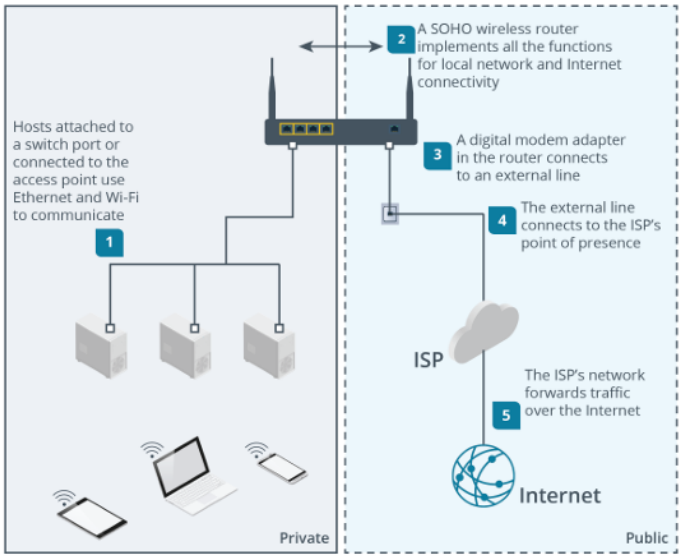
Topic 5A: Compare Internet Connection Types:

LAN is of limited use. The full functionality of networking is only realized by connecting local networks to the Internet. Being able to compare the technologies used by ISPs to facilitate Internet connections will allow you to assist customers in selecting suitable options.

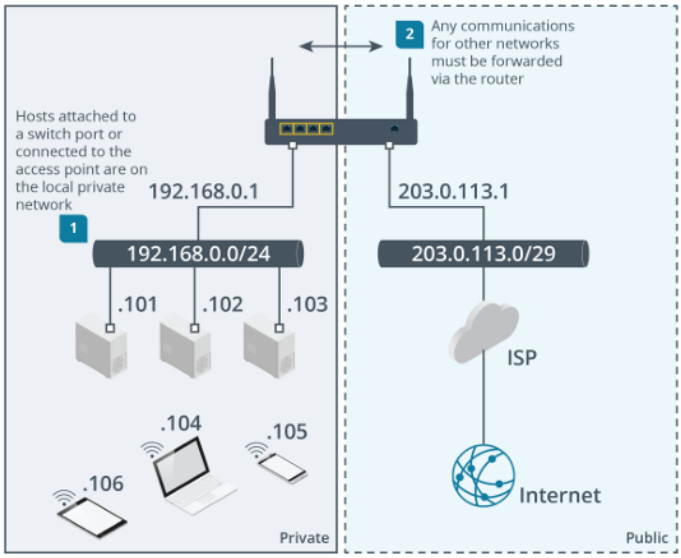
Internet Connection Types and Modems:

The Internet is a global network that connects millions of devices and smaller networks worldwide. At its core, high-speed **fiber optic links** connect **Internet Exchange Points (IXPs)**, where large networks exchange traffic. These IXPs, created by telecom companies and institutions, enable **Internet Service Providers (ISPs)** to connect their customers to the Internet. Customers access the Internet through the ISP's **Point of Presence (PoP)**, which acts as a local connection hub, often located at a telephone exchange or datacenter. The technology and infrastructure used to link homes or offices to an ISP's **PoP** determine the **Internet connection type** and the hardware required.

Customers connect to the Internet via an ISP's network.



Role of a digital modem to connect a local network to an ISP's network for Internet access.



Role of the router and Internet Protocol (IP) in distinguishing logical networks.

Imagine you are at home, connected to your Wi-Fi. Your laptop has the IP address **192.168.0.104**, and your phone has **192.168.0.106**. When you open a web browser and visit www.google.com, your router (192.168.0.1) takes your request, translates your private IP to **203.0.113.1** (your public IP), and sends it to Google's servers. Google replies to **203.0.113.1**, and your router then forwards the response back to your laptop at **192.168.0.104**. This process happens instantly for every device in your home network.

Digital Subscriber Line Modems:

DSL modems are used to provide internet access over **copper telephone lines** that were originally designed for voice communication. This is possible because DSL technology utilizes **higher frequencies** on these telephone lines, allowing for data transmission without interfering with voice calls. The **public switched telephone network (PSTN)**, which forms the backbone of telephone communications, consists mainly of **fiber optic cables**, but the final connection to homes and businesses—known as the **local loop** or **last mile**—still relies on traditional **two-pair copper wiring**.

How DSL Works

DSL operates by sending **digital data** over these copper lines. It uses **modulation techniques** and **echo cancellation** to enable high-speed, **full-duplex** (simultaneous upload and download) transmissions. Unlike older dial-up connections, DSL allows users to **browse the internet and make phone calls at the same time** by using different frequency ranges for data and voice.

Types of DSL

1. Asymmetrical DSL (ADSL)

ADSL is the most common type of DSL, especially for home users. It provides **faster download speeds** (downlink) than upload speeds (uplink). This is because most internet users consume more data (e.g., streaming, web browsing) than they upload.

- **ADSL2+**, the latest version of ADSL, offers speeds of up to **24 Mbps downlink** and **1.25–2.5 Mbps uplink**.
- ADSL is widely used for home broadband connections but is being gradually replaced by **fiber and cable** for higher-speed internet.

Real-Life Example:

A home user streaming Netflix and browsing social media primarily benefits from a **fast download speed**, making ADSL a good choice. However, if they start uploading large files frequently (e.g., video conferencing or cloud backups), they may experience slow speeds due to the limited uplink bandwidth.

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2. Symmetrical DSL (SDSL)

Unlike ADSL, **SDSL provides equal upload and download speeds**. This is particularly useful for **businesses** that frequently upload large files, host web services, or use **VoIP (Voice over IP) communication**.

Real-Life Example:

A small business that frequently **uploads large files to cloud storage**, hosts **video conferences**, or **runs a server** would benefit from an SDSL connection because of the higher and balanced upload speeds.

DSL Modems and Connections

To connect to a DSL network, users need a **DSL modem**, which acts as the bridge between their home network and the telephone line. DSL modems can be either:

- **Standalone devices**: Connect to a router via an **RJ45 Ethernet cable**.
- **Integrated into a SOHO (Small Office/Home Office) Router**: Combines modem and router functions into a single device.

A DSL modem connects to the telephone line using an **RJ11 cable**, while it connects to the local network via an **RJ45 Ethernet port**.

Real-Life Example:

A household using DSL for internet would have a **DSL modem** connected to the **telephone socket** via an **RJ11 cable**, with an **RJ45 cable** linking the modem to a Wi-Fi router for wireless access throughout the home.

Role of Splitters (Filters)

Since DSL shares the same telephone line as voice calls, **filters (splitters)** are required to separate **voice and data signals**. These can be installed in two ways:

1. **External Splitters**: Plugged into each phone socket manually by the user.
2. **Built-in Splitters**: Found in modern telephone sockets, eliminating the need for external filters.

Real-Life Example:

If a home user experiences **static noise during phone calls** or **slow internet speeds**, it might indicate a missing or faulty DSL filter. Installing a proper **splitter** ensures that internet traffic and voice calls do not interfere with each other.

Key Exam Takeaways

1. **DSL uses telephone lines** to provide internet, utilizing higher frequencies for data while allowing voice calls simultaneously.
2. **Types of DSL**:
    - **ADSL (Asymmetrical DSL)** → Faster downloads than uploads, used for home internet.
    - **SDSL (Symmetrical DSL)** → Equal upload and download speeds, better for business use.
3. **DSL Modem Connections**:
    - **RJ11 port** (connects to telephone line).
    - **RJ45 port** (connects to router or directly to a computer).
4. **Splitters (Filters) are necessary** to prevent interference between phone calls and DSL internet.

Cable Modem:

Cable modems provide high-speed Internet access using the **cable TV (CATV) network**. This type of connection is commonly referred to as **broadband cable** or simply **cable Internet**. Unlike DSL, which uses telephone lines, cable Internet operates over **coaxial cables**, which are designed to carry large amounts of data. This makes it a faster and more widely used option for home broadband. A CATV network is often described as hybrid fiber coax (HFC), as it combines a fiber optic core network with copper coaxial cable links to customer premises equipment. It can also be described as a broadband cable or just as cable.

Key Points to Remember for the Exam (Cable Modems)

1. **Uses Cable TV (CATV) Network** – Connects via **coaxial cables**.
2. **Hybrid Fiber-Coaxial (HFC) Network** – Fiber for long distances, coaxial for last-mile connection.
3. **DOCSIS Standard** – Enables high speeds:
    - **DOCSIS 3.0+** → Supports **1 Gbps+** with **channel bonding**.
4. **Connections** – Uses **F-type coaxial cable** to ISP, **RJ45 Ethernet** to router.
5. **High Speed** – Faster than DSL, great for streaming and gaming.
6. **Shared Bandwidth** – Slows down during **peak usage hours**.
7. **Availability** – Common in **cities/suburbs** but **limited in rural areas**.

A cable modem: The RJ45 port connects to the local network router, while the coax port connects to the service provider network. (Image © 123RF.com.)

A F-type connector is screwed down to secure it. Do not overtighten it.

Fiber to the Curb (FTTC) and Very High-Speed DSL (VDSL):

Imagine your internet provider runs a super-fast fiber optic cable to a box near your street but uses existing copper phone lines to connect it to your home—that's **Fiber to the Curb (FTTC)**. It's like taking a high-speed train to your neighborhood and then switching to a regular bus for the last part of the journey. Copper wiring slows things down a bit, but **VDSL** technology helps make it faster than traditional DSL.

Very High-Speed DSL (VDSL) is a faster version of DSL that works over **shorter distances**. It supports **both asymmetric and symmetric modes**:

- **Up to 52 Mbps down / 6 Mbps up** (asymmetric, up to 300m/1,000ft).
- **Up to 26 Mbps both ways** (symmetric, up to 300m/1,000ft).
- **VDSL2 (100m/300ft)** can reach **100 Mbps bidirectional**.

Important Note: ADSL modems do not support VDSL, but most **VDSL modems support ADSL** for compatibility.

Fiber to the Premises (FTTP) and Optical Network Terminals:

Optical network terminal—the PON port terminates the external fiber cable and the LAN ports connect to local routers or computers over RJ45 patch cords. (Image by artush © 123RF.com)

Imagine you want the fastest internet at home, like having a personal highway just for your data. With **Fiber to the Premises (FTTP)**, the internet provider runs a fiber optic cable **all the way to your house**, instead of stopping at a street box like older connections. Think of it like getting a direct water pipeline to your home instead of sharing a public well. The **Optical Network Terminal (ONT)** is like a water filter at your house—it takes the high-speed fiber signal and converts it into a regular internet signal that your Wi-Fi router can use. From there, an **RJ45 cable** (like a garden hose) connects the ONT to your router, so you get blazing-fast internet inside your home. So that means, this is a **full fiber** connection where fiber optic cable is used from **ISP** to the **ONT,** but from **ONT** to the **router,** an **RJ45 Ethernet cable** is required.

Fixed Wireless Internet Access:

Geostationary Orbital Satellite Internet:

Imagine you live in a remote village where no cables or fiber connections reach. Instead, your internet comes from a satellite high up in space, always staying in the same position above Earth. Your home has a **satellite dish (VSAT)** i.e. **Very Small Aperture Terminal** that sends and receives signals to and from this satellite. While this allows internet access even in the most isolated places, there's a catch—because the signal has to travel thousands of miles up and back down, there's a delay (latency). This makes real-time activities like video calls and online gaming slower compared to wired internet. Because the satellite does not move relative to the dish, there should be no need for any realignment. The antenna is connected via coaxial cabling to a Digital Video Broadcast Satellite (DVB-S) modem.

Think of RTT like sending a letter and waiting for a reply. Imagine you mail a letter to a friend in another city, and they send a response back. The total time from sending your letter to receiving their reply is the **Round-Trip Time (RTT)**. In networking, RTT is the time it takes for a data packet to travel from your device to a server and back. A lower RTT (like 10–20ms on DSL) means faster responses, while a higher RTT (600–800ms on satellite internet) causes noticeable delays, making activities like video calls or gaming feel laggy.

So, in the case of Geostationary Orbital Satellite Internet, RTT is the two-way latency, or the time taken for a probe to be sent and a response to be received.

Low Earth Orbital (LEO) Satellite Internet:

Imagine instead of using one giant satellite far away in space, your internet comes from a group of satellites orbiting much closer to Earth. These **LEO satellites** provide faster speeds and lower delays (latency) than traditional satellites, making activities like video calls and gaming much smoother. However, since they **move across the sky**, your home's antenna needs to track them, often using a special **phased array** system to switch between satellites automatically. For this to work well, the antenna needs a clear view of the sky.

Wireless Internet Service Providers (WISP):

Imagine your internet comes from a **radio tower** instead of cables. A **Wireless Internet Service Provider (WISP)** sends signals from their tower to a special **antenna on your house**, giving you internet without needing underground wires. This setup is faster than satellite and has lower delays, but it needs a **clear line of sight** between your antenna and the tower. Bad weather, like heavy rain or snow, and interference from other signals can sometimes weaken the connection. If the provider uses unlicensed frequencies, there are risks of interference from other wireless networks and devices.

Cellular Radio Internet Connections:

3G:

Imagine you're on a road trip and your phone connects to the nearest cell tower (like a pit stop) to get a signal. That tower covers a certain area, like a Wi-Fi hotspot but much bigger—up to 5 miles! Your phone uses radio waves to communicate, and in the U.S., it usually works on **850** or **1,900 MHz** and for the rest of the world on **900 or 1800 MHz**. There are two types of 3G phones: **GSM (Global System for Mobile Communication)**, which uses SIM cards (like swapping a game cartridge in a console to switch networks), and **CDMA (Code Division Multiple Access)**, where the phone is locked to the provider (like a cable box that only works with one company) and there is no removable SIM card. Buildings can block signals, just like how walls weaken Wi-Fi at home.

4G:

Think of LTE as the upgraded highway for mobile data—faster and smoother than 3G. Unlike before, where GSM used SIM cards and CDMA didn't, LTE requires **all** devices to have a SIM card, no matter the network. It works with both GSM and CDMA providers, meaning everyone is on the same high-speed road, just with different carriers. This is why even CDMA-based networks like Verizon started using SIM cards with LTE.

5G:

5G (Fifth Generation) is the latest and fastest mobile network, designed to handle more devices with super high speeds and low delay (latency). Think of it like upgrading from a regular road (4G LTE) to a super-fast highway with multiple lanes, allowing data to travel much quicker and smoother.
There are three types of 5G signals:

- **Low-band** (like AM radio) – Covers long distances but isn't super fast. Speed around **50 Mbps.**
- **Mid-band** (like FM radio) – A balance of speed and range, common in cities.
- **High-band (mmWave)** – Crazy fast but only works in short distances (like Wi-Fi). Speed around **10Gbps.**

With 5G, you can download movies in seconds, play online games without lag, and even support future tech like self-driving cars and smart cities!

Remember, both 4G and 5G can be used as fixed access broadband as well as in mobile devices.

Fixed Access Broadband:

Fixed access broadband refers to high-speed internet that is **physically connected** to a home or business rather than using mobile or satellite networks. It provides a **stable and reliable** connection through **wired infrastructure**, such as:

- **Fiber-optic broadband** – Uses glass fibers for ultra-fast speeds.
- **Cable broadband** – Uses coaxial cables (like TV services).
- **DSL (Digital Subscriber Line)** – Uses telephone lines.
- **Fixed wireless broadband** – Uses radio signals from a local tower but stays in a fixed location.

Unlike **mobile broadband** (which moves with you), fixed broadband is **installed at a specific address**, making it ideal for homes and businesses needing consistent internet access.

Routers:

A **router** is like a traffic director for the internet, ensuring data moves between a private network (**LAN**) and the wider internet (**WAN**). Within a local network, devices communicate using **MAC addresses**, which work like house numbers, allowing data to move between devices in the same area. However, MAC addresses don't work for sending data beyond the local network, so **IP addresses** are used instead, similar to full mailing addresses that help data travel across the internet. Unlike switches and Wi-Fi access points that forward data based on MAC addresses, routers forward data using IP addresses, ensuring that information reaches the correct network and device. Different types of routers serve different purposes: a **SOHO (Small Office/Home Office) router** connects home or small business devices to the internet; a **LAN router** divides a large network into smaller sections to improve performance and security by reducing unnecessary traffic; and a **WAN or border router** connects private networks to the internet or other distant networks. This is especially important for large organizations that need to manage network traffic efficiently. Without routers, different network segments wouldn't be able to communicate, and local networks wouldn't have access to the internet. And as a reminder, it works on **third layer** in the OSI Model which is **Network Layer** because it **forwards data** based on **IP addresses.**

Firewalls:

A **firewall** acts like a security guard for your network, deciding which devices and types of data can pass through. It uses a set of rules called an **Access Control List (ACL)** to allow or block traffic based on **IP addresses, protocols, and ports**. Firewalls can be placed at the **edge of the network** (between a private network and the internet) or **inside a private network** to restrict access between devices. Many **routers** have built-in firewall features, but there are also **standalone firewall appliances** that offer advanced security, often as part of a **Unified Threat Management (UTM) system**. Additionally, individual computers can have **software firewalls** to protect against threats even within a trusted network. Firewalls are essential for blocking hackers, malware, and unauthorized access. 🚀 🔒

Some Questions and Answers:

2. You are setting up an ADSL router/modem for a client, but the cables are missing. What type of cable do you need to connect the router's WAN interface?

Answer: You need an **RJ11 cable** to connect the ADSL modem to the phone line via a **DSL filter**.

- **Example:** Think of an ADSL connection like an old-school landline phone. The router needs a phone cable (RJ11) to plug into the wall and connect to the internet.

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3. A customer with a full fiber connection lost their router cable and thinks they need a fiber optic cable. What type of cable do they actually need?

Answer: They need an **RJ45 Ethernet cable** (Cat5e, Cat6, or higher). The **ONT converts fiber into an Ethernet signal**, which the router uses.

- **Example:** Imagine the ONT as a translator—it receives fiber optic data and "translates" it into something the router understands (Ethernet). The router then shares the connection with all devices at home.

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4. True or False: Both 4G and 5G cellular can be used for fixed access broadband, not just mobile devices.
Answer: True! 4G and 5G can work as **home internet** or a **backup connection**. Some routers have a SIM card slot to use cellular networks.

- **Example:** If your home has no wired internet options, you can get a 5G home internet plan that works just like Wi-Fi but using the mobile network.

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5. True or False: A SOHO router combines a modem and Ethernet adapter into a single hardware port.
Answer: False! A **SOHO (Small Office/Home Office) router** has separate ports for the **modem and Ethernet interface**.

- **Example:** Your home router has a **WAN port** for the modem and multiple **LAN ports** for wired devices. They don’t share the same connection.