# Wide Area Networks

*by Sophia*

# 1. What is a WAN?

As local area networks grew and developed, it became increasingly necessary to be able to connect their resources together over long distances using a **Wide Area Network (WAN)**.

### ✎ KEY CONCEPT

These challenges were initially addressed by phone company networks, called the **Public Switched Telephone Network (PSTN)**, and the first successful network able to establish voice communications between different locations was born. The PSTN provides a fully operational, circuit-switching network, enabling every phone call to establish a unique circuit from one endpoint (phone) to another through a path of switches.

In contrast, modern computer networks use packet switching rather than circuit switching as their communications-delivery method. In other words, rather than establishing a circuit between two points and keeping it open for the duration of the communication, they deliver data on a packet-by-packet basis. But even though the delivery is different, the two systems often share the same infrastructure.

### ⚑ HINT

Today's WANs frequently use phone companies (service providers) in concert with their circuit-switched networks to connect LANs.

The Internet also provides an alternative way to connect LANs, and the public benefits from the resulting reduction in the cost of connectivity. Creating WAN connections using the Internet can greatly reduce the cost of a WAN's infrastructure, because the hardware and cables connecting the points are already in place.

WAN protocols and technologies all occupy at least two of the OSI model's lower three layers,

- Layer 1 (Physical)
- Layer 2 (Data Link)
- Layer 3 (Network)

Let's examine the various types of connections, technologies, topologies, and devices used with WANs as well as how to create WAN connections using different transmission media such as RF (wireless and satellite), and both copper and glass fiber for wired connections.

📄 TERMS TO KNOW

**Wide Area Network (WAN)**
A computer network that covers a large geographic area.

**Public Switched Telephone Network (PSTN)**
Network infrastructure provided by public telecommunications carriers.

## 1a. Defining WAN Terms

Before you run out and order a WAN service type from a provider, you really need to understand the following terms that service providers typically use:

- **Customer premises equipment (CPE)** is equipment that is owned by the service provider but located on the subscriber's (your) property.
- **Channel service unit/data service unit (CSU/DSU)** is a Layer 1 device that connects the serial ports on your router to the provider's network and connects directly to the **demarcation point** (demarc) or location. These devices can be external, as shown in diagram below, or they can be internal cards on the router.



ISP can perform a loopback test from CO to NIU.
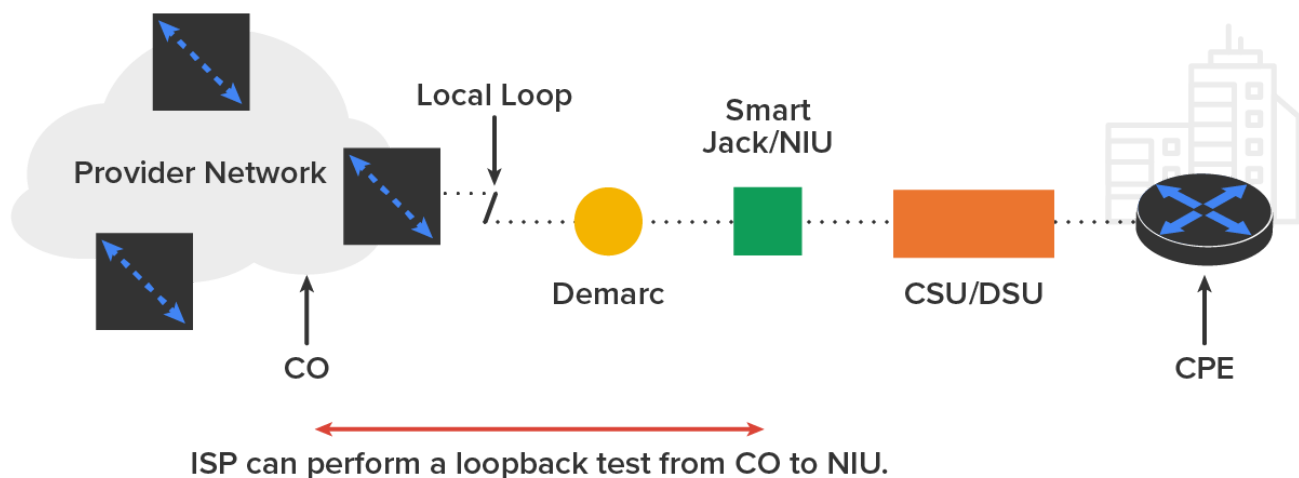
As you can see in the diagram above, there is a **smart jack**, or **network interface unit (NIU)**, installed between the demarcation location and the CSU/DSU at the customer premises equipment (CPE) location. A smart jack can provide signal conversion by converting codes and protocols into something the customer equipment requires. Plus, the NIU can buffer and/or regenerate the signal to compensate for signal degradation from line transmission. This is very similar to what a repeater does.

Smart jacks also typically provide diagnostic capabilities to the ISP, something a demarcation location just cannot do. A very common and vital capability gained via a smart jack is the ability to perform a loopback test, where the signal from the provider is transmitted back to the provider's location. Doing this allows the ISP to test the line from the central office, without the need to have test equipment or a technician at the customer site.

> 🖋 **KEY CONCEPT**
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> A demarcation point is the precise spot where the service provider's or local exchange carrier's responsibility ends and the CPE begins. It is generally a device in a telecommunications closet owned and installed by the telecommunications company (telco).

A cable consisting of a pair of copper wires called the **local loop** connects the demarc to the closest switching office, known as a **central office (CO)**. This could be a phone company who's building connects a customer's network to the provider's switching network. CO is sometimes referred to as a **point of presence (POP)**. The **toll network** is a trunk line inside a WAN provider's network. This network is a collection of switches and facilities owned by the ISP.

> 📄 **TERMS TO KNOW**
>
> **Customer Premises Equipment (CPE)**
> Any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication circuit at the demarcation point.
>
> **Channel Service Unit/Data Service Unit (CSU/DSU)**
> A hardware device that converts a digital data frame from a local area network (LAN) protocol into a frame format of a wide-area network (WAN) protocol.
>
> **Demarcation Point**
> The point of demarcation where the provider's network (and responsibility) ends and that of the customer begins.
>
> **Smart Jack**
> A device that serves as the demarcation point between the carrier's local loop and the customer's premises wiring.
>
> **Network Interface Unit (NIU)**
> A device that serves as the demarcation point between the carrier's local loop and the customer's premises wiring.
>
> **Local Loop**

The physical link or circuit that connects from the demarcation point of the customer premises to the edge of the common carrier or telecommunications service provider's network.

**Central Office (CO)**

A telecommunications system used in the public switched telephone network (PSTN) to interconnect telephone subscriber lines or virtual circuits of digital systems to establish telephone calls between subscribers.

**Point of Presence (POP)**

A demarcation point or network interface point between communicating entities.

**Toll Network**

A trunk line inside a WAN provider's network.

## 1b. The Public Switched Telephone Network

As mentioned earlier, the portion of the PSTN that runs from your house to the rest of the world is known as **plain old telephone service (POTS)**, and it is a popular method for connecting remote users to a local network due to simplicity, low cost, and easy installation. Connecting to PSTN via ISDN, DSL, a cable modem, or even your cellular service is becoming increasingly popular.

Two key concepts to keep in mind about PSTN are public and switched.

> 🖊 **KEY CONCEPT**

Public basically means that, for a fee, anyone can lease the use of the network without being required to run any cabling.

> 🖊 **KEY CONCEPT**

Switched explains how the phone system works. Even though one or more wires are actually connected to your home and/or office, all of them aren't always online or being used. Any dormant wires are still available to you in their offline state so you can get online and join the network whenever you want.

> ❓ **REFLECT**

Think of it as like a standing reservation and your phone number is used as an ID to access it. Because you initiate the connection by dialing a certain phone number, it is easy to imagine how technically impractical, if not impossible, it would be for this method to work if every phone number stayed connected all the time. If connections stayed active 24/7, the resulting backbone cabling requirements and problems would be insurmountable.

**IN CONTEXT**

Take, for instance, the U.S. and worldwide telephone systems. The actual numbering sequence varies in other countries, but the concept is identical. The phone company runs the local loop from the demarc to the CO. All the pairs from all the local loop cables within a small regional area come together at a central point a lot like a patch panel in a LAN based on unshielded twisted-pair (UTP)

cable.

This centralized point has a piece of equipment attached called a switch (a different kind than you've learned about so far in the context of networking). The switch opens a communications session when it is initiated by a user who has dialed the phone number of the receiver and keeps it open until the 'conversation' ends and the session is closed. On one side of the switch is the neighborhood wiring, and on the other side are lines that connect to either another switch or a local set of wiring.

To make this concept really clear, picture the following scenario: When you want to make a traditional landline phone call, you pick up the phone, which completes a circuit, and in most cases that gives you a dial tone. The tone is the switch's way of saying, "I am ready." When you do not get that dial tone, it means that either there is a break in the equipment chain or the switch is too busy processing other requests. In many areas of the world, you hear a fast on-and-off tone (somewhat like a fast busy signal) after giving a command string (phone number) to the local switch. This means that the other switches that the local switch is attempting to communicate with are too busy at that time.
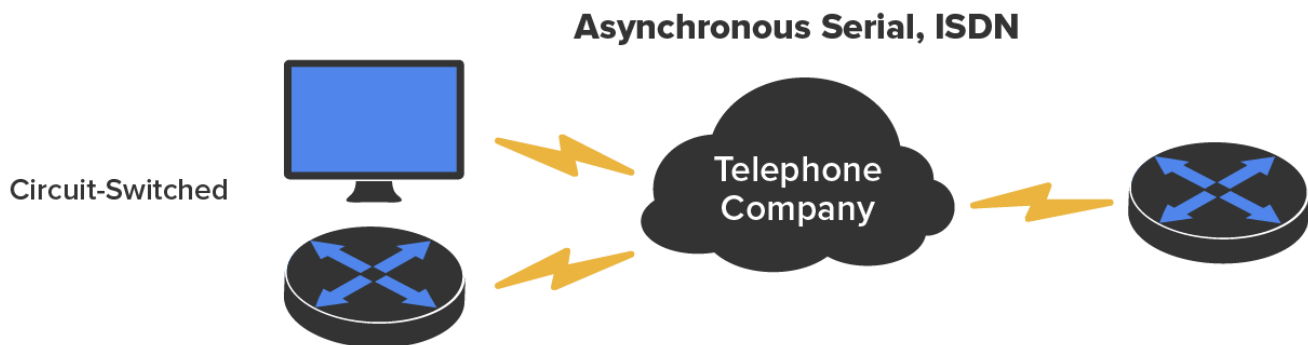
📄 TERM TO KNOW

**Plain Old Telephone Service (POTS)**
The traditional landline telephone system.

## 1c. WAN Connection Types

We will now explore the various types of WAN connections you will find on the market today. The diagram below shows the different WAN connection types that can be used to connect your LANs together.

## Synchronous Serial

**Dedicated**

## Asynchronous Serial, ISDN

**Circuit-Switched**

Telephone
Company

## Synchronous Serial

**Packet-Switched**

Service
Provider

Let's talk about the different WAN connection types you see pictured here:

Dedicated (Leased) Lines are usually referred to as point-to-point or dedicated connections. A dedicated **leased line** is a pre established WAN communications path that goes from the CPE through the **Data Circuit Terminating Equipment (DCE)** any functional unit that transmits or receives data in form of an analog or digital signal through a network. This includes functional units that transmit from a switch and then over to the CPE of the remote site. The CPE enables **Data Terminal Equipment (DTE)** networks to communicate at any time with no cumbersome setup procedures to muddle through before transmitting data. When you have significant revenue to invest, this is the way to go because it uses synchronous serial lines up to 10 Gbps. High-Level Data Link Control (HDLC) and Point-to-Point Protocol (PPP) encapsulations are frequently used on leased lines.

When you hear the term **Circuit Switching**, think about a traditional landline telephone call. The big advantage is cost because you only pay for the time you actually use. No data can transfer before an end-to-end connection is established. Circuit switching uses dial-up modems or ISDN and is used for low-bandwidth data transfers.

**Packet Switching** is a means of directing digitally encoded information in a communication network from its source to its destination. Messages are divided into smaller entities called packets, each of which travels independently through the network in paths based on moment to moment routing decisions made by the nodes through which they pass. This WAN switching method allows you to share bandwidth with other companies to

save money. Packet switching can be thought of as using a network that is designed to look like a leased line yet charges you more like circuit switching does.

LANs use packet-switching technology. The source and destination addresses in the packet header guide the network as it moves the packet closer and closer to the destination.

⇌ EXAMPLE  This is done in the same way the post office takes an addressed letter and keeps it moving incrementally closer to its destination.

This approach avoids the necessity of establishing an actual contiguous electrical circuit from one end to the other, which is the method phone companies use to facilitate a phone call in their circuit-switched networks.

Most WAN connections work on the phone company's circuit-switched network where the point-to-point nature of most connections eliminates the need for addressing because there's only one possible destination between endpoints. But you still need a proper addressing scheme within your LAN to ensure that data packets reach their correct destinations.

☆ **BIG IDEA**

Circuit switching provides dedicated bandwidth, while packet switching enables bandwidth sharing by a service provider's customers which lowers the cost.

🗎 **TERMS TO KNOW**

**Leased Line**
A private telecommunications circuit between two or more locations provided according to a commercial contract.

**Data Circuit Terminating Equipment (DCE)**
Any functional unit that transmits or receives data in the form of an analog or digital signal through a network.

**Data Terminal Equipment (DTE)**
Any unit that functions either as a source of or as a destination for binary digital data.

**Circuit Switching**
A method of implementing a telecommunications network in which two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate.

**Packet Switching**
A means of directing digitally encoded information in a communication network from its source to its destination, in which messages may be divided into smaller entities called packets, each of which travels independently through the network in paths based on moment to moment routing decisions made by the nodes through which they pass.

☑ SUMMARY

In this lesson, you learned about **Wide Area Networks (WANs)**. We discussed what a WAN is and defined common terms relevant to WAN technologies. We deepened our understanding of the Public Switched Telephone Network (PSTN) and discussed various options for WAN connectivity, including dedicated leased lines, circuit switching, and packet switching.

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  The point of demarcation where the provider's network (and responsibility) ends and that of the customer begins.

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  A private telecommunications circuit between two or more locations provided according to a commercial contract.

**Local loop**

The physical link or circuit that connects from the demarcation point of the customer premises to the edge of the common carrier or telecommunications service provider's network.

**Network interface unit (NIU)**

A device that serves as the demarcation point between the carrier's local loop and the customer's premises wiring.

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