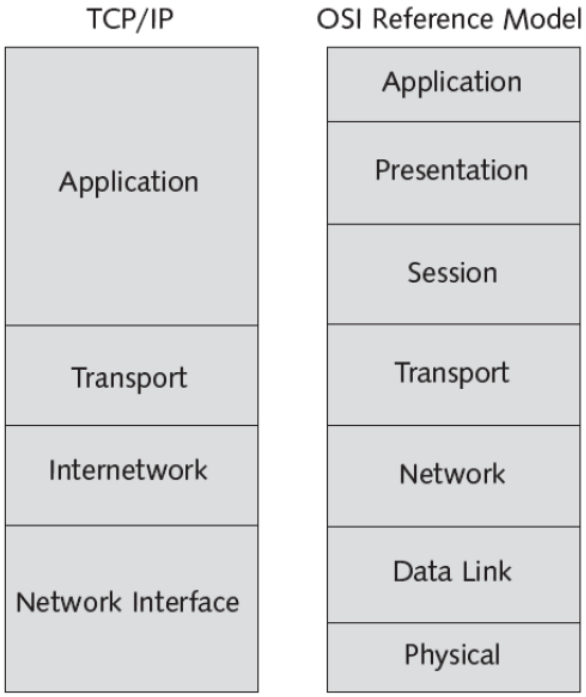
Overview of TCP/IP

TCP (Transmission Control Protocol) and IP (Internet Protocol) are two different networking protocols but are mostly used together. **TCP/IP** became the standard terminology to refer to this protocol suite which was invented before wireless communications emerged and was used primarily for **wired network communications** where TCP transfers data across an IP network. TCP is a connection-oriented protocol that establishes virtual connections between the networking devices using request-reply messages across the physical network.

- TCP divides the file or the message into packets, transmits them over the internet and reassembles them at the destination.
- IP provides the addressing for the packets to deliver them to their correct destination.
- TCP is Reliable, *full-duplex, connection-oriented, stream* delivery.
  - Data is guaranteed to arrive, and in the correct order without duplications
    - Or the connection will be dropped.
  - Imposes significant overheads.
- The TCP/IP model explains how the protocol suite works to provide communications
- Four layers: Application, Transport, Internetwork, and Network Interface



Protocol architecture comparison

Layers of TCP/IP Protocol Suite

There are four layers of the TCP/IP protocol suite:

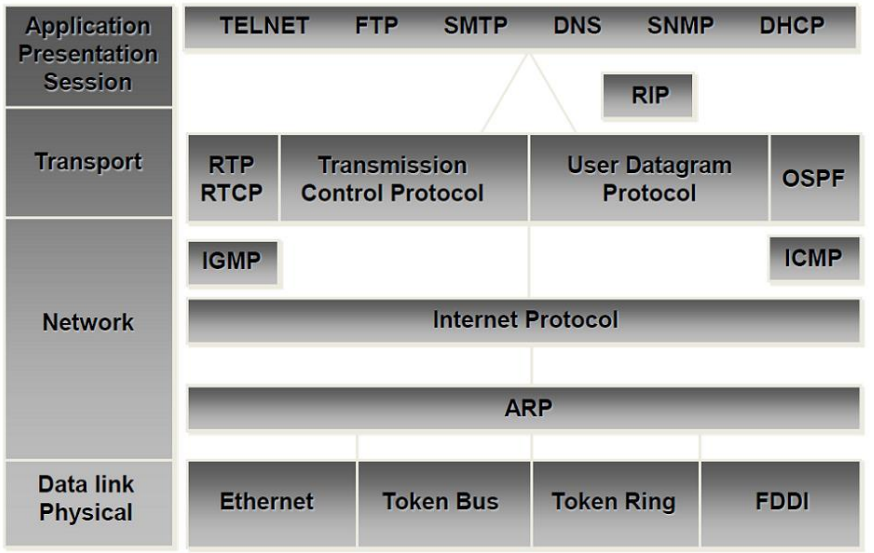
- **Datalink Layer:** It consists of protocols and methods which operate on links connecting hosts or nodes in a network. The common protocols of this layer are ARP (Address Resolution Protocol) and Ethernet.

- **Internet (Network) Layer:** It connects various independent networks for transporting data packets across various network boundaries. The important protocols of the internet layer are ICMP and IP.
- **Transport Layer:** It is responsible for communication between computer systems. This layer handles reliability, multiplexing and flow control. Protocols of this layer are UDP (User Datagram protocol) and TCP.
- **Application Layer:** It handles data exchanges between various applications. Important protocols of this layer are FTP, HTTP, POP (Post office Protocol) and SMTP (Simple Mail Transfer Protocol).

TCP/IP Layer Overview

TCP/IP Layers (OSI model*)	Tasks	Protocol Examples
Application (7)	Application specific	Telnet, rlogin, FTP, SMTP, SNMP, HTTP, ...
Transport (4)	End-to-end flow of data between application processes	TCP, UDP
Network (3)	Routing of packets between hosts	IP, ICMP
Link (2)	Hardware interface Packet transfer be-tween network nodes	PPP, Ethernet, IEEE 802.x, ARP

TCP/IP Architecture



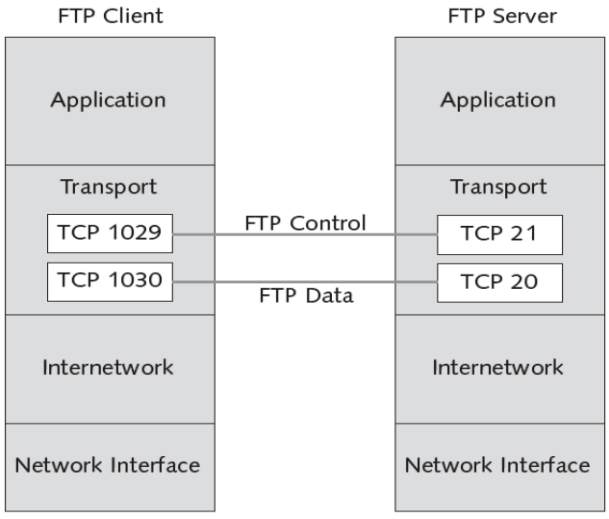
Application Layer

Protocols at the TCP/IP Application layer include:

- File Transfer Protocol (**FTP**)
- Trivial File Transfer Protocol (**TFTP**)
- Network File System (**NFS**)
- Simple Mail Transfer Protocol (**SMTP**)
- Terminal emulation protocol (**telnet**)
- Remote login application (**rlogin**)
- Simple Network Management Protocol (**SNMP**)
- Domain Name System (**DNS**)
- Hypertext Transfer Protocol (**HTTP**)

Transport Layer

- Performs end-to-end packet delivery, reliability, and flow control
- Protocols:
  - **TCP** provides reliable, connection-oriented communications between two hosts.
    - Requires more network overhead.
  - **UDP** provides connectionless datagram services between two hosts
    - Faster but less reliable.
    - Reliability is left to the Application layer.
- TCP and UDP use port numbers for communications between hosts
  - Port numbers are divided into three ranges:
    - Well Known Ports are those from 1 through 1,023.
    - Registered Ports are those from 1,024 through 49,151.
    - Dynamic/Private Ports are those from 49,152 through 65,535.



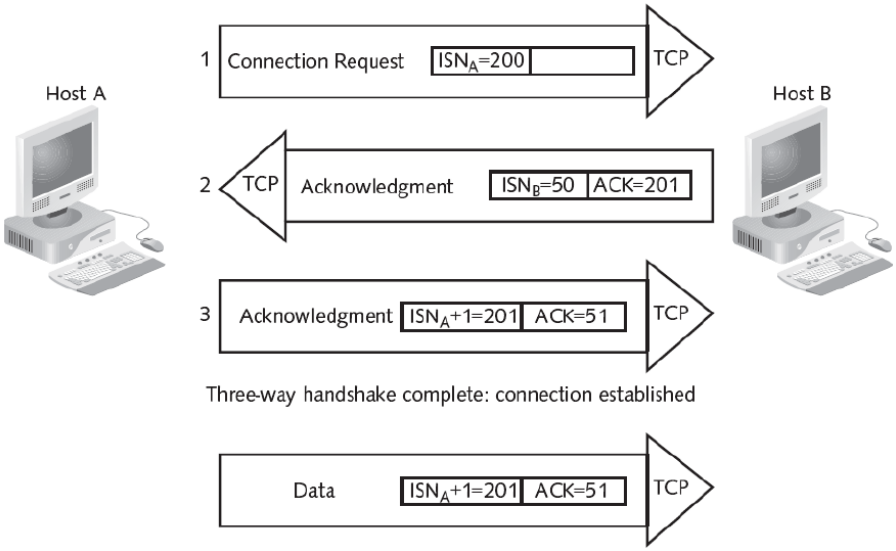
TCP port usage in FTP communications

- TCP three-way handshake
  - Establishes a reliable connection between two points.
  - TCP transmits three packets before the actual data transfer occurs.

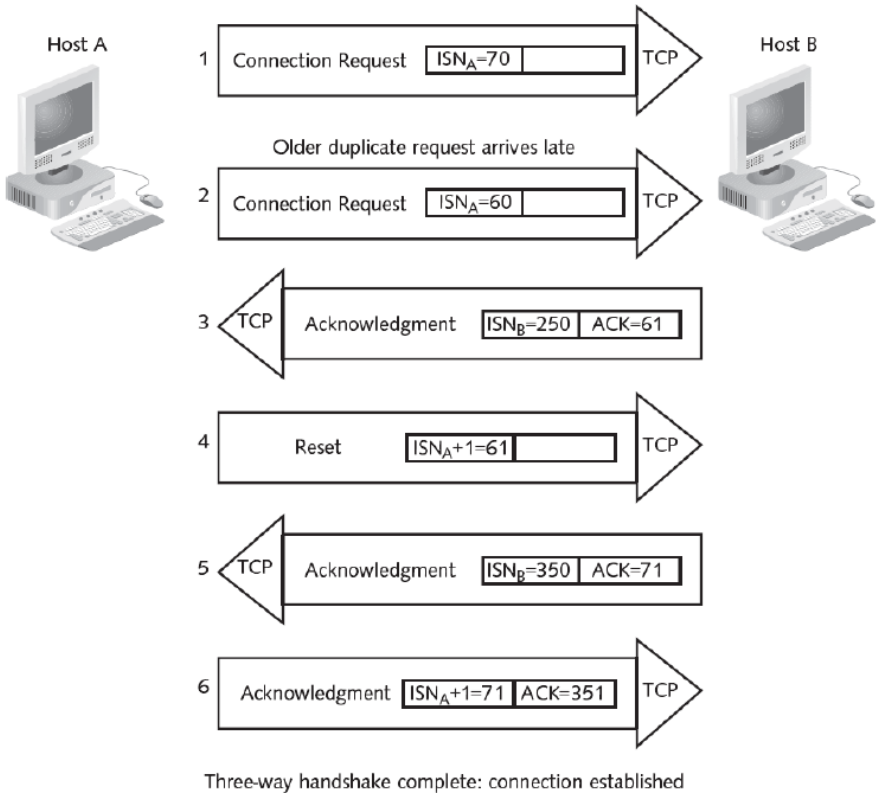
- Before two computers can communicate over TCP, they must synchronize their **initial sequence numbers (ISN).**
- A **reset packet (RST)** indicates that a TCP connection is to be terminated without further interaction.

Source Port (16 bits)	Destination Port (16 bits)
Sequence Number (32 bits)	
Acknowledgment Number (32 bits)	
Offset, Reserved Bits, Flags (16 bits)	Receive Window Size (16 bits)
Checksum (16 bits)	Urgent Pointer (16 bits)
Options and Padding (32 bits)	
Data (variable length) Information for the next higher layer (Application layer)	

TCP packet header



TCP three-way handshake

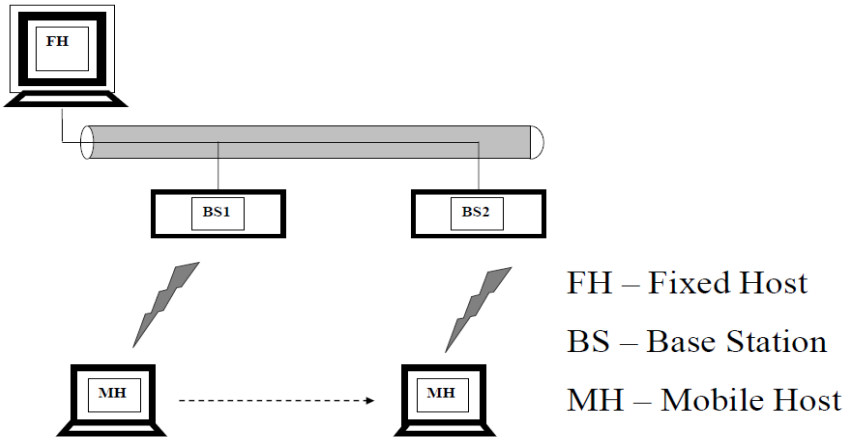


Three-way handshake complete: connection established

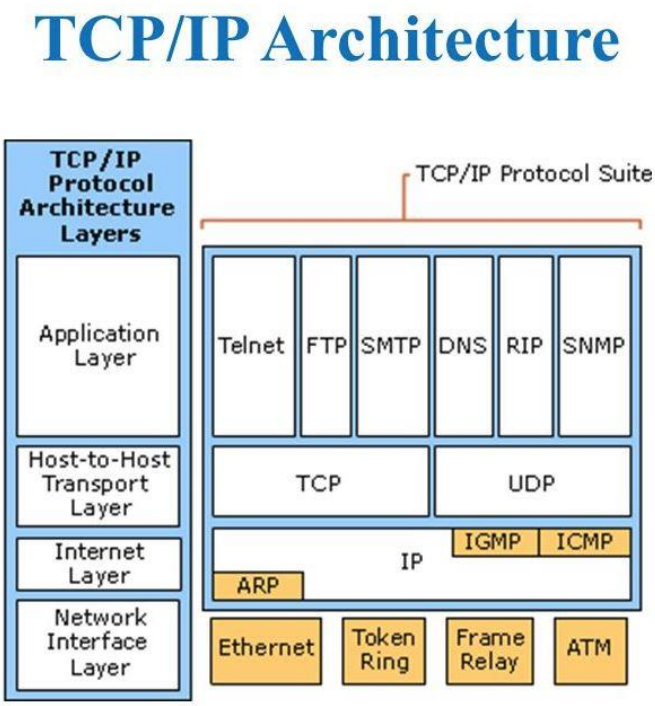
Adaption of TCP Window

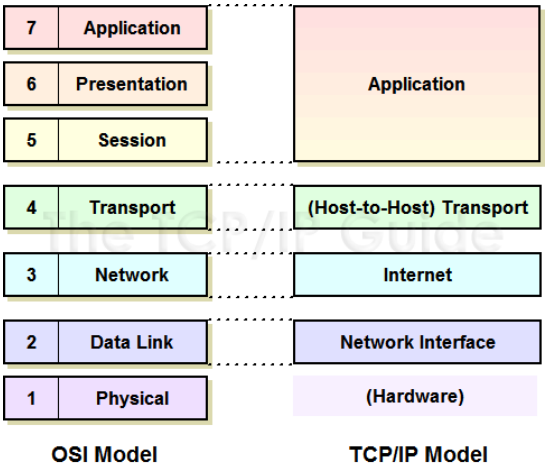
- TCP **sliding windows.**
  - Control the flow and efficiency of communication.
  - Also known as windowing.
    - A method of controlling packet flow between hosts.
    - Allows multiple packets to be sent and affirmed with a single acknowledgment packet.
  - The size of the TCP window determines the number of acknowledgments sent for a given data transfer.
  - Networks that perform large data transfers should use large window sizes.

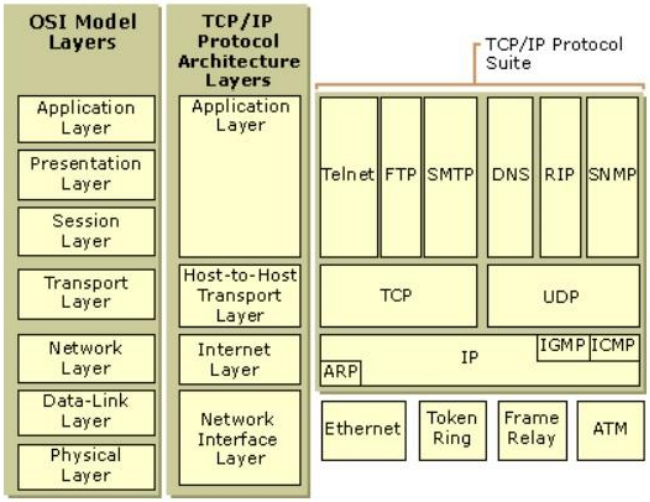
Mobile Networks Topology



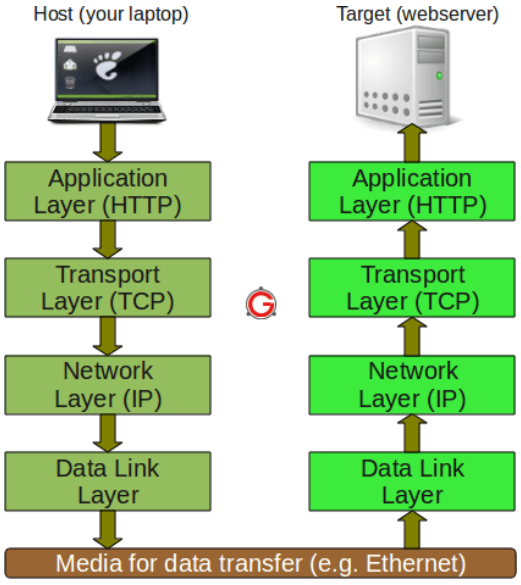
Architecture of TCP/IP





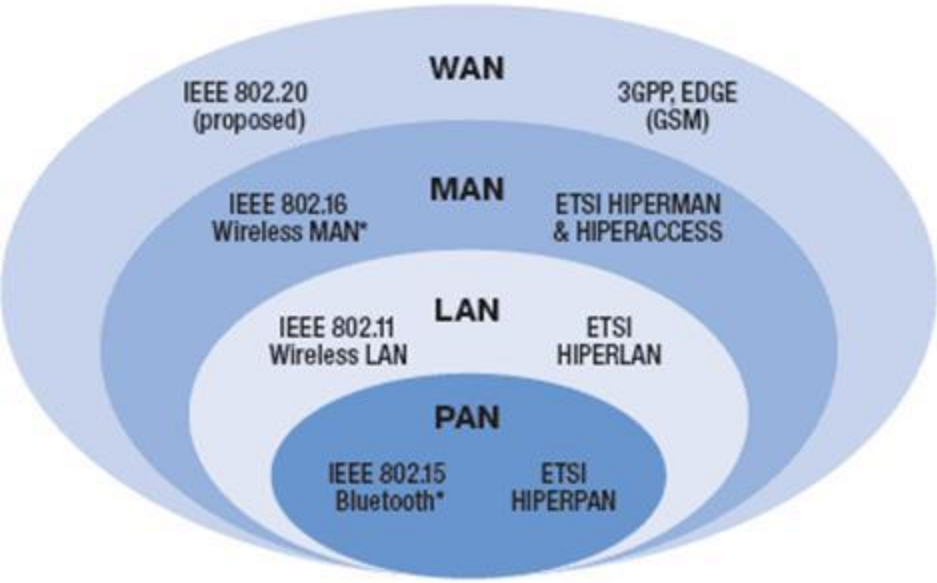


TCP/IP PROTOCOL



Wireless communications standards

Different methods and standards of wireless communication have developed across the world, based on various commercially driven requirements. These technologies can roughly be classified into four individual categories, based on their **specific application** and **transmission range**. These categories are summarized in the figure below.



Wireless networks

Wireless networks are computer networks that are not connected by cables of any kind. The use of a wireless network enables enterprises to avoid the costly process of introducing cables into buildings or as a connection between different equipment locations.
Wireless networks use radio waves to connect devices such as laptops to the Internet, the business network and applications. When laptops are connected to Wi-Fi hot spots in public places, the connection is established to that business's wireless network.

Types of Wireless Networks

Type	Range	Standards
Personal area **network** (PAN)	Within reach of a person	Bluetooth, ZigBee, NFC
Local area **network** (**LAN**)	Within a building or campus	IEEE 802.11 (**WiFi**)
Metropolitan area **network** (MAN)	Within a city	IEEE 802.15 (WiMAX)
Wide area **network** (WAN)	Worldwide	**Cellular** (UMTS, LTE, etc.)

Personal Area Network (PAN)

A Personal Area Network (PAN) is a computer network used for communication among computer devices (including telephones and personal digital assistants) close to one person. The reach of a PAN is typically a few meters. PAN's can be used for communication among the personal devices themselves (intrapersonal communication), or for connecting to a higher level network and the Internet.
Personal area networks may be wired with computer buses such as USB and FireWire. However, a Wireless Personal Area Network (WPAN) is made possible with network technologies such as Infrared (IrDA) and Bluetooth. (WPANs) connect devices within a small area, somewhere around within a person's reach. A WPAN has a typical range of about 30 feet.

Bluetooth: Bluetooth is an industrial specification for wireless personal area networks (PANs), also known as IEEE 802.15.1. Bluetooth provides a way to connect and exchange information between devices such as personal digital assistants (PDAs), mobile phones, laptops, PCs, printers, digital cameras and video game consoles via a secure, globally unlicensed short-range radio frequency.
Bluetooth is a radio standard and communications protocol primarily designed for low power consumption, with a short range (power class dependent: 1 meter, 10 meters, 100 meters) based around low-cost transceiver microchips in each device.

- ***Infrared (IrDA):*** The Infrared Data Association (IrDA) defines physical specifications communications protocol standards for the short range exchange of data over infrared light, for typical use in Personal Area Networks.

Local Area Network (LAN)

A wireless LAN or WLAN is a wireless Local Area Network, which is the linking of two or more computers without using wires. It uses radio communication to accomplish the same functionality that a wired LAN has. **WLAN** utilizes spread-spectrum technology based on radio waves to enable communication between devices in a limited area, also known as the basic service set. This gives users the mobility to move around within a broad coverage area and still be connected to the network.

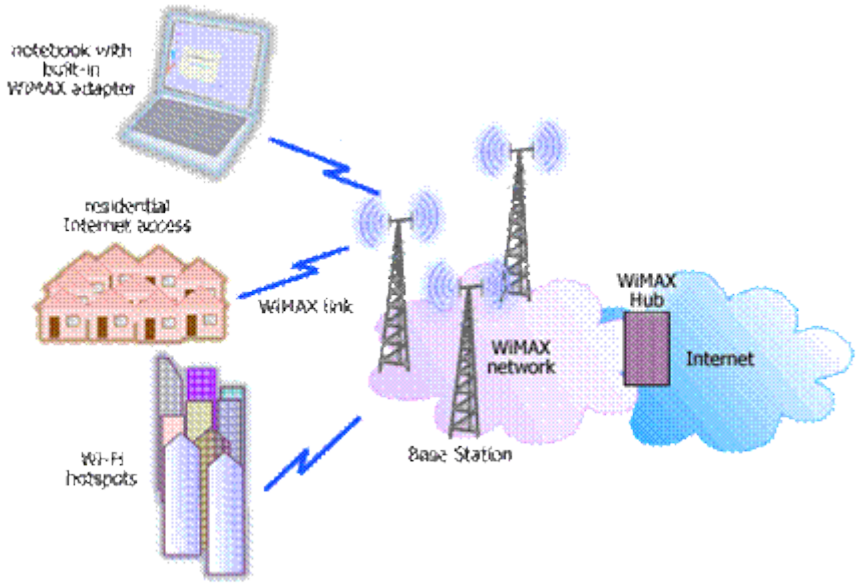
- ***IEEE 802.11:*** IEEE 802.11, the Wi-Fi standard, denotes a set of Wireless LAN/WLAN standards developed by working group 11 of the IEEE LAN/MAN Standards Committee (IEEE 802). The 802.11 family currently includes six over-the-air modulation techniques that all use the same protocol. The most popular (and prolific) techniques are those defined by the b, a, and g amendments to the original standard.

The table below summarizes the different 802.11 standards:

Protocol	Release Date	Op. Frequency	Data Rate (Typical)	Data Rate (Max)	Range (Indoor)
Legacy	1997	2.4 -2.5 GHz	1 Mbit/s	2 Mbit/s	?
802.11a	1999	5.15-5.35/5.47-5.725/5.725-5.875 GHz	25 Mbit/s	54 Mbit/s	~30 meters (~100 feet)
802.11b	1999	2.4-2.5 GHz	6.5 Mbit/s	11 Mbit/s	~50 meters (~150 feet)
802.11g	2003	2.4-2.5 GHz	11 Mbit/s	54 Mbit/s	~30 meters (~100 feet)
802.11n	2006 (draft)	2.4 GHz or 5 GHz bands	200 Mbit/s	540 Mbit/s	~50 meters (~160 feet)

Metropolitan Area Network (MAN)

Wireless Metropolitan Area Network (MAN) is the name trademarked by the IEEE 802.16 Working Group on Broadband Wireless Access Standards for its wireless metropolitan area network standard (commercially known as WiMAX), which defines broadband Internet access from fixed or mobile devices via antennas. Subscriber stations communicate with base-stations that are connected to a core network. This is a good alternative to fixed line networks and it is simple to build and relatively inexpensive.



Wide Area Network (WAN)

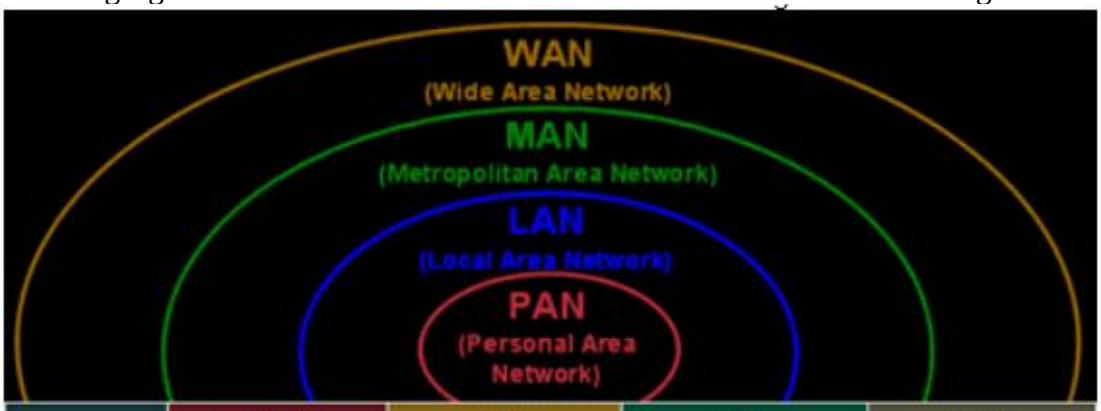
A Wide Area Network or WAN is a computer network covering a broad geographical area. Contrast with personal area networks (PAN's), local area networks (LAN's) or metropolitan area networks (MAN's) that are usually limited to a room, building or campus. The largest and most well-known example of a WAN is the Internet.
WAN's are used to connect local area networks (LAN's) together, so that users and computers in one location can communicate with users and computers in other locations. Many WAN's are built for one particular organization and are private. Others, built by Internet service providers, provide connections from an organization's LAN to the Internet.
In addition, WAN's also refer to Mobile Data Communications, such as GSM, GPRS and 3G.

The benefits of a Wi-Fi wireless network

- **Convenience**: Access your network resources from any location within your wireless network's coverage area or from any Wi-Fi hotspot.
- **Mobility**: You're not tied to your desk, as you are with a wired connection. You and your employees can go online in conference room meetings, for example.
- **Productivity**: Wireless access to the Internet and to your company's key applications and resources helps your staff get the job done and encourages collaboration.
- **Easy setup**: You don't have to string cables, so installation can be quick and cost effective.
- **Expandability**: You can easily expand wireless networks with existing equipment, whereas a wired network might require additional wiring.
- **Security**: Advances in wireless networks provide robust security protections.
- **Reduced cost**: Because wireless networks eliminate or reduce wiring expenses, they can cost less to operate than wired networks.

Technology Summary

These wireless communication technologies evolved over time to enable the transmission of larger amounts of data at greater speeds across a global network. The following figure summarizes the technical details of each cluster of technologies.



	PAN	LAN	MAN	WAN
Standards	Bluetooth	802.11 HiperLAN2	802.11 MMDS, LMDS WiMAX (802.16)	GSM, GPRS, CDMA,HSDPA 2.5-3G-3.5G
Speed	< 1Mbps	11 to 54 Mbps	11 to 100+ Mbps	10 to 384Kbps 1.8/3.6 – 7.2Mbps
Range	Short	Medium	Medium-Long	Long
Applications	Peer-to-Peer Device-to-Device	Enterprise networks	E1 replacement, last mile access	Mobile Phones, cellular data