WIMAX

802.16, also called WiMAX, is a wireless technology that provides high-speed internet over long distances.

What Does It Do?

- It allows people to access the internet without needing cables like fiber or DSL.

- Works in large areas, even in places where normal Wi-Fi can't reach.

- Can be used for homes, businesses, and even entire cities.

How Is It Different from Wi-Fi?

- Wi-Fi covers small areas (like a home or café).

- 802.16 covers big areas (like a town or countryside).

- Wi-Fi is short-range, while 802.16 can work over 50 km for fixed connections

Question :- Difference between 802.11 and 802.16 .

Answer :-

IEEE 802.11 and IEEE 802.16 are both wireless communication standards, but they serve different purposes. Here's a simple comparison:

802.11 (Wi-Fi) vs. 802.16 (WiMAX)

Feature	802.11 (Wi-Fi)	802.16 (WiMAX)
Technology	Wireless Local Area Network (WLAN)	Wireless Metropolitan Area Network (WirelessMAN)
Usage	Short-range wireless connectivity (homes, offices, cafes)	Long-range broadband access (cities, rural areas)
Coverage	30 to 100 meters	7 km to 50 km
Speed	Up to several Gbps (depending on version)	Up to 100 Mbps
Frequency Bands	2.4 GHz, 5 GHz	2 GHz to 11 GHz
Quality of Service (QoS)	Limited QoS support (802.11e)	Advanced QoS options for better performance
Encryption	Uses WPA, WPA2, WPA3 for security	Uses DES and AES encryption

Key Differences

- **802.11 (Wi-Fi)** is designed for **short-range** wireless connections, like connecting your laptop to a router at home.
- **802.16 (WiMAX)** is built for **long-range** wireless broadband, providing internet access over large areas.

Ques : why we dont use 802.16 instead of 802.11

Answer :

Why Wi-Fi (802.11) is Preferred Over WiMAX (802.16)

1. **Cost & Infrastructure**

   - Wi-Fi is **cheaper** to deploy and maintain.

   - WiMAX requires **specialized base stations**, making it more expensive.

2. **Device Compatibility**

- Almost all modern devices (laptops, smartphones, tablets) support **Wi-Fi**.

- WiMAX adoption was limited, and fewer consumer devices were built for it.

3. **Coverage vs. Convenience**

- WiMAX provides **long-range coverage** (up to 50 km), but it's mainly used for **broadband access** rather than local networking.

- Wi-Fi is **short-range** but perfect for **homes, offices, and public spaces**.

4. **Speed & Performance**

- Wi-Fi has evolved with **faster speeds** (Wi-Fi 6, Wi-Fi 7).

- WiMAX was **not as fast** and struggled to compete with fiber and 4G/5G networks.

5. **Decline of WiMAX**

- WiMAX was once seen as a competitor to **4G LTE**, but LTE became the dominant mobile broadband technology.

- Many telecom companies **phased out WiMAX** in favor of LTE and 5G.

Microwave Transmission

Microwave transmission is a way of sending signals **wirelessly using **microwave frequencies** (which are a type of radio wave).**

How It Works (Simple Explanation)

- Imagine shining a flashlight in a straight line—microwave signals work similarly.

- These signals travel **through the air** from one antenna to another.

- They are used for **long-distance communication** without needing cables.

**Where Is It Used?**

- **Mobile Networks – Used to connect cell towers.**

- **Satellite Communication – Helps send signals between satellites and Earth.**

- **TV & Radio Broadcasting – Used for transmitting signals over large areas.**

- **Military & Radar Systems – Helps in defense and surveillance.**

Optical Wireless communication

****Optical Wireless Communication** (OWC)** is a technology that uses **light waves** (instead of radio waves) to transmit data **wirelessly**. It includes methods like **Visible Light Communication (VLC)** and **Free Space Optical (FSO) communication**.

How It Works (Simple Explanation)

- Instead of using Wi-Fi or mobile signals, OWC uses **infrared, visible, or ultraviolet light** to send data.

- It works by ****flashing light signals**** at high speeds, which are then decoded into information.

- It requires a ****clear line of sight**** between the transmitter and receiver.

Where Is It Used?

- ****Li-Fi (Light Fidelity)**** – Uses LED lights to provide internet access.

- ****Satellite Communication**** – Optical signals are used for space-based data transfer.

- ****Underwater Communication**** – Works better than radio waves in water environments.

- ****Secure Data Transmission**** – Harder to intercept than traditional wireless signals.

Wireless Technologies

2G

What it is: 2G was the first digital mobile network. It allowed people to make phone calls and send text messages.

2G is the second generation of mobile cellular network , under the standard global system for mobile communication (GSM)

Speed: It’s slow when compared to newer generations. It could only handle basic data, so things like internet browsing or using apps weren't really possible

Use case: Mainly used for calls and text messages.

GSM (Global System for Mobile Communications) is the most common standard used for mobile communication in 2G networks.

Here's a simple explanation:

What it is: GSM is a technology standard used in 2G networks for mobile phones. It defines how phones communicate with cell towers and how calls and text messages are handled.

How it works:==

When you make a call or send a text, your phone connects to a cell tower using radio waves. The GSM system helps manage these signals and makes sure your calls/texts go to the right places.

GSM divides the radio spectrum into small channels (like lanes on a highway), allowing multiple people to use the same tower at the same time without interference.

Key features of GSM:

1. **Digital signal**: Unlike older systems, GSM uses digital signals, which made it more efficient and reliable.
2. **SIM cards**: GSM introduced the SIM card (Subscriber Identity Module), which is a small card inserted into your phone. It stores your phone number, contacts, and other important data, so you can switch phones without losing your info.

International roaming: Since GSM was a global standard, it allowed you to use your phone in many countries by just changing your SIM card, making it more convenient for travel.

2.5 G

Combination of 2G and **GPRS == 2.5 G**

2.5G is like a "half-step" between the older 2G (the basic mobile network) and the faster 3G. It was introduced to give us better internet and multimedia messaging on our phones, but it wasn’t as fast as what we have today with 3G or 4G.

Imagine this:

2G is like using a landline phone at home. It's great for making calls and texting, but there's no internet or sending pictures.

2.5G is like getting dial-up internet on your mobile phone. You can now browse the web, send photos (through MMS), and check your email, but it's slower than the internet we use today.

Key Features of 2.5G:

GPRS (General Packet Radio Service):

Think of GPRS as a way to let your phone use internet data. It's not super fast, but it lets you do basic things like browse simple websites and send emails.

Example: You could open a simple webpage on your phone, check your email, or even play an online game, but the pages would load slowly compared to today's standards.

EDGE (Enhanced Data rates for GSM Evolution):

This was like a faster version of GPRS. It allowed for better data speeds (but still much slower than what we get on 3G or 4G).

Example: With EDGE, you could send pictures and videos as part of a MMS (Multimedia Messaging Service). If you tried this on 2G (without EDGE), the picture would take a long time to send, or it might fail!

3G

3G stands for "third generation" of mobile network technology. It's the type of network that allows

smartphones and other devices to connect to the internet, make calls, and send data (like text messages or videos) wirelessly.

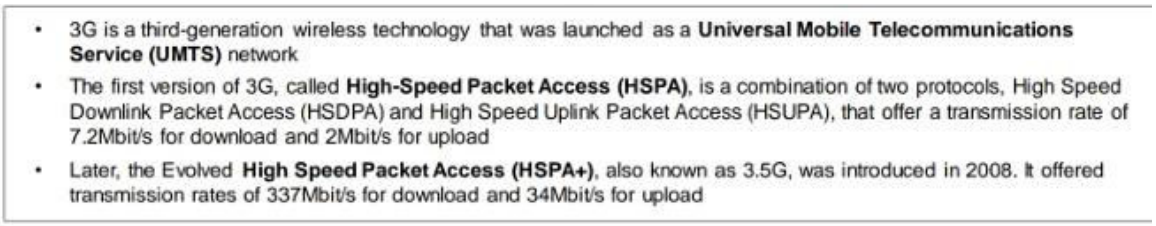
Here’s a simple breakdown:

1. **Speed**: 3G is faster than the older 2G network. It allows for things like video calling, faster internet browsing, and smoother streaming.

2. **Internet Access**: With 3G, you can access the internet on your phone, even when you're not connected to Wi-Fi. It made smartphones much more useful because you could use apps, browse social media, and check emails anywhere you go.

3. **Improved Call Quality**: 3G also improved the quality of voice calls and allowed for things like video calls, where you could see the person you're talking to.

In short, 3G was a big step up from earlier networks because it brought better speed, internet access, and features to mobile phones!


- 3G is a third-generation wireless technology that was launched as a **Universal Mobile Telecommunications Service (UMTS)** network
- The first version of 3G, called **High-Speed Packet Access (HSPA)**, is a combination of two protocols, High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA), that offer a transmission rate of 7.2Mbit/s for download and 2Mbit/s for upload
- Later, the Evolved **High Speed Packet Access (HSPA+)**, also known as 3.5G, was introduced in 2008. It offered transmission rates of 337Mbit/s for download and 34Mbit/s for upload

UMTS stands for **Universal Mobile Telecommunications System, and it's a type of mobile network technology that’s part of the **3G** family.**

Here’s what it does in simple terms:

1. **Faster Internet**: UMTS is the technology that powers 3G networks, giving you faster mobile internet speeds than older 2G networks. It’s what made things like mobile video streaming, web browsing, and video calls possible on smartphones.

2. **Voice & Data Together**: UMTS allows you to use the internet (data) and make phone calls at the

same time without problems. With earlier networks, using one often made the other slower or impossible.

3. **Global Standard**: UMTS is used in many parts of the world, especially Europe and Asia. It helped make mobile technology more universal by setting a standard for 3G networks.

So, in short: UMTS is a type of 3G tech that made mobile internet much faster and more reliable, allowing you to do more things on your phone!

4G

4G is the **fourth generation** of mobile network technology. It's a huge leap forward from 3G and provides much faster data speeds and better overall performance for mobile phones and other devices. Here's a simple explanation:

What Makes 4G Different?

1. **Much Faster Speeds:==** * 4G is **way faster** than 3G. With 4G, you can download files, stream videos, play games, and use apps much quicker.

* **Download speeds** can go up to **100 Mbps** (in regular usage) and **up to 1 Gbps** (for stationary use like in home routers or fixed locations). That means you can download a movie in a matter of seconds!

2. **Better for Streaming and Gaming==** * 4G allows for **smooth HD video streaming** (Netflix, YouTube) without buffering.

* It's also great for **online gaming** since it reduces lag and improves responsiveness in multiplayer games.

3. **Improved Connectivity:==** * 4G offers **more stable connections** and handles more users at once without slowing down. This is important for areas with a lot of people, like stadiums or concerts.

4. **Supports More Devices:==** * 4G is also capable of supporting more types of devices (like smartwatches, smart homes, and other connected gadgets), not just smartphones.

5. **Lower Latency:==** * Latency is the delay before data starts transferring. 4G has **lower latency** compared to 3G, which means actions like loading a website or making a video call happen much faster.

Real-World Examples of 4G Use:

* **Streaming**: You can stream **4K video** on platforms like YouTube or Netflix on your phone without major buffering.

* **Video Calls**: Crystal-clear video calls on apps like Zoom or FaceTime, even with lots of people.

* **Mobile Hotspots**: If you need to use the internet on your laptop while traveling, 4G makes mobile hotspots very fast, turning your phone into a portable internet device.

Summary:

* **Speed**: **Way faster** than 3G.

* **Usage**: Ideal for HD streaming, gaming, and fast downloads.

* **Connections**: More stable and reliable, even with many people using it at once.

4G really made mobile internet feel like broadband at home — it's fast, reliable, and allows for much more intense uses of mobile data.

Let’s break down **LTE and **ITU** in simple terms:**

**LTE (Long-Term Evolution)**

* **What it is**: LTE is a type of **4G technology** that provides **faster internet** and **better performance** on mobile networks. It’s essentially the “standard” for 4G networks today.

*** **How it works**: LTE uses advanced radio technology to send data faster between your phone and the cell towers. This gives you **better speeds, lower latency (faster response times),** and more efficient network use compared to older 3G technologies like HSPA.**

* **Why it matters**: It's the foundation for most of the 4G networks around the world today, providing high-speed data for things like:

* ****Streaming HD video****
* *** **Online gaming****
* *** **Fast downloads****
* *** **Smooth video calls****

LTE Advanced (sometimes called **LTE+**) is an even faster version of LTE that provides speeds of up to **1 Gbps**.

****ITU (International Telecommunication Union)****

* **What it is**: The **ITU** is a specialized agency of the **United Nations** that helps regulate and set global standards for telecommunications, including mobile networks, radio frequencies, and more.

* **Why it matters**: The ITU helps make sure that technologies like LTE, 5G, and others are compatible and can work together across different countries. It sets the **global standards** for communication technologies, making sure that:

* Countries agree on technical specs and frequencies for networks.
* There's coordination between different types of devices and networks (so things work seamlessly around the world).

For example, the ITU defines what “**4G**” and “**5G**” should actually mean, helping guide network providers on how to build and deploy them.

Key Differences:

*** **LTE** is a **specific technology** used for fast mobile internet (4G).**

*** **ITU** is an **organization** that helps set global rules and standards for telecommunications, including 4G (LTE) and future technologies like **5G**.**

In short, **LTE** is the tech that powers **4G networks**, and the **ITU** is the global body that ensures everything from **LTE** to **5G** works smoothly worldwide.

Tetra

- TETRA (Terrestrial trunked radio) is a European standard that describes a **professional mobile radio** communication infrastructure
- It is a standard for **Private Mobile Radio (PMR)** and **Public Access Mobile Radio (PAMR)** that is aimed at emergency users such as police forces, military, ambulance, and transport services
- The low frequency of tetra permits coverage of a large geographic area with fewer transmitters, which reduces infrastructure costs

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Wireless Technologies (Cont'd)

Bluetooth

- Bluetooth is a **short-range device-to-device** data transmission technology developed for mobile devices
- It is used to transmit data between cell phones, computers, and other networking devices
- Signals transmitted from Bluetooth can cover distances of up to 10 meters
- Bluetooth transfers **data at less than 1 Mbps** and operates within a frequency range of 2.4 GHz to 2.485 GHz
- This technology comes under **IEEE 802.15** and uses a radio technology called frequency-hopping spread spectrum to transfer data to other Bluetooth enabled devices

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Network Topologies

Network topology is a specification that **deals with a network's overall design and flow of its data**

Types of Topology

- **Physical Topology** – The physical layout of nodes, workstations and cables in the network
- **Logical Topology** – The information flow between different components

Physical Network Topologies

Bus Topology

Network devices are connected to the central cable, called a bus, using interface connectors

Star Topology

Network devices are connected to a central computer called a hub which functions as a router to send messages

Ring Topology

Network devices are connected in a closed loop. Data travels from node to node, with each node handling every packet along the way

Mesh Topology

Network devices are connected in such a way that every device has a point-to-point link with every other device on the network

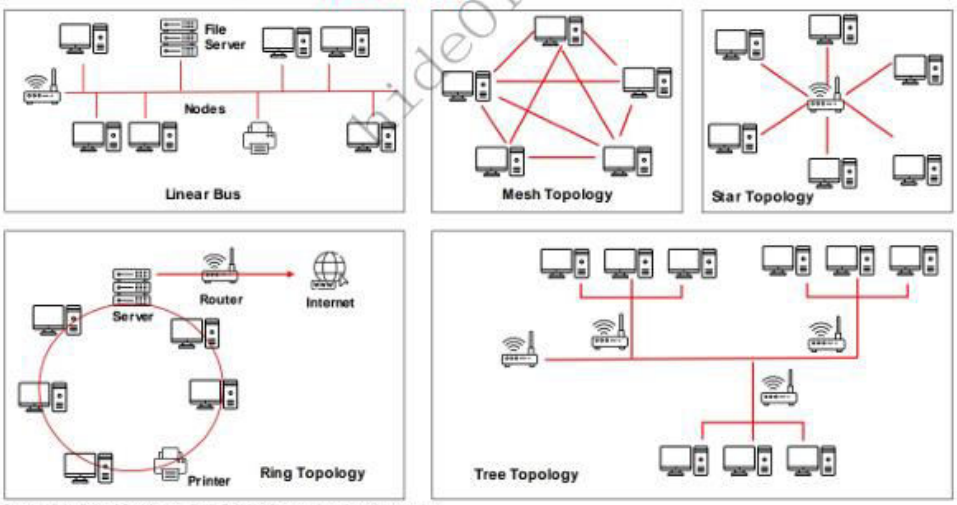
Tree Topology

A hybrid of bus and star topologies, in which groups of star-configured networks are connected to a linear bus backbone cable

Hybrid Topology

A combination of any two or more different topologies. Star-Bus or Star-Ring topologies are widely used

Network Topologies (Cont'd)



Network Hardware Components

Network Interface Card (NIC)	Allows the computers to **connect and communicate** with the network
Repeater	Used to **increase** the strength of an incoming signal in a network
Hub	Used to connect segments of a **LAN**. All the LAN segments can see all the packets
Switch	Is similar to a hub. However, packets are not visible to any **equipment** in the LAN s except the target node
Router	**Receives** data packets from one network segment and **forwards** them to another
Bridges	Combines two network segments and manages **network traffic**
Gateways	**Enables** communication between different types of environments and protocols

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Types Of LAN Technology

1. ### 🧠 **What is Asynchronous Transfer Mode (ATM)?**

ATM is a **network technology** that sends **all types of data**—like voice, video, or files—**in small fixed-size pieces** called **cells**.**

Each **cell is 53 bytes: 5 bytes for control info, and 48 bytes for the data itself.**

Think of it like a **postal system where every package is exactly the same size, no matter what's inside—letters, books, or clothes.**

🎁 **Why Fixed-Size Cells?**

Using small, fixed-size cells:

* Makes ATM **very fast**

* Helps send time-sensitive data like **video and voice** smoothly (no delay or lag)

* Makes it easy for hardware (like switches and routers) to process the data quickly

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📞 **Why “Asynchronous”?**

"**Asynchronous**" means ATM doesn't send data at regular time intervals.

It **only sends data when needed**, making it efficient—especially when sending different types of data.

✅ **Example 1: Video Call**

Imagine you're on a video call.

* Your voice, video, and screen sharing are all being sent.

* ATM breaks all this into **tiny cells** and sends them across the network.

* Because every cell is the same size, they move quickly and are easy to manage.

* Result: **Smooth call with no lag.**

✅ **Example 2: Bank Network**

A bank has branches all over the country.

* They use ATM to securely and quickly transmit **transactions**, **security camera feeds**, and

voice calls between locations.

* The ATM network ensures all types of data are delivered with **high reliability and low delay**.

📝 Summary (in simple terms)

Feature	Explanation
What	A method of sending data in tiny, same-sized chunks (53 bytes)
Why	Fast, reliable, and works well for voice, video, and data
How	Only sends data when there's something to send (asynchronous)
Used in	Video calls, banking systems, telecom networks (especially in the past)

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2. POE

⚡ What is PoE (Power over Ethernet)?

Power over Ethernet (PoE) is a technology that lets network cables carry both data and electrical power at the same time.

🧠 Simple Explanation

- Normally, devices like Wi-Fi routers, security cameras, or VoIP phones need:
- One cable for internet/data
- Another cable for power

PoE combines both into a single Ethernet cable (like Cat5e or Cat6), so:

- You don’t need separate power cables
- You save time, money, and clutter

✅ **Example Devices That Use PoE:**

- 📶 Wi-Fi Access Points (like those in schools or offices)
- 📹 IP Security Cameras
- 📞 VoIP Phones (used in many business phone systems)
- 💡 Smart Lighting Systems

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3. Ethernet and Fast Ethernet

🧠 **What is Ethernet?**

Ethernet is a way to connect computers and other devices together using **cables**, so they can **share files, printers, and internet**.

*** It's like giving each computer a **road** to send and receive data.**

*** **Speed**: Sends data at **10 Mbps** (megabits per second) — pretty slow by today's standards.**

⚡ **What is Fast Ethernet?**

Fast Ethernet is just a **faster version** of Ethernet.

* It sends data **10 times faster** — at **100 Mbps**.

* It's better for things like watching videos, faster file downloads, or online games.

🎁 **Simple Example:**

- Let's say you're moving boxes (data) between two houses (computers):

* **Ethernet** = You walk, carrying one box at a time (slow).

* **Fast Ethernet** = You use a bike, carrying ten boxes at once (faster).

📝 Summary

Type	Speed	Good For
Ethernet	10 Mbps	Old computers, small tasks
Fast Ethernet	100 Mbps	Faster internet, file sharing

Today, we use **even faster networks** like **Gigabit Ethernet (1000 Mbps)**, but understanding Ethernet and Fast Ethernet helps you see how networking started.

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3. Gigabit Ethernet and 10 Gigabit Ethernet

Absolutely! Here's a **simple explanation** of **Gigabit Ethernet** and **10 Gigabit Ethernet**:

⚡ **1. Gigabit Ethernet (1 Gbps)**

* **Speed**: Sends data at **1 gigabit per second** (Gbps)

  → That's **1,000 megabits per second (Mbps)**

* **10 times faster** than Fast Ethernet (100 Mbps)

* **Used for**: Most modern home and office networks

* **Cables**: Usually **Cat5e** or **Cat6**

🎁 **Example**:

Imagine sending a big movie file (1 GB) between two computers:

* With Fast Ethernet (100 Mbps), it might take \~80 seconds

* With **Gigabit Ethernet**, it takes only \~8 seconds

🚀 **2. 10 Gigabit Ethernet (10 Gbps)**

* **Speed**: **10 Gbps** — **10 times faster** than Gigabit Ethernet

* **Super fast** for data centers, servers, and high-end business use

* **Used for**:

    * Cloud servers

    * Video editing networks

    * Transferring huge files quickly

*** **Cables**: Needs higher quality cables like **Cat6a**, **Cat7**, or **fiber optic****

🎁 **Example**:

Transfer that same movie file (1 GB) in **less than 1 second** with 10 Gigabit Ethernet!

📊 Simple Comparison Table

| Type | Speed | Cable

Needed | Where It's Used |

| ---------- - | ---------- | ---------- | ---------- |

| **Gigabit Ethernet** | 1 Gbps (1,000 Mbps) | Cat5e or Cat6 | Homes, offices, smart TVs

| **10 Gigabit Ethernet** | 10 Gbps | Cat6a, Cat7, Fiber | Servers, high-speed workspaces |

🧠 Think of It Like Vehicles:

* **Fast Ethernet (100 Mbps)** = Bicycle

* **Gigabit Ethernet (1 Gbps)** = Car

* **10 Gigabit Ethernet (10 Gbps)** = High-speed train

Types of LAN Technology (Cont'd)

Specifications of LAN Technology

Name	IEEE Standard	Data Rate	Media Type	Maximum Distance
Ethernet	802.3	10 Mbps	10Base-T	100 meters
Fast Ethernet/ 100Base-T	802.3u	100 Mbps	100Base-TX 100Base-FX	100 meters 2000 meters
Gigabit Ethernet/ GigE	802.3z	1000 Mbps	1000Base-T 1000Base-SX 1000Base-LX	100 meters 275/550 meters 550/5000 meters
10 Gigabit Ethernet	IEEE 802.3ae	10 Gbps	10GBase-SR 10GBase-LX4 10GBase-LR/ER 10GBase-SW/LW/EW	300 meters 300 m MMF/ 10 km SMF 10 km/40 km 300 m/10 km/40 km