



EEE 545

Computer Networks 1

Course Information

- **Name of the Course:** Computer Networks I

Lecturer : Dr. Mahmut Aykaç

Text Book and References:

- **1-** An Introduction to Computer Networking, Thomas G. Robetazzi
- **2-** An Introduction to Computer Networks, Release 1.8.16, Peter L Dordal
- **3-** Computer Networks, Andrew S. Tanenbaum

CH1 - An overview of Networks

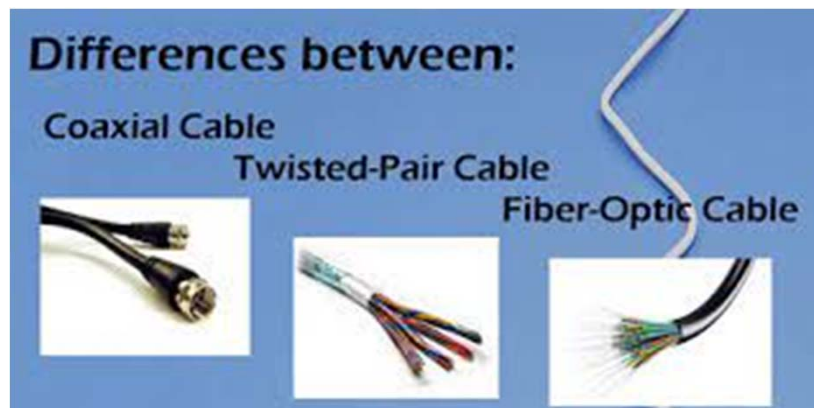
1.1 Introduction

- ▶ What is a network? It is a collection of computers (nodes) and transmission channels (links) that allow people to communicate over distances, large and small.
- ▶ A Bluetooth (shown in figure) personal area network may simply connect your home PC with its peripherals. An undersea fiber optic cable may traverse an ocean. The Internet and telephone networks span the globe. Networks range in size from networks on chips to deep space networks.



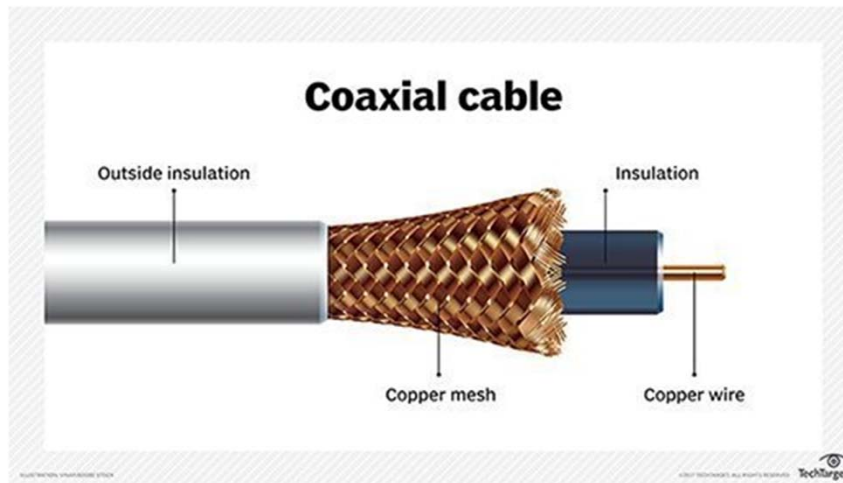
1.2 Achieving Connectivity

- ▶ A variety of transmission methods, both wired and wireless, are available today to provide connectivity between computers, networks, and people. Wired transmission media include coaxial cable, twisted pair wiring, and fiber optics. (Figure 1)
- ▶ Wireless technology includes microwave line of sight, satellites, cellular systems, ad hoc networks, and wireless sensor networks. (Figure 2)



1.2.1 Coaxial Cable

- ▶ This is the thick cable you may have in your house to connect your cable TV set-up box to the outside wiring plant.
- ▶ A coaxial cable has four parts: a copper inner core, surrounded by insulating material, surrounded by a metallic outer conductor, finally surrounded by a plastic outer cover. Essentially in a coaxial cable, there are two wires (copper inner core and outer conductor) with one geometrically inside the other. This configuration reduces interference to/from the coaxial cable with respect to other nearby wires.



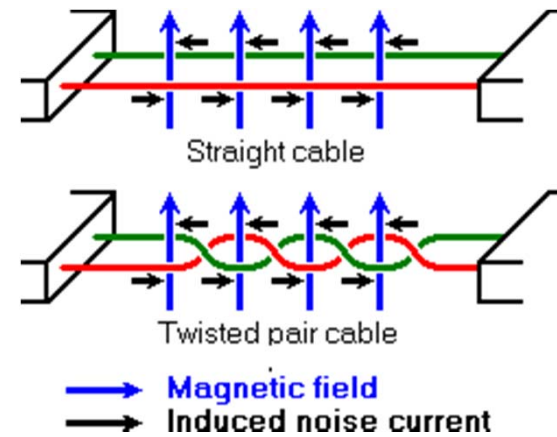
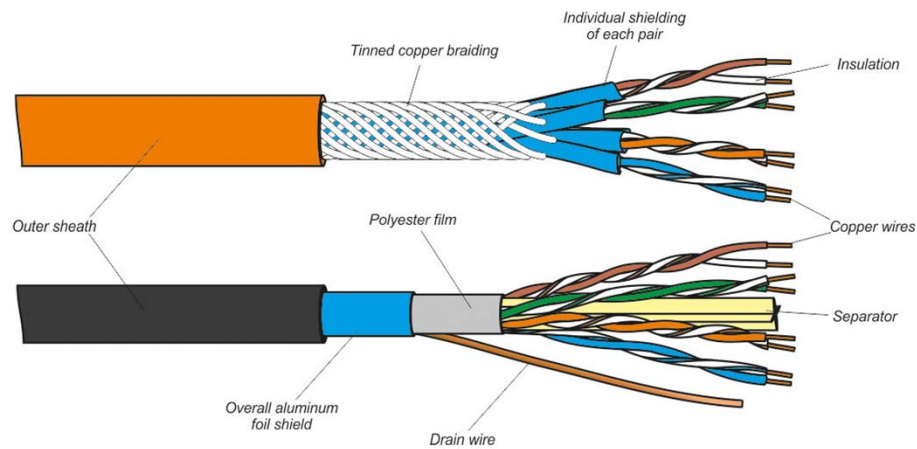
1.2.1 Coaxial Cable

- ▶ The bandwidth of a coaxial cable is on the order of 1 GHz. How many bits per second can it carry? Modulation is used to match a digital stream to the spectrum carrying ability of the cable. Depending on the efficiency of the modulation scheme used, 1 bps requires anywhere from 1/14 to 4 Hz. For short distances, a coaxial cable may use 8 bits/Hz or carry 8Gbps.

1.2.2 Twisted Pair Wiring

- ▶ Coaxial cable is generally no longer used for wiring local area networks. One type of replacement wiring has been twisted pair. Twisted pair wiring typically had been previously used to wire phones to the telephone network.
- ▶ A twisted pair consists of two wires twisted together over their length. The twisted geometry reduces electromagnetic leakage (i.e., cross talk) with nearby wires. Twisted pairs can run several kilometers without the need for amplifiers. The quality of a twisted pair (carrying capacity) depends on the number of twists per inch.
- ▶ The fact that twisted pair is lighter and thinner than coaxial cable has speeded its widespread acceptance.

1.2.2 Twisted Pair Wiring



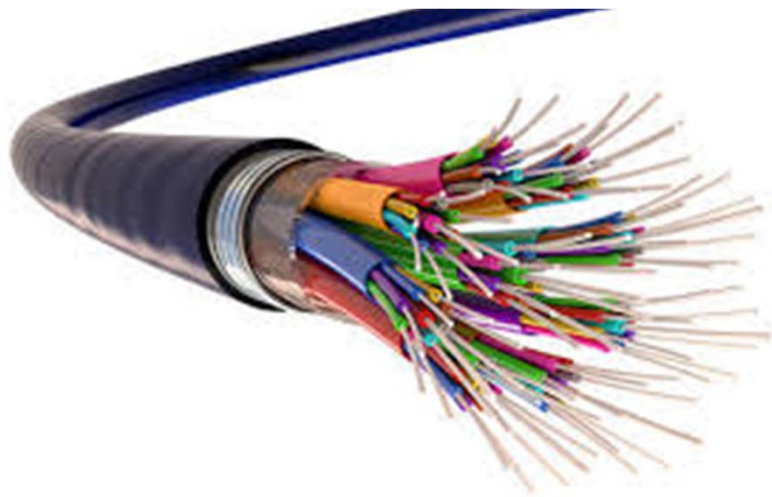
1.2.2 Twisted Pair Wiring

- ▶ About 1990, it became possible to send 10 Mbps (for Ethernet) over unshielded twisted pair (UTP). Higher speeds are also possible if the cable and connector parameters are carefully implemented.
- ▶ One type of unshielded twisted pair is category 3 UTP. It consists of four pairs of twisted pair surrounded by a sheath. It has a bandwidth of 16 MHz. Many offices used to be wired with category 3 wiring.
- ▶ Category 5 UTP has more twists per inch. Thus, it has a higher bandwidth (100 MHz). Newer standards include category 6 versions (250MHz or more) and category 7 versions (600MHz or more). Category 8 at 1600–2000MHz for 40 Gbps Ethernet is under development.

1.2.3 Fiber Optics

- ▶ Fiber optic cable consists of a silicon glass core that conducts light, rather than electricity as in coaxial cables and twisted pair wiring. The core is surrounded by cladding and then a plastic jacket.
- ▶ Fiber optic cables have the highest data carrying capacity of any wired medium. A typical fiber has a capacity of 50 Tbps (terabits per second or 50×10^{12} bits per second).
- ▶ There are two major types of fiber: multi-mode and single mode. Pulse shapes are more accurately preserved in single mode fiber, lending to a higher potential data rate.

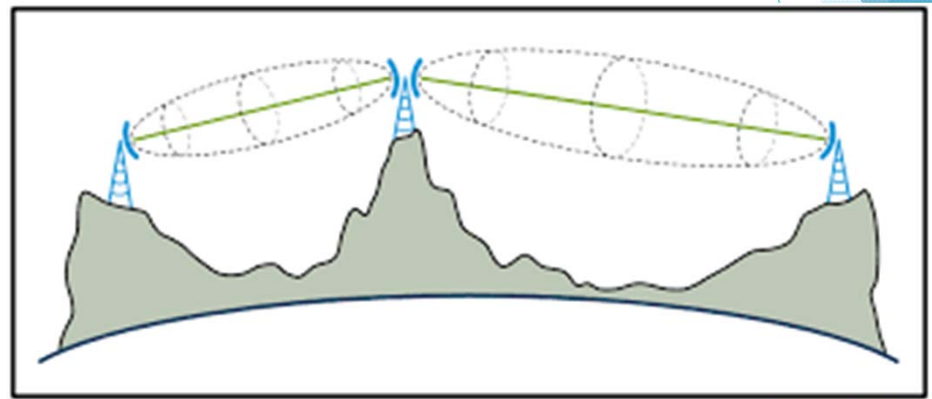
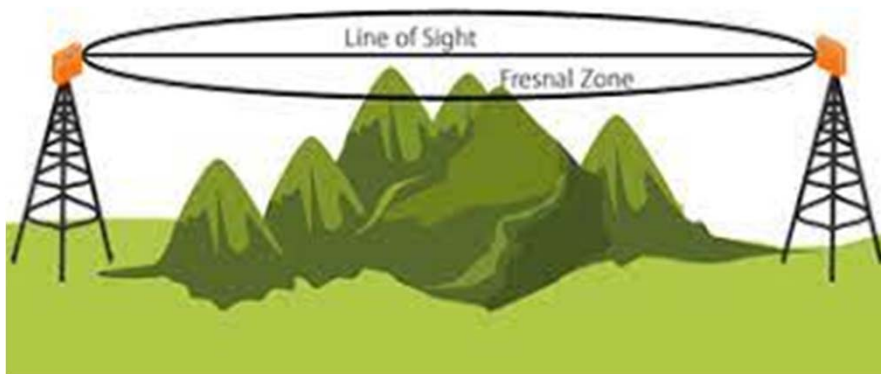
1.2.3 Fiber Optics



1.2.4 Microwave Line of Sight

- ▶ Microwave radio energy travels largely in straight lines. Thus, some network operators construct networks of tall towers kilometers apart and place microwave antennas at different heights on each tower. While the advantage is that there is no need to dig trenches for cables, the expense of tower construction and maintenance must be taken into account. It should be noted that transmissions in the microwave frequencies are also used in other applications such as cellular phones and space communications (including satellite communications).

1.2.4 Microwave Line of Sight



1.2.5 Satellites

- ▶ There are about 3600 satellites of all types in orbit, of which about 1000 are operational.
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- ▶ Satellites are now extensively used for communication purposes. They fill certain technological niches very well: providing connectivity to mobile users, for large area broadcasts and for communications to areas with poor infrastructure.



1.2.6 Cellular Systems

- ▶ Cellular telephone systems which provide connectivity between mobile phones and the public switched telephone network were deployed. In such systems, signals go from/to a cell phone to/from a local “base station” antenna which is hard wired into the public switched telephone network.

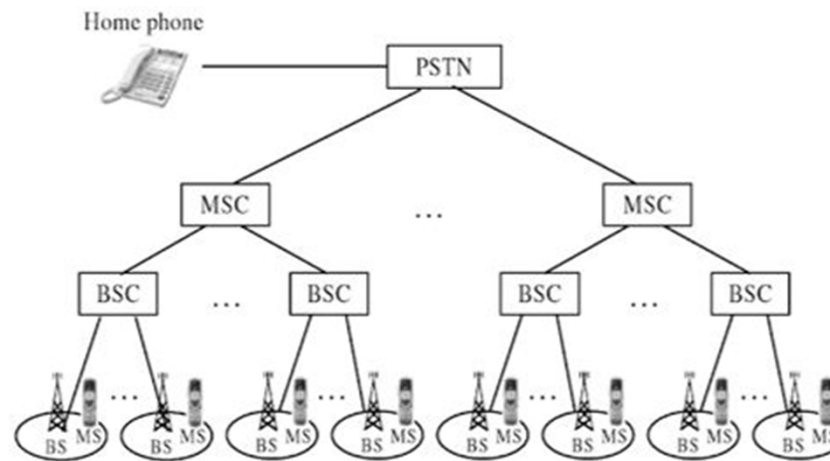
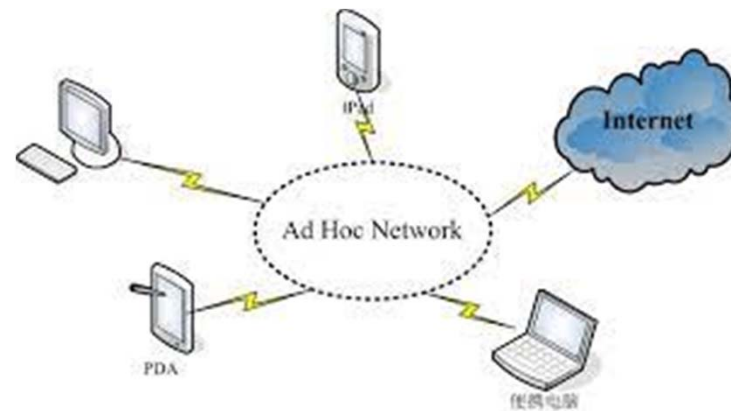


Fig: cellular system infrastructure

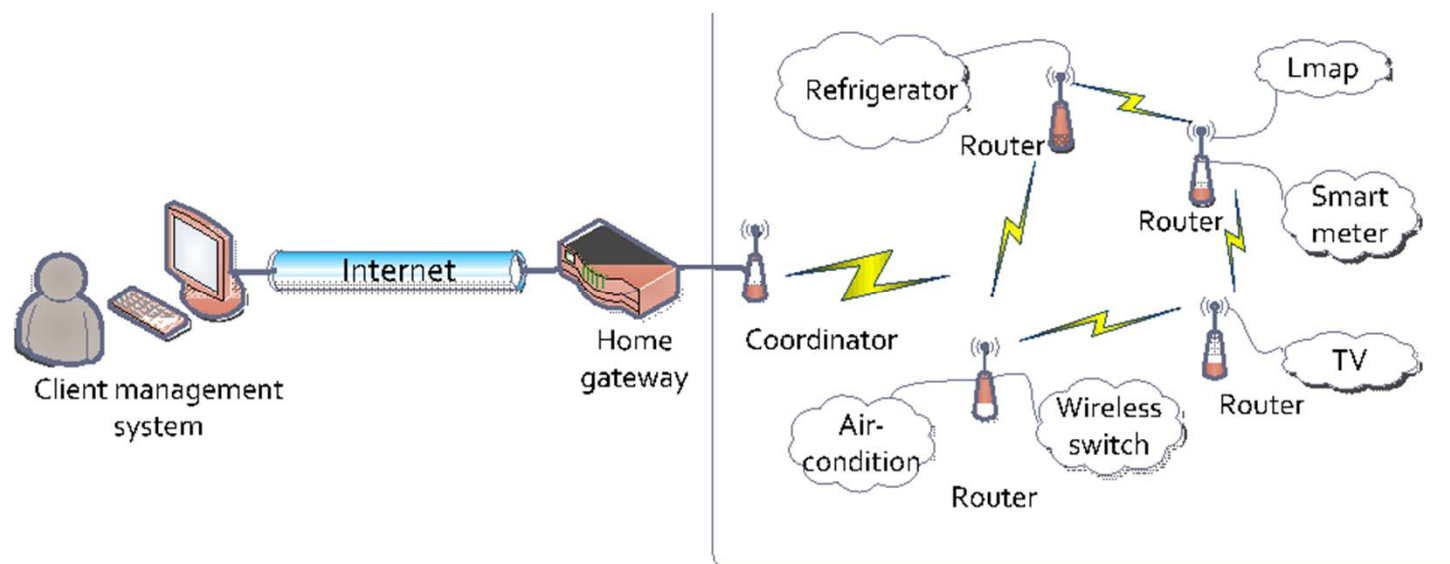
1.2.7 Ad Hoc Networks

- ▶ Ad hoc networks are radio networks where (often mobile) nodes can come together, transparently form a network without any user interaction and maintain the network as long as the nodes are in range of each other and energy supplies last.
- ▶ In an ad hoc network messages hop from node to node to reach an ultimate destination. For this reason ad hoc networks used to be called multihop radio networks.



1.2.7 Wireless Sensor Networks

- ▶ The integration of wireless, computer, and sensor technology has the potential to make possible networks of miniature elements that can acquire sensor data and transmit the data to a human observer.
- ▶ Sensors can be placed in machines (where vibration can sometimes supply energy) such as rotating machines, semiconductor processing chambers, robots, and engines. Wireless sensors in engines could be used for pollution control telemetry.



1.3 Multiplexing

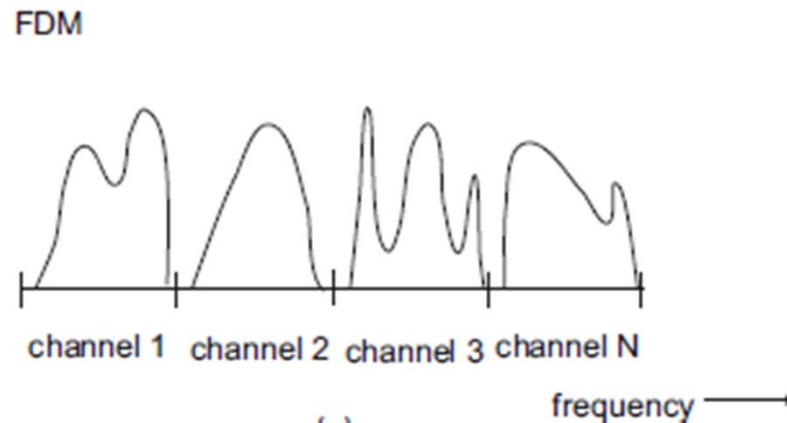
- ▶ Multiplexing involves sending multiple signals over a single medium.



Multiplexing and Demultiplexing

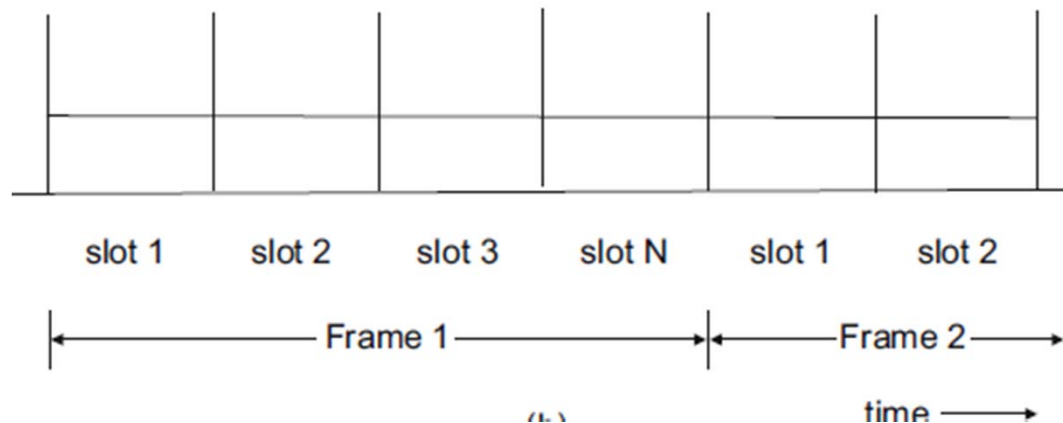
1.3.1 Frequency Division Multiplexing

- ▶ All channels are transmitted simultaneously but a tunable filter at the receiver only allows one channel at a time to be received. This is how AM, FM, and analog television signals are transmitted.



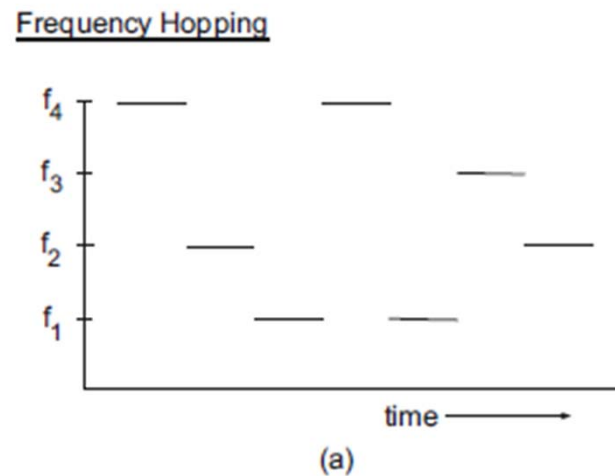
1.3.1 Time Division Multiplexing

- ▶ Time division multiplexing is a digital technology that, on a serial link, breaks time into equi-duration slots.



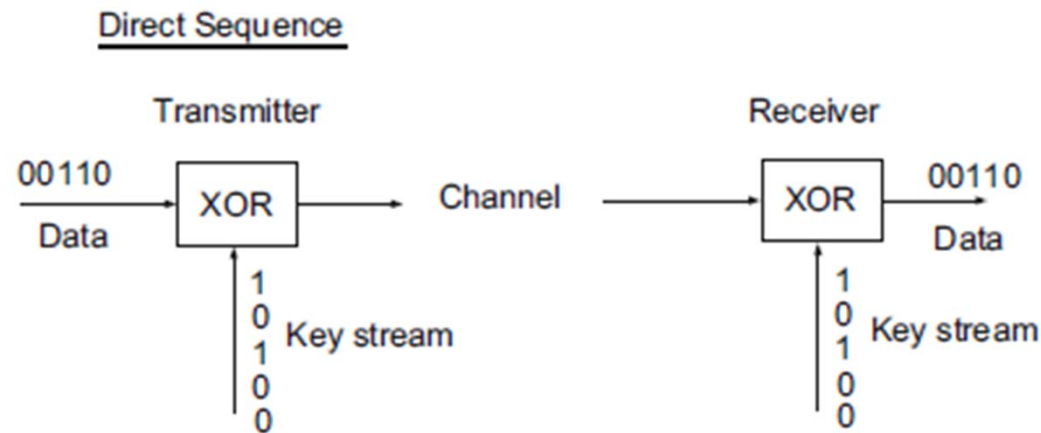
1.3.3 Frequency Hopping

- ▶ Frequency hopping is one form of spread spectrum technology and is typically used on radio channels. The carrier (center) frequency of a transmission is pseudorandomly hopped among a number of frequencies.
- ▶ The hopping is done in a deterministic, but random looking pattern that is known to both transmitter and receiver (i.e., “pseudo-random sequence”). If the hopping pattern is known only to the transmitter and receiver, one has good security. Frequency hopping also provides good interference rejection.



1.3.4 Direct Sequence Spread Spectrum

- ▶ This alternative spread spectrum technology uses exclusive or (xor) gates as scramblers and de-scramblers (Fig. 1.4b). At the transmitter data is fed into one input of an xor gate and a pseudo-random key stream into the other input.

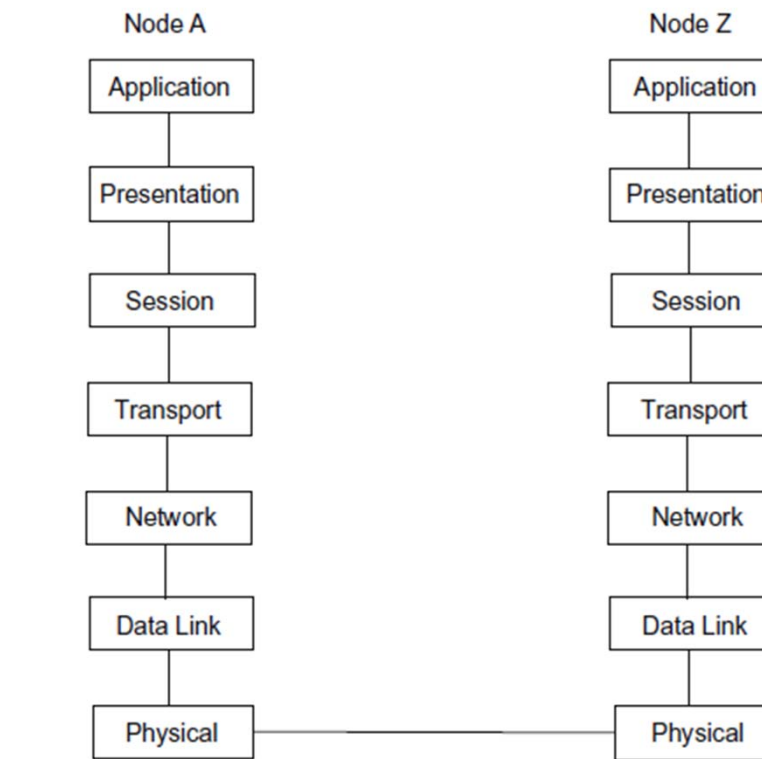


Key	Data	Output
0	0	0
0	1	1
1	0	1
1	1	0

1.5 Layered Protocols

- ▶ Protocols are the rules of operation of a network. A common way to engineer a complex system is to break it into more manageable and coherent components. Network protocols are often divided into layers in the layered protocol approach.
- ▶ Figure illustrates the generic OSI (open systems interconnection) protocol stack. Proprietary protocols may have different names for the layers and/or a different layer organization but pretty much all networking protocols have the same functionality.

1.5 Layered Protocols



OSI protocol stack for a communicating source and destination

1.5 Layered Protocols

- ▶ *Application Layer* include email, remote login, file transfer, and the world wide web. But an application may also be more specialized, such as distributed software to run a network of catalog company order depots.
- ▶ *Presentation Layer* controls how information is formatted, such as on a screen (number of lines, number of characters across).
- ▶ *Session Layer* is important for managing a session, as in remote logins. In other cases, this is not a concern.
- ▶ *Transport Layer* is designed to give the impression to the layers above that they are dealing with a reliable network, even though the layers below the transport layer may not be perfectly reliable.
- ▶ *Network Layer* manages multiple links. Its most important function is to do routing. Routing involves selecting the best path for a circuit or packet stream.

1.5 Layered Protocols

- ▶ *Data Link Layer*, Whereas, the network layer manages multiple link functions, a data link protocol manages a single link. One of its potential functions is encryption, which can either be done on a link by link basis (i.e., at the data link layer) or on an end-to-end basis (i.e., at the transport layer) or both.
- ▶ *Physical Layer* is concerned with the raw transmission of bits. Thus, it includes engineering physical transmission media, modulation and demodulation, and radio technology.