

Unguided media – wireless transmission:

Unguided media utilize electromagnetic waves to transmit data through the **air or vacuum** without a physical conductor. This category includes radio waves, microwaves, and infrared signals used for Wi-Fi, Bluetooth, and cellular communication. The source of the electromagnetic waves is the radio transmitter operating on a desired part of radio frequency spectrum. On the other side the receivers can be found inside out phones, LTE or 5G routers and, in form of Wi-Fi receivers in our phones as well, in laptops, smartwatches, fridges and microwaves. The higher the frequency, the more data you can carry, but the shorter the range becomes.

Mobility: Users can stay connected while moving due to large **coverage area**

Ease of Deployment: No need to dig trenches or run cables through walls, which is great for remote or historic areas.

Scalability: Adding a new user often just requires a password, not a new physical port.

Interference: Signals can be disrupted by walls, weather, **static**, **crosstalk**, or other electronic devices.

Security: Since the signal is broadcast into the air, it is easier to intercept (requiring strong encryption).

Bandwidth Limits: Wireless spectrum is a finite resource; the more users you have in one spot, the slower it gets due to network **congestion**.

Bluetooth / Wi-Fi networks: Connecting peripherals (headphones, mice) and providing high-speed internet within homes, offices, and coffee shops.

Mobile Telephony: High-speed data and voice coverage over large geographic areas, enabling the "always-on" mobile economy and autonomous vehicle communication.

Satellite Communications: Global Positioning Systems (GPS), satellite TV, and providing internet to extremely remote regions (Starlink) or maritime vessels in the middle of the ocean.

Cellular network infrastructure:

The infrastructure for mobile communication relies on a grid of cells, each served by a Base Transceiver Station (BTS). Each **base station** is connected to a core network via high capacity backhaul links, usually fibre or microwave point-to-point links. This architecture allows for frequency reuse, cell **overlap**, and seamless handovers as users move between different geographic areas.

Satellite communication systems:

Satellites act as microwave **space relays**, providing coverage where terrestrial infrastructure is impossible to build.

Geostationary (GEO) satellites stay fixed over one point, while Low Earth Orbit (LEO) constellations provide high-speed, low-latency internet to remote regions. They are essential for **GPS**, weather forecasting, and global broadcasting.

Universal Coverage: Reachable in mountains, oceans, and rural "dead zones" where cables can't go.

Disaster Resilience: Functions when ground towers are destroyed by floods or earthquakes.

Scalability: A single satellite can broadcast to millions of receivers simultaneously.

Latency: Signals travel 72,000 km (up and back) to GEO satellites, causing a ~0.5s delay.

Weather Interference: Heavy rain or snow (Rain Fade) can weaken or block the signal.

High Cost: Launching and maintaining satellites involves massive capital and insurance risks.

Remote Internet Access: Providing broadband to rural areas or "digital nomads" via constellations like Starlink.

Global Navigation (GNSS): Systems like GPS, Galileo, and GLONASS rely entirely on satellite signals for positioning.

Broadcasting: Delivering Direct-to-Home (DTH) television and radio signals across entire continents.

Military, Maritime and Aviation: The only reliable way to provide high-speed internet and tracking for ships at sea and planes in flight.

Future trends – 5G and beyond:

The evolution of telecom is currently defined by the rollout of 5G, which offers ultra-low latency and massive device connectivity for the Internet of Things (IoT). Looking ahead, **6G** research is already exploring terahertz frequencies and AI-driven network management. These advancements will enable technologies like autonomous vehicles, remote surgery, and fully immersive virtual reality.