LANs and WANs

ITS323: Introduction to Data Communications
CSS331: Fundamentals of Data Communications

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Contents

Categorizing Network Technologies

Transmission Medium

- Wired vs Wireless

Link Configuration

- Point-to-point vs Point-to-multipoint

User Mobility

- Fixed vs mobile

Types of Users

- Access vs core (backbone)

Coverage Area

Selecting the Transmission Medium

Wired

+ No interference from others → high data rates, easy to upgrade capacity
+ Small, predictable delay
– Expensive to install in hard to access locations
– Device locations are fixed

Wireless

+ No physical connection → mobility, convenience
– Interference, varying channel conditions → poor performance
– Licenses often required
– Hard to add more capacity
– Physical security is difficult

Selecting the Link Configuration

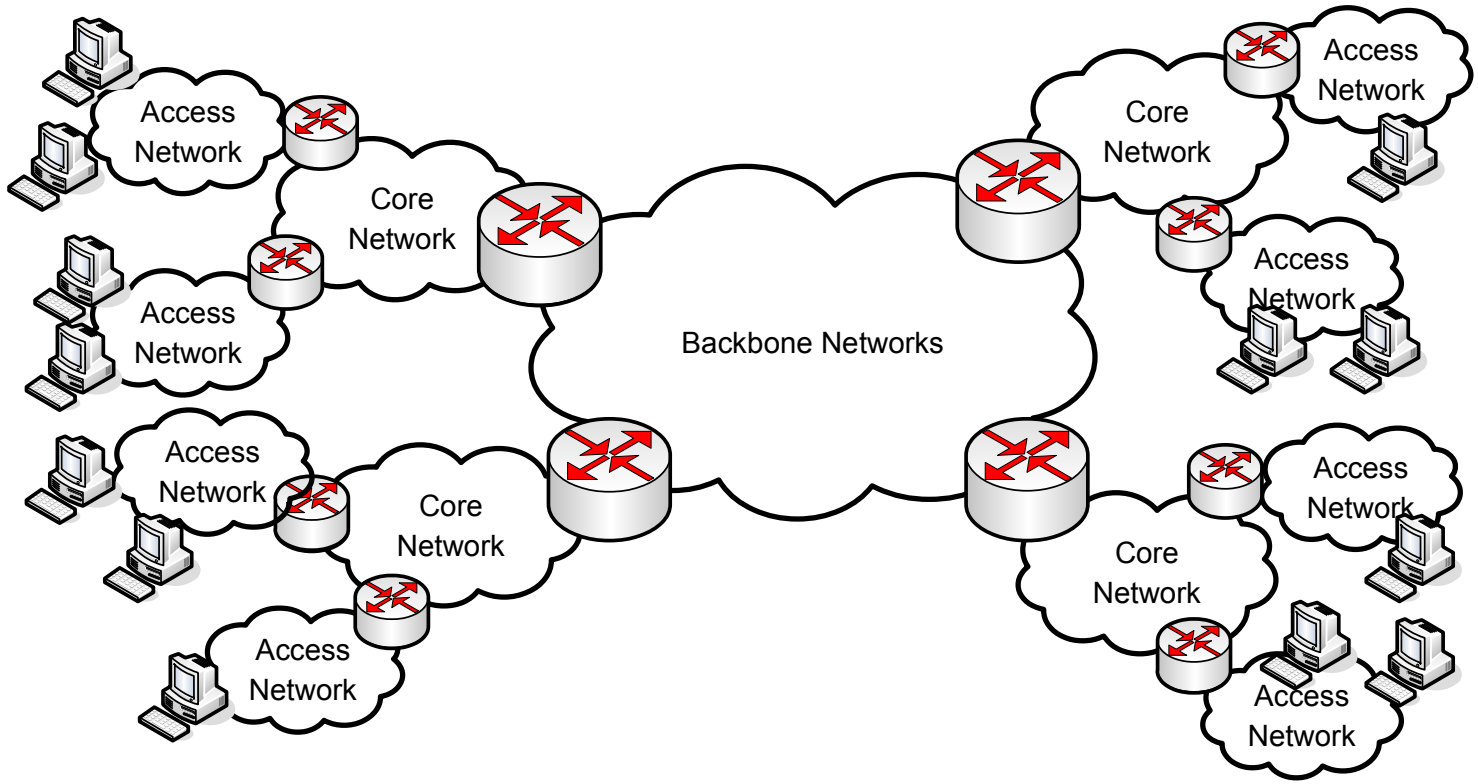
Point-to-point

+ Dedicated link for users → high, predictable performance
– Need many links, planning of end-points (Topology)
• Wired links, wireless links with directional antennas

Point-to-multipoint

+ Cover multiple users with single link
– Requires sharing of medium: multiple access, Medium Access Control protocol
• Wireless links with omnidirectional antennas, shared wired links

Access vs Core Network



Coverage Area

- *centimetres*; people, objects
  - Body Area Network
  - Personal Area Network
  - Infrared, Bluetooth, ZigBee, IEEE 802.15.4, ...
- *metres*; homes, offices, buildings
  - Local Area Network
  - Home Area Network
  - Storage Area Network
  - IEEE 802.3 (Ethernet), IEEE 802.11 (WiFi), Fibre Channel ...
- *kilometres*; cities, countries, between countries
  - Metropolitan Area Network
  - Wide Area Network
  - PDH, SDH, ATM, Frame-Relay, WiMax, satellite, ...
- *megametres*; globe, between planets
  - Global Area Network
  - the Internet, interplanetary networks

WANs and LANs

Wide Area Networks

- Connect devices/networks over large geographical area
- Between campuses, office buildings, cities, countries
- Owned and operated by organisations on behalf of users, e.g. TOT, CAT, TT&T
- Leased to users, e.g. unis, companies, smaller ISPs

Local Area Networks

- Connect end-user devices over small area
- Within campuses, buildings, homes
- Owned and operated by organisation using the network
- Typically support higher data rates than WANs (internal communications, multiplexing)

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Network Topologies

- Topology: arrangement of nodes (devices) and links
- Devices with data to communicate to others: stations, hosts, end nodes
- Devices that support communications: switches, repeaters, hubs
- Links: point-to-point, point-to-multipoint

  Mesh every station has point-to-point link to every other station

  Bus every station connected via a multipoint link

  Ring point-to-point links between pairs of stations, or via special link, to form ring

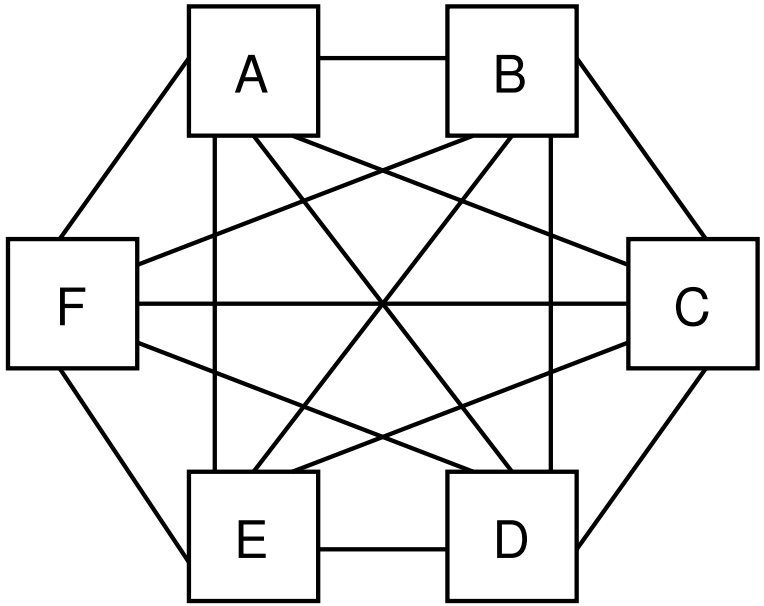
  Star every station has point-to-point link to central device

  Hybrid combination of 2 or more of above, e.g. tree is combination of star and bus topologies

Topology Design Requirements

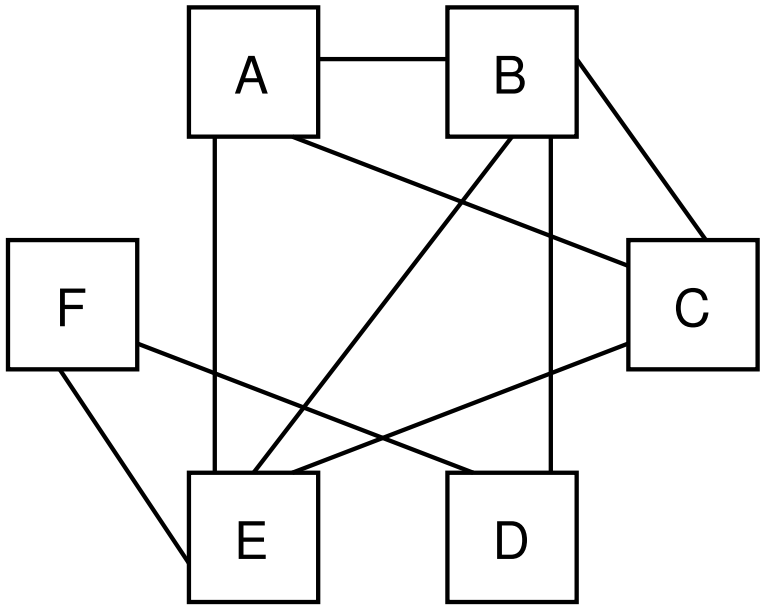
- Station should be able to communicate with any other station
- Dedicated point-to-point links are better than shared multipoint links
- Use as few links as possible
- Scales well: adding a new node requires little effort
- Fault-tolerant: failure of a link still allows other nodes to communicate; failure of a device doesn't prevent other nodes from communicating
- Fault-detection: a fault can be automatically detected by network

Mesh Topology



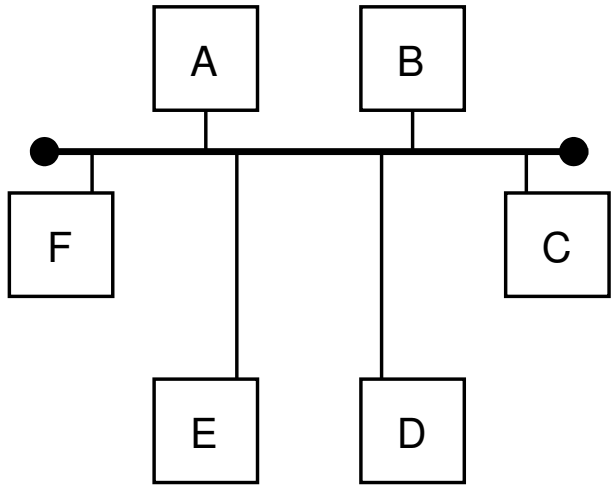
- Used in small WANs; becomes too complex as number of nodes increase
- Each pair of nodes have dedicated point-to-point link
- Addresses not needed in frames

Partial Mesh Topology



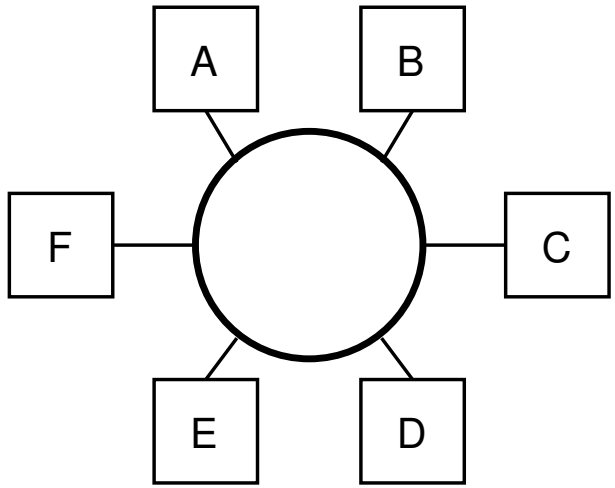
- Selection of node pairs have point-to-point link
- Some pairs cannot communicate, unless nodes can forward data (see Internet topic)
- Used in WANs

Bus Topology



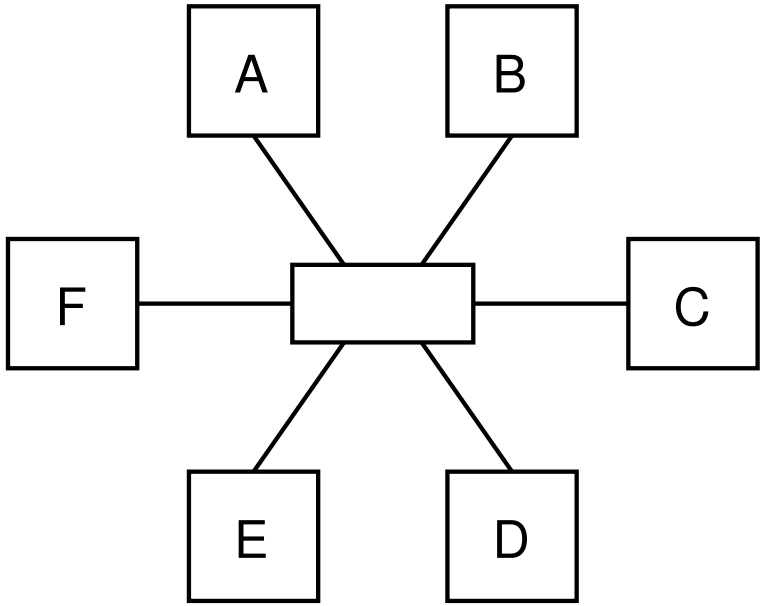
- Used in early (Ethernet) LANs, but replaced by star
- Single multipoint link connects all stations
- Transmission propagates throughout medium and is heard by all stations
- Terminator absorbs frames at end of medium/cable
- Frames need addresses
- Pros: easy installation
- Cons: require protocols to share medium; faulty link stops all communications; limited number of stations

Ring Topology



- Unidirectional point-to-point links to form loop
- Stations attach to repeaters
- Frames need addresses
- Pros: simple to install and reconfigure; easy to identify faults
- Cons: require protocols to share medium; traffic flows in one direction
- Usage: old LANs (e.g. IBM/IEEE 802.5 Token Ring); MANs and WANs

Star Topology



- Traffic between stations goes via the central node
- Usually two point-to-point links between station and central node (or duplex link)
- Frames needed addresses
- Pros: easy to install; fault tolerance for links
- Cons: depends on central node
- Usage: Most LANs today

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Multiple Users Using in Point-to-Multipoint Links

- Multiple users share a point-to-multipoint link
- Typical for wireless systems (WiFi, mobile phone) and some wired LANs
- Use *multiple access* schemes to determine who transmits and when

Fixed Assignment FDMA, TDMA, CDMA, SDMA

– requires planning and coordination, inefficient with dynamic traffic

Demand Assignment reservation, polling

– complex, high overheads or central coordinator

Random Access Aloha, CSMA

– unpredictable performance

Demand assignment and random access called Medium Access Control (MAC)

Medium Access Control

- In a shared medium, if two (or more) stations transmit at the same time, there is a chance the two transmissions will interfere with each other
- Collision of frames: receiver receives two or more frames partially overlapping in time; assume all frames are corrupted/lost
- Medium Access Control: allow one station to use the shared medium at a time (avoiding collisions)
- MAC techniques must give stations opportunities to transmit: fair and efficient

Demand Assignment reservation, polling, round-robin

- Stations are coordinated by a schedule

Random Access Aloha, CSMA

- Stations wait a random time and transmit if no-one else is currently transmitting

MAC Examples

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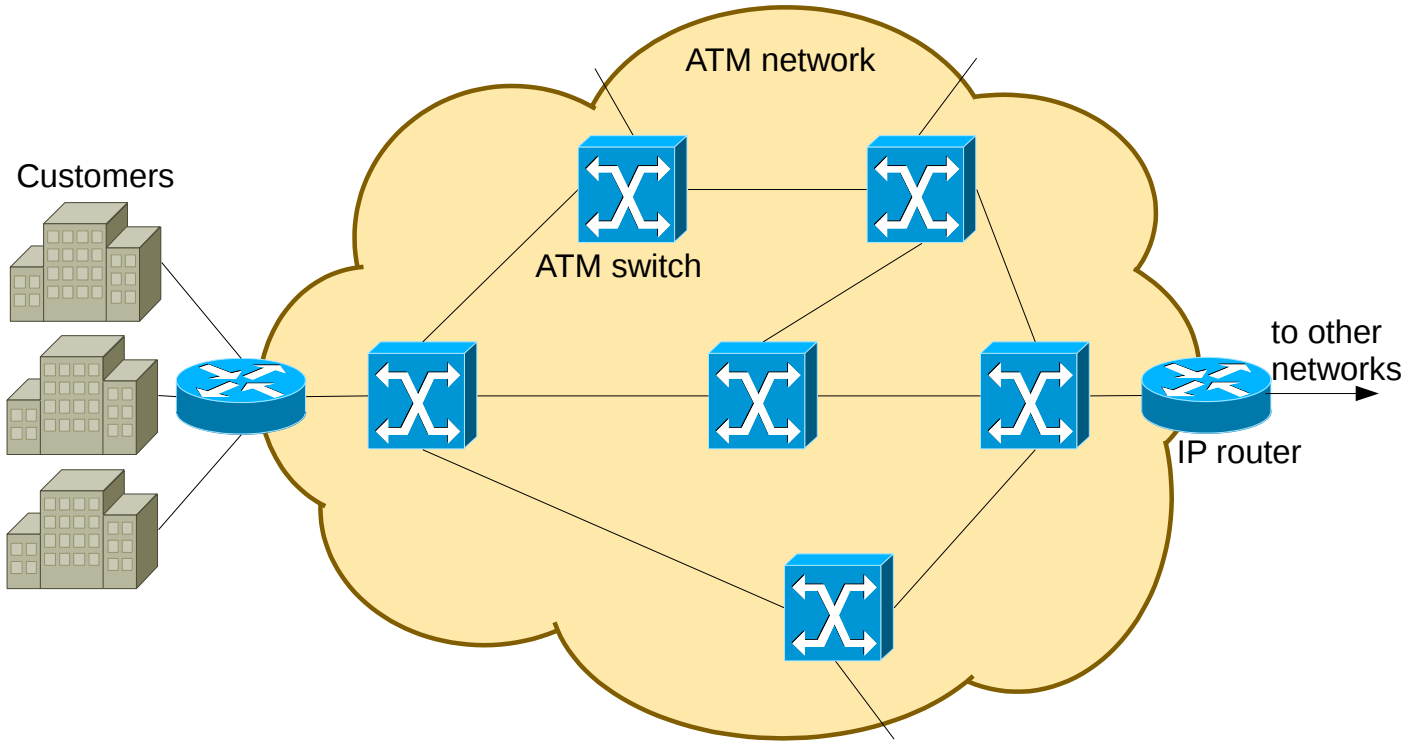
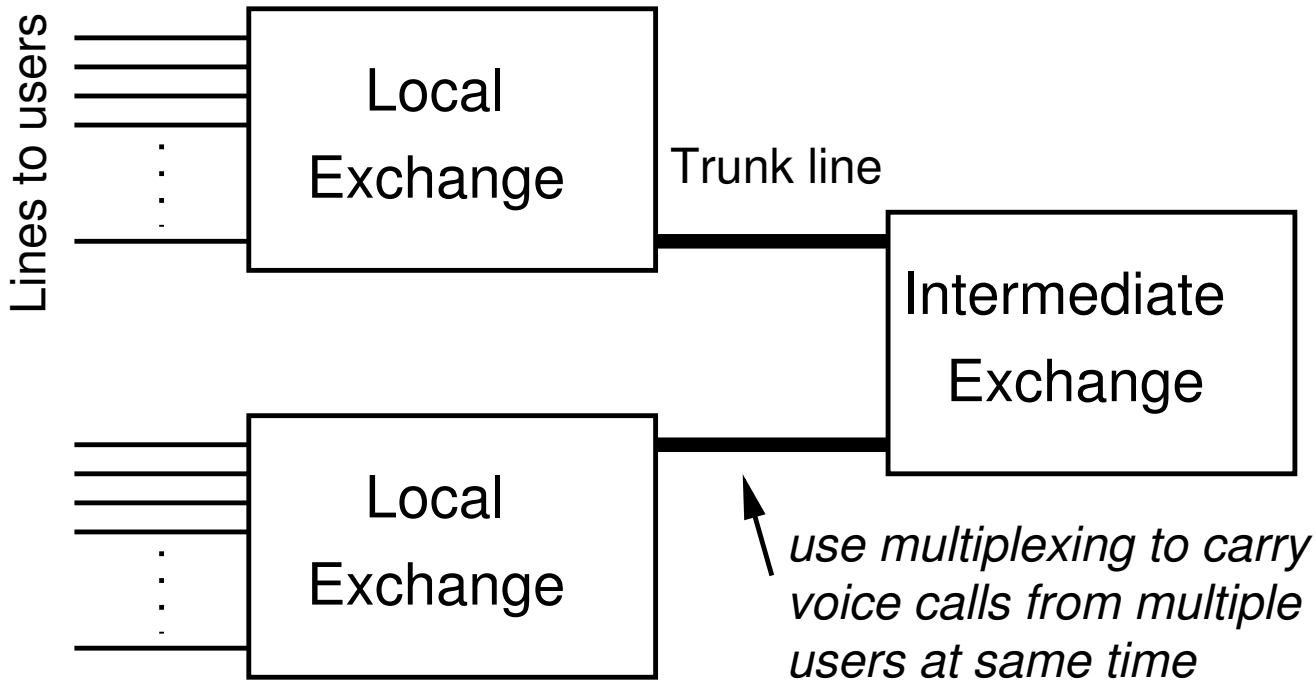
Asynchronous Transfer Mode

- Virtual circuit packet switching network technology
- Fixed sized packets, asynchronous (statistical) TDM, connection-oriented
- Can offer performance guarantees, Quality of Service (QoS) control
- Data rates up to 622 Mb/s
- Popular with telephone companies (e.g. connect telephone exchanges, mobile phone base stations); but being replaced by all IP networks
- Used in some DSL links: PPP over ATM, alternative is PPP over Ethernet
- Related technologies: X.25, Frame-Relay, MPLS, IP

ATM Network Example



Multiplexing in Telephone Networks



- Analog signal from home user to local exchange
- Exchange converts to digital to transmit to next exchange
  - Voice: bandwidth 4 kHz, sampling rate 8 kHz, 8-bit PCM $\rightarrow$ 64 kb/s

T-Carrier, E-Carrier and PDH

- Telecom companies used digital transmission with electrical signals and TDM to carry multiple voice calls
- 1 voice call = 64 kb/s
- Originally Transmission System 1 (T1) carried 24 voice calls in US
- Increased data rates (in Europe, E-Carrier)
  - T1: 1.5 Mb/s; T2: 6Mb/s; T3: 44 Mb/s; T4: 274Mb/s
  - E1: 2 Mb/s; E2: 8Mb/s; E3: 34 Mb/s; E4: 140 Mb/s
- Transmitter and receiver must know when time slots start/end $\rightarrow$ require accurate synchronisation
- General name: Plesionchronous Digital Hierarchy
- Although original designed based on carrying voice, can carry any digital data
- Leased lines: telecom companies lease a line (e.g. E1, E2, E3) to other organisations

PDH and SDH Data Rates

PDH (E-Carrier)

Level	Channels	Data Rate
E1	32	2 Mb/s
E2	128	8 Mb/s
E3	512	34 Mb/s
E4	2048	140 Mb/s
E5	8192	565 Mb/s

SDH

Optical	Level	Data Rate
OC-3	STM-1	155 Mb/s
OC-12	STM-4	622 Mb/s
OC-48	STM-16	2.5 Gb/s
OC-192	STM-64	10 Gb/s
OC-768	STM-256	40 Gb/s

Synchronous Digital Hierarchy

- Developed to increase performance of PDH, support optical carrier (OC) signals
- SONET in US, SDH in rest of world
- Transmit frame every 125 μs; requires more accurate synchronisation than PDH (atomic clocks)
- Built-in fault tolerance: transmit on at least two fibres; can support ring topology with redundant transmissions in each direction
- Used in many networks across cities/countries, and links between countries
- Optical fibres:
  - Single optical fibre can carry multiple optical signals using Wavelength Division Multiplexing
  - Each optical signal may carry SDH or 10 Gb/s Ethernet

LAN Technologies

- IEEE 802.3 (Ethernet)
- IEEE 802.11 wireless LANs (WiFi)
- Older technologies, e.g. Token Ring, FDDI
- Infiniband: connect servers, storage devices, high-performance computers
- Power-line communications (PLC): HomePlug, IEEE 1901, ITU-T G.hn

And Many Others

- Narrowband: dialup modems, ISDN
- Broadband: HDSL, SDSL, ADSL, VDSL, DOCSIS, PON
- Mobile Telephony: GSM, GPRS, EDGE, 3G (UMTS), HSPA, LTE; WiMax
- Wireless PANs: IrDA, IEEE 802.15.4, Bluetooth, Wireless USB
- ...