Reencapsulating IP Packets*

In summary, a leased line with HDLC creates a WAN link between two routers so that they can forward packets for the devices on the attached LANs. The leased line itself provides the physical means to transmit the bits, in both directions. The HDLC frames provide the means to encapsulate the network layer packet correctly so that it crosses the link between routers.

Today, in this second decade of the twenty-first century, many WAN service providers (SP) offer WAN services that take advantage of Ethernet. SPs offer a wide variety of these Ethernet WAN services, with many different names. But all of them use a similar model, with Ethernet used between the customer site and the SP's network, as shown in Figure 3-9.

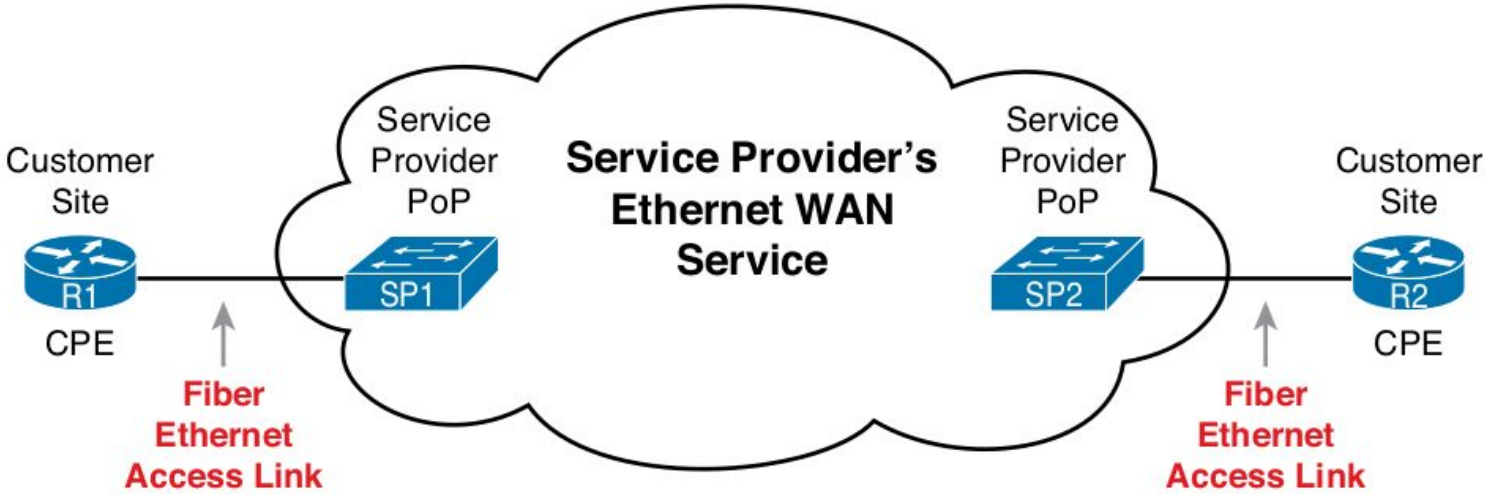

Figure 3-9 *Fiber Ethernet Link to Connect a CPE Router to a Service Provider's WAN*

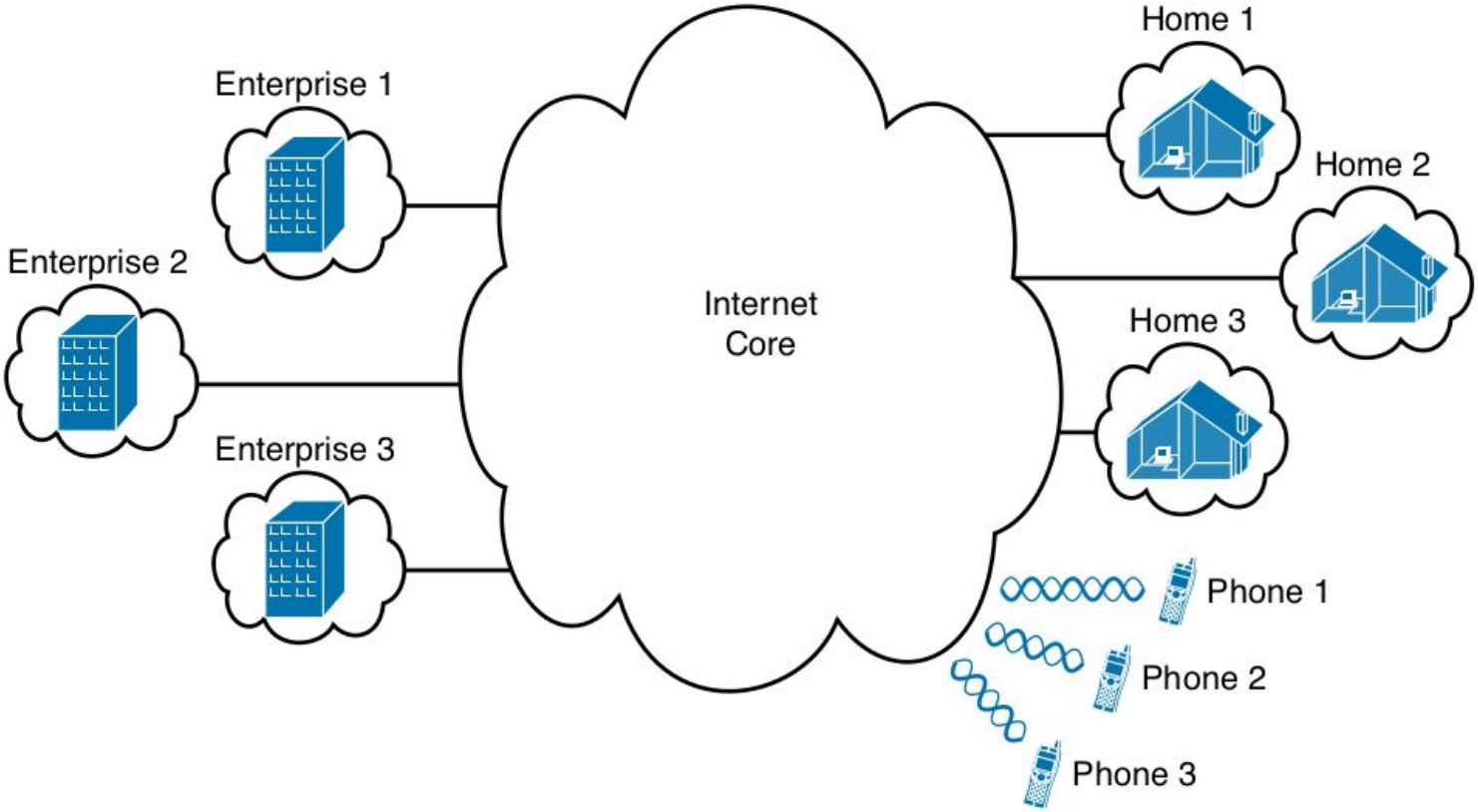

Figure 3-12 *Internet with Enterprise, Home, and Phone Subscribers*

The Internet as a Large WAN

The Internet is an amazing cultural phenomenon. Most of us use it every day. We post messages on social media sites, we search for information using a search engine like Google, and we send emails. We use apps on our phones to pull down information, like weather reports, maps, and movie reviews. We use the Internet to purchase physical products and to buy and download digital products like music and videos. The Internet has created completely new things to do and changed the old ways of living life compared to a generation ago.

However, if you instead focus on the networking technology that creates the Internet, the Internet is simply one huge TCP/IP network. In fact, the name "Internet" comes from the core network layer protocol: Internet Protocol. The Internet includes many LANs, and because the Internet spans the globe, it of course needs WAN links to connect different sites.

As a network of networks, the Internet is actually owned by countless companies and people. The Internet includes most every enterprise TCP/IP network and a huge number of home-based networks, as well as a huge number of individuals from their phones and other wireless devices, as shown in Figure 3-12.

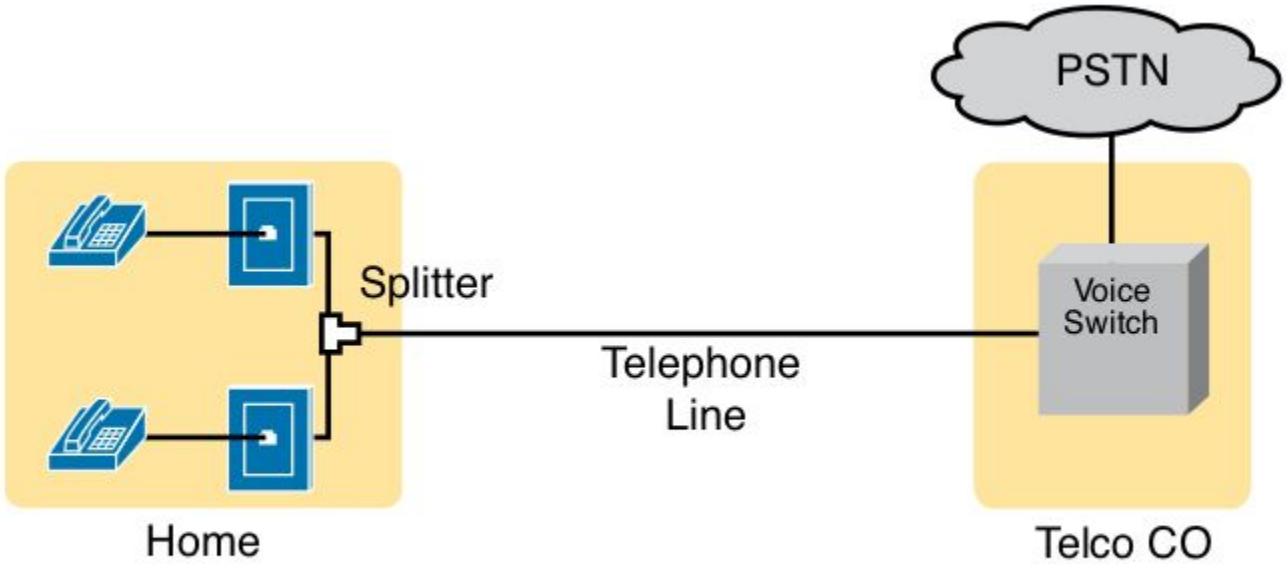

Figure 3-15 *Typical Voice Cabling Concepts in the United States*

DSL (DIGITAL SUBSCRIBER LINE)

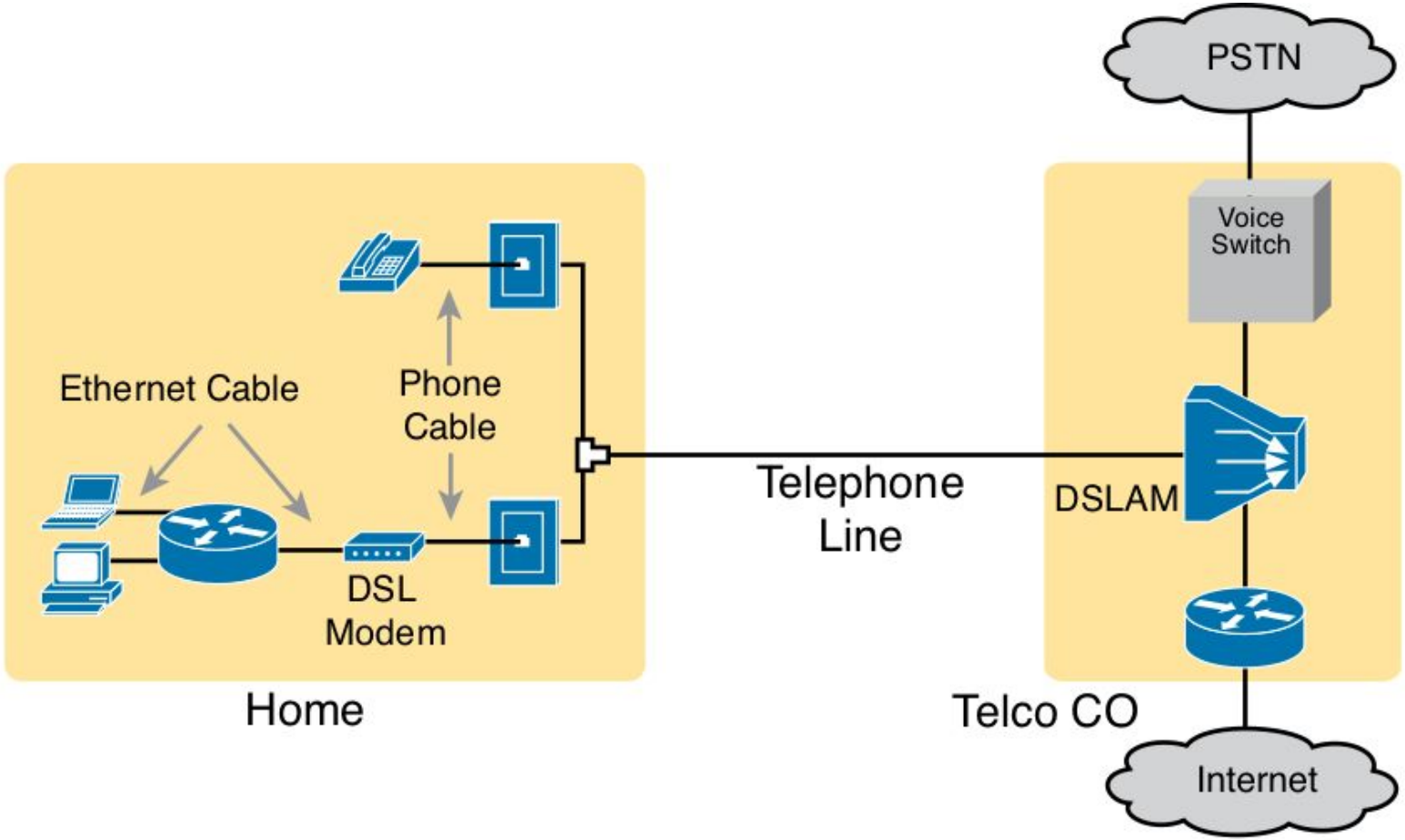

Figure 3-16 *Wiring and Devices for a Home DSL Link*

CABLE CONNECTION

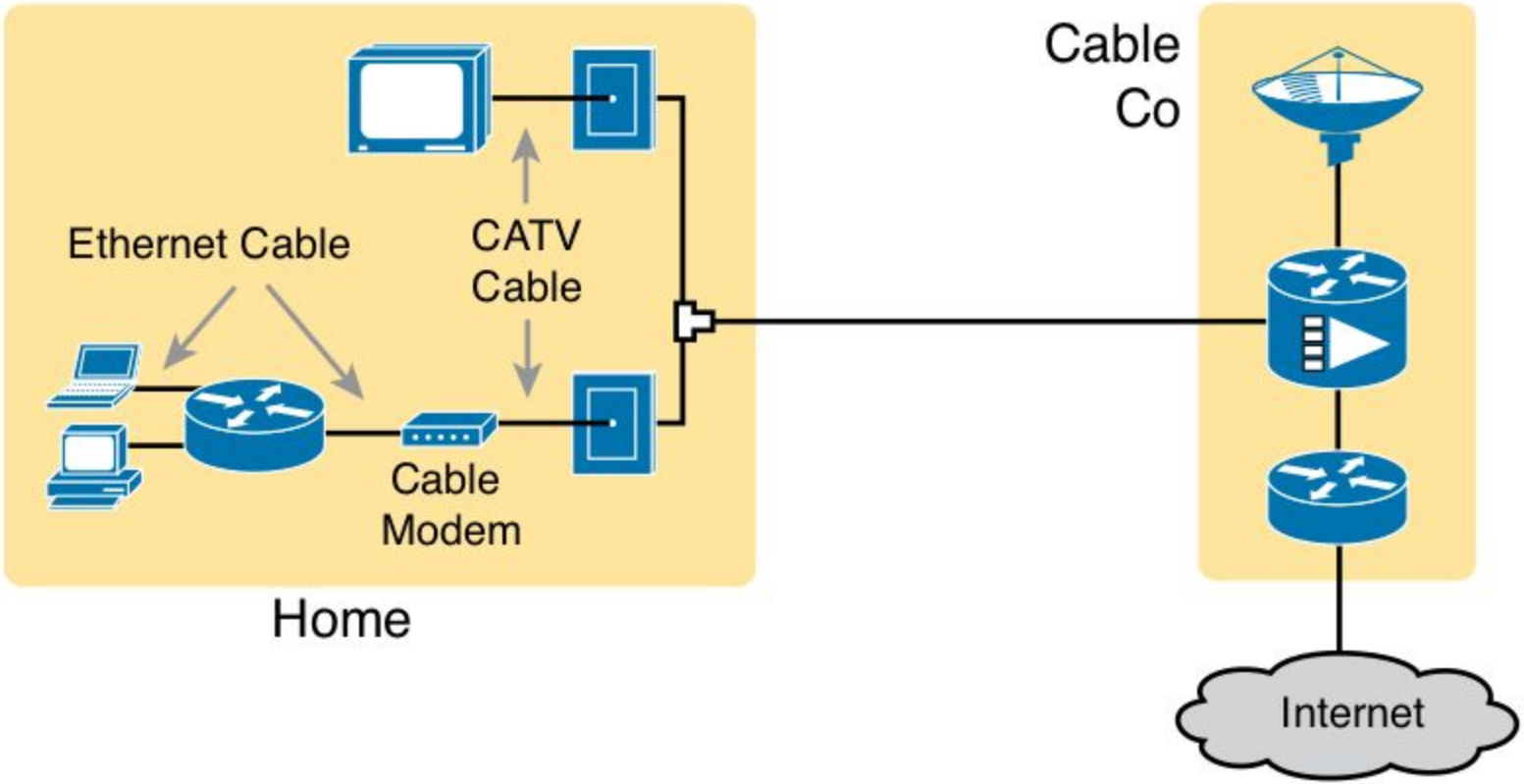

Figure 3-17 *Wiring and Devices for a Home Cable Internet Link*