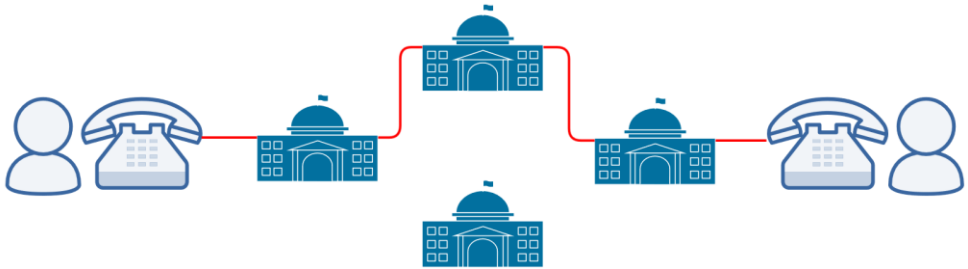
WAN Connection Types

WAN Connection Types

- WAN connections can be broken up into three different categories:
  - Circuit-Switched Connections
  - Packet-Switched Connections
  - Dedicated Leased Lines

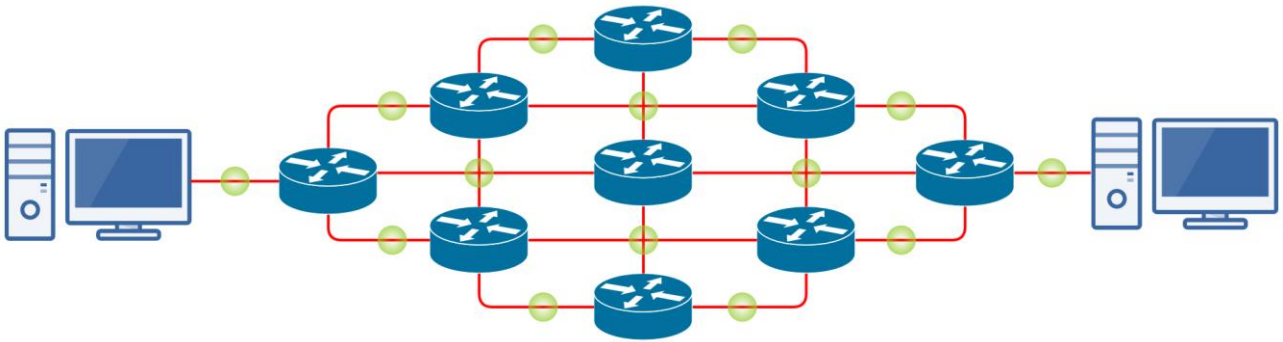
Circuit-Switched Connection

- Designed in 1878, was originally designed for telephone calls.
- Uses a dedicated point-to-point connection (circuit) using a telecommunications network.
  - Creates a dedicated link with fixed bandwidth between communicating nodes.
  - Others can't utilize the circuit during the connection, which may waste bandwidth.
  - Transmissions are sent and received in order, unlike with packet switching, where they can arrive out of order.
- **Examples**:
  - Dedicated Leased-Lines & Dial-Up



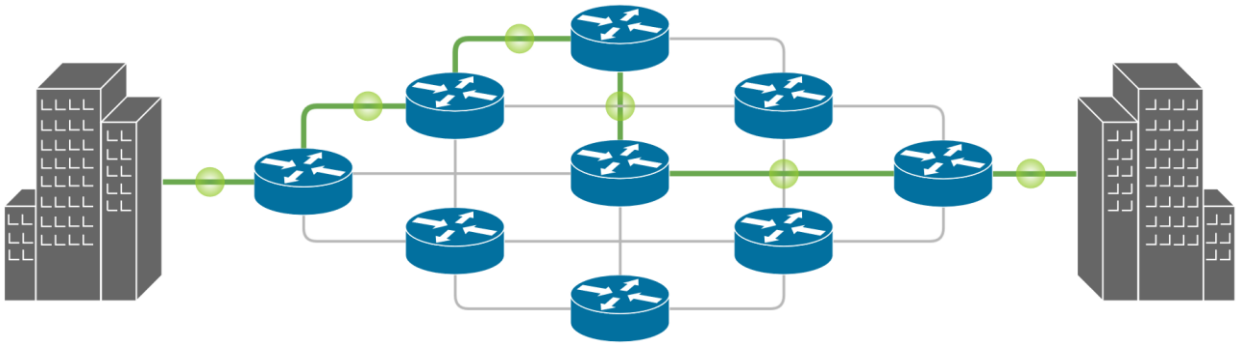
Packet-Switched Connection

- Data is broken into packets, which are routed to different links to the other endpoint.
- The path varies based on the best route at the time the data is sent.
  - Packets may arrive out of order and must be re-assembled in the correct order.
- Unlike circuit switching, packet switching shares bandwidth and connections with others.
- This method of data transmission is the core technology for the Internet and most LANs.
- Packet-switched connections can create virtual circuits, which we'll discuss on the next slide.



Virtual Circuit

- Connection-oriented packet-switched connections create virtual circuits.
  - A means of forwarding packets of data in such a way that it appears as if there is a dedicated physical link (circuit) between the source and destination.
- Virtual circuits allow service providers to offer better QoS based on a service level agreement (SLA).
- There are two types:
  - **Permanent Virtual Circuit (PVC)**: Always Exists
  - **Switched Virtual Circuit (SVC)**: Considered On-Demand



Dedicated Leased Line

- Like its name implies, it's a dedicated leased line.
- Commonly called a Point-to-Point link.
- A reserved circuit that provides a fixed bandwidth point-to-point data connection, usually between two offices.
    - It's always active and provides a guaranteed bandwidth for a fixed monthly fee.
- The leased line may be a dedicated physical line or a permanent virtual circuit.

WAN Transmission Mediums

WAN Transmission Mediums

Copper

- Copper cabling is used in a variety to WAN applications:
  - Dial-Up
  - DSL
  - Broadband Cable
- Copper has limited distances and speeds, so fiber is becoming more common.

Fiber

- Fiber is a popular WAN transmission medium, as it offers extremely fast speeds over long distances.
- Speeds greater than 10Gbps achievable with distances up to 75 miles.
- Synchronous optical networking (SONET) is the standard for fiber WAN transmissions.
- SONET uses the Optical Carrier (OC) standard, which we'll discuss later in this section.

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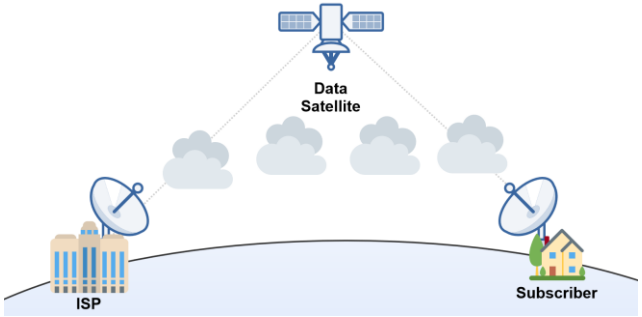
WAN Transmission Mediums

Wireless (Cellular)

- 4G and 5G cellular technologies make wireless cellular a realistic option for WAN connectivity.
  - **Average 4G Speeds**: 25 to 30Mbps
  - **Average 5G Speeds**: 40Mbps to 1.5Gbps
- Dedicated devices and phones can be utilized as Internet hotspots in places where other options aren't available:
  - Ships, Places, Remote Locations

Satellite



- A viable solution when wired connections aren't available.
  - Typical speeds range from 12 to 100Mbps
  - Can be expensive
  - Prone to severe latency (delay) problems
  - Sensitive to weather conditions
- The subscriber has a satellite dish installed, which is called a very small aperture terminal (VSAT).

WAN Termination Concepts

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WAN Termination Concepts

Demarcation (Demac) Point

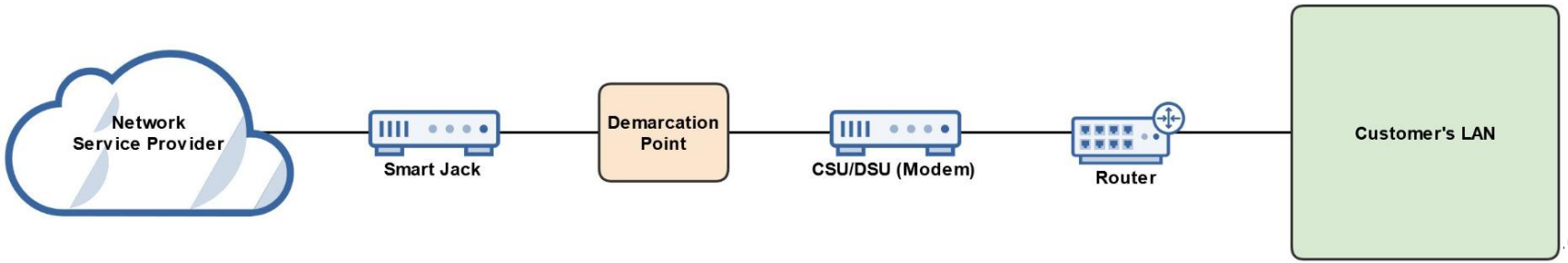
- The point where the ISP's network ends and the organization's network begins.
- The dividing line between the service provider and customer's network.

Channel Service Unit/Data Service Unit (CSU/DSU)

- A WAN connectivity device that connects a WAN link to a customer's LAN, and is typically a modem.
- The CSU connects to the network service provider's network, while the DSU connects to the customer's data termination equipment (DTE), which is typically a router.

Smart Jack

- A smart jack is often used with a CSU/DSU, which enables the service provider to diagnosis network issues and perform loopback tests.



WAN Broadband Services

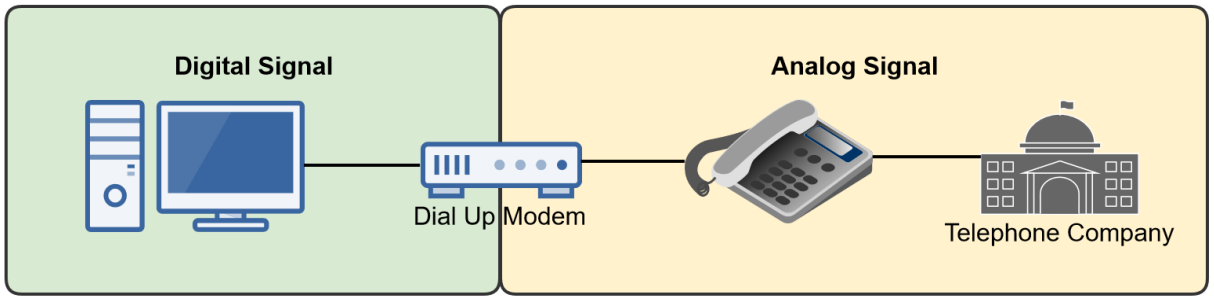
WAN Broadband Services

- We'll now discuss the following WAN broadband services:
  - Dial-Up
  - T-Carrier Signal Lines
  - DSL
  - Cable Broadband
  - Metropolitan Ethernet

Dial-Up

Dial-Up Connection

- The original Internet connection methodology.
  - 56Kbps (kilobits per second) maximum speed.
- Uses POTS (Plan old telephone service) also referred to as a PSTN (public switched telephone network).
- Utilizes Circuit Switching
  - A modem initiates a call and the dedicated circuit exists only while the connection is active.



T-Carrier & E-Carrier Digital Signal Lines

T-Carrier & E-Carrier Digital Signal Lines

- Commonly referred to as “dedicated” leased lines, because they are leased from the telecommunications company to provide a dedicated circuit.
  - Circuit-Switched Technology
- T-Carrier and E Carrier Locations:
  - **T-Carrier Lines**: North America, Japan, and South Korea
  - **E-Carrier Lines**: Europe

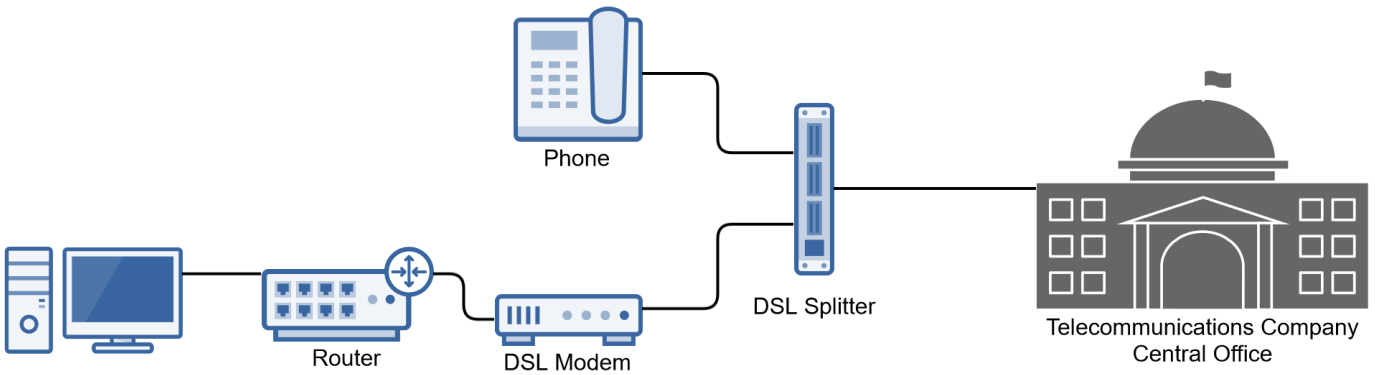
Comparing T1, E1, T3, and E3 Speeds

Type	Speed	Details
DS0	64Kbps	Single Channel
T1 (DS1)	1.544Mbps	24 x DS0 64Kbps Channels
E1 (DS1)	2.048Mbps	30 x DS0 64Kbps Channels
E3 (DS3)	34.368Mbps	512 x 64Kbps Channels
T3 (DS3)	44.736Mbps	672 x 64Kbps Channels

DSL

Digital Subscriber Line (DSL)

- High-speed Internet technology utilizing POTS.
  - Sends data digitally over telephone lines.
  - Utilizes a DSL modem and splitter to accomplish this task.
- DSL Limitation:
  - DSL modem must be within 4,000 to 18,000 ft. of telecommunications company's central office (CO) based on the type of DSL.



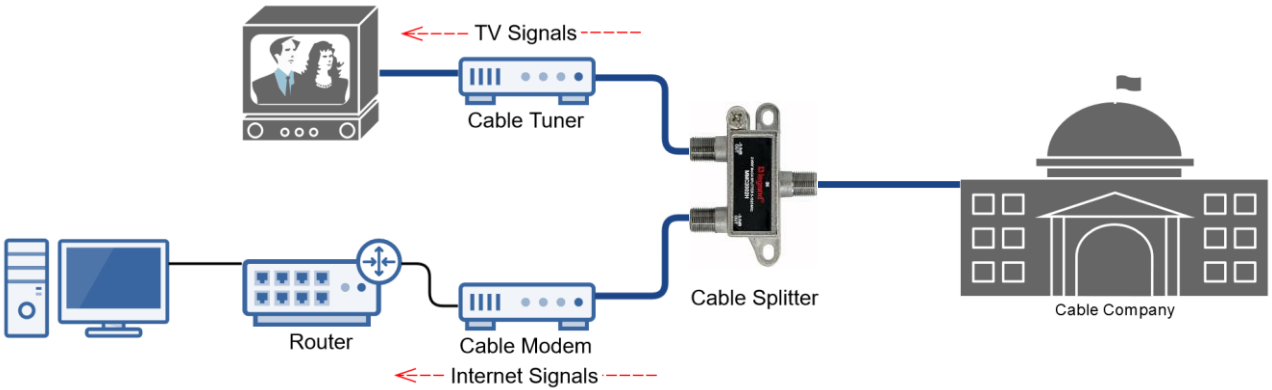
Types of DSL

- **Asymmetric DSL (ADSL)**
  - Consumer version of DSL that allocates more bandwidth to downstream than upstream data flow.
  - Latest version (ADSL+) offers download speeds around 24 Mbps and upload speeds around 1 Mbps.
- **Symmetric DSL (SDSL)**
  - Provides equal bandwidth for downstream and upstream data flows.
    - 1.544 Mbps (U.S. and Canada) – T1 Equivalent
    - 2.048 Mbps (Europe) – E1 Equivalent.
  - Less popular in residential installations.
- **Very High Bitrate DSL (VDSL)**
  - Today's replacement for ADSL and SDSL.
  - Latest version (VDSL2-Vplus) can provide the following speeds:
    - **Asymmetric**: 300 Mbps download and 100 Mbps upload
    - **Symmetric**: 100 Mbps download and upload

Cable Broadband

Cable Broadband

- High-speed Internet technology utilizing your cable service.
  - Uses Data Over Cable Service Interface Specification (DOCSIS) standard to provide Internet access via a cable modem.
- Understanding Broadband
  - The simultaneous transmission of multiple signals over different frequencies at the same time.
  - This allows for different cable TV channels and your Internet data to be assigned to different frequencies, all being transmitted simultaneously.



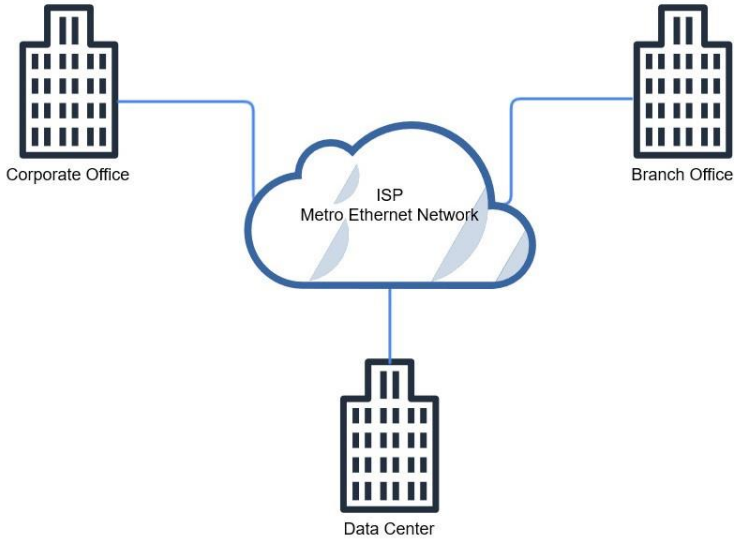
DOCSIS Standards

Version	Date	Max Download Speed	Max Upload Speed
1.0	1997	40 Mbps	10 Mbps
1.1	2001	40 Mbps	10 Mbps
2.0	2002	40 Mbps	30 Mbps
3.0	2006	1 Gbps	200 Mbps
3.1	2013	10 Gbps	1 – 2 Gbps
4.0	2017	10 Gbps	6 Gbps

Metropolitan Ethernet

Metropolitan Ethernet (Metro-E)

- A WAN technology based on Ethernet standards.
- Extends Ethernet, a LAN technology onto WANs:
  - Commonly uses fiber optics cabling to overcome twisted-pair copper cabling distance limitations.
- From the customer's perspective, it's like being connected to an Ethernet switch.
- Popular implementations offer 1 Gbps up to distances of 100km or 100 Gbps up to 10km.
- Popular business solution used to connect multiple sites together.



WAN Protocols

WAN Protocols