MOBILE AND WIRELESS COMMUNICATION

Course code	ESC-CSE-308G				
Category	Engineering Science Course				
Course title	Mobile and wireless communication				
Scheme and Credits	L	T	P	Credits	Semester 6
	3	0	0	3	
Class work	25 Marks				
Exam	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Objectives of the course:

- Understand the wireless/cellular radio concepts such as frequency reuse, handoff and interference between mobiles and base stations.
- Identify the techno-political aspects of wireless and mobile communications such as the allocation of the limited wireless spectrum by regulatory agencies.
- Understand the information theoretical aspects such as channel capacity, propagation effects, modeling the impact of signal bandwidth and motion in mobile systems.
- Describe the current and future Mobile Communication Systems, GSM, Satellite, Broadcasting, Bluetooth, Wireless LANs, Mobile Adhoc Networks.
- Describe the mobility support mechanism, WWW and WAPs.

UNIT 1

Introduction: Application, History, Market Scenario, Reference Model and Overview, Wireless Local Loop and Cellular system.

Wireless Transmission: Frequencies, Signals, Antennae, Signal Propagation, Multiplexing, Modulation, Spread Spectrum.

MAC Layer: Specialized MAC, SDMA, FDMA, TDMA – Fixed TDM, Classical ALOHA, Slotted, ALOHA, CSMA, DAMA, PKMA, Reservation TDMA. Collision Avoidance, Polling, Inhibit Sense Multiple Access, CDMA.

Broadcasting: Unidirectional Distribution Systems, Digital Audio Broadcasting, Digital Video Broadcasting, Convergence of Mobile and Broadcasting Techniques.

UNIT 2

GSM: Mobile Services, Architecture Radio, Interface, Protocol, Localization, Calling Handover, Security, New data services.

Wireless LAN: IEEE 802 11- System and Protocol Architecture, Physical Layer, MAC Layered Management.

Bluetooth: User scenarios, Physical layer, MAC Layer, Networking, Security and Link Management. Wimax

UNIT 3

Mobile Network Layer: Mobile IP-Goals, Assumptions, Requirement, Entities, Terminology, IP Packet delivery, Agent Advertisement and Discovery, Registration, Tunneling, Encapsulation, Optimization, Reserve Tunneling, Security, IPv6 , DHCP.

Mobile Adhoc Networks: Routing, Destination Sequence Distance Vector, Dynamic Source Routing, Hierarchical algorithms, Performance Metrics.

Mobile Transport Layer: Traditional TCP, Indirect TCP, Snooping, TCP, Mobile TCP, Fast-retransmission TCP, Transaction oriented TCP.

UNIT 4

Satellite Systems: History, Applications, GEO, LEO, MEO, Routing, Localization, Handover in Satellite System.

Support for Mobility: File System, WWW, HTML, System Architecture.

WAP: Architecture, Wireless Datagram, Protocol, Wireless Transport Layer Security, Wireless Transaction Protocol, Application Environment, Telephony Applications.

What is Mobile Computing?

- It is a technology that allows transmission of data via, a computer without having to be connected to a fixed physical link.
- Mobile computing environment as being made up of three main components: a computer (that moves), a N/W (that is either wired or wireless) & co-ordination S/W that ties them together.
- In mobile N/W computing activities are not disrupted when the user changes the computer's points of attachment to the internet.

What is Wireless?

- Wireless refers to the method of transferring information between computing devices, such as a personal data assistant (PDA) and a data source such as an agency database server, without a physical connection or wires.
- The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications).
- Not all wireless communication technologies are mobile.

Mobile devices

Personal digital assistant is a term for **a small, mobile, handheld device that provides computing and information storage and retrieval capabilities for personal or business use**

Pager
- receive only
- tiny displays
- simple text messages

PDA
- simple graphical displays
- character recognition
- simplified WWW

Laptop
- fully functional
- standard applications

Sensors, embedded controllers

Mobile phones
- voice, data
- simple text displays

Palmtop
- tiny keyboard
- simple versions of standard applications

performance

INTRODUCTION

- Application
- History
- Market Scenario
- Reference Model & Overview
- Wireless Local Loop & Cellular System

Applications(1)

- **Vehicles :**
  - Transmission of news, road condition, weather, music via DAB(*Digital Audio Broadcasting*)
  - Personal communication using GSM(Global System for Mobile Communications)/UMTS(*Universa Mobile Telecommunications System*)
  - Position via GPS(*Global Positioning System*)
  - local ad-hoc network with vehicles close-by to prevent accidents, guidance system
  - vehicle data (e.g., from busses, high-speed trains) can be transmitted in advance for maintenance

Applications(2)

- **Education:**
- Wireless technology is an ideal application of colleges and schools.
- An instructor can create a classroom presentation on the notebook computer in his home or school office and this presentation can access in classroom using wireless devices.
- Teachers can also distribute handouts directly to students who have brought their own wireless devices to class.

Applications(3)

- **Home Entertainment:**
- Several large computer manufacturers are introducing specialized media PCs that enable movie and audio enthusiasts to download, distribute and control all forms of digital entertainment from anywhere in the house.
- Some of the systems also have the ability to control lights, air conditioners and other household devices.

Applications(4)

- **In Companies:**
- In companies mangers can use mobile computer in, say critical presentations to major customers.
- They can access the latest market share information.
- At a small recess, they can revise the presentation take advantages of this information.
- They can communicate with the office about possible new offers and call meetings for discussing responds to the new proposals.
- Therefore, mobile computers can leverage competitive advantages.

Applications(5)

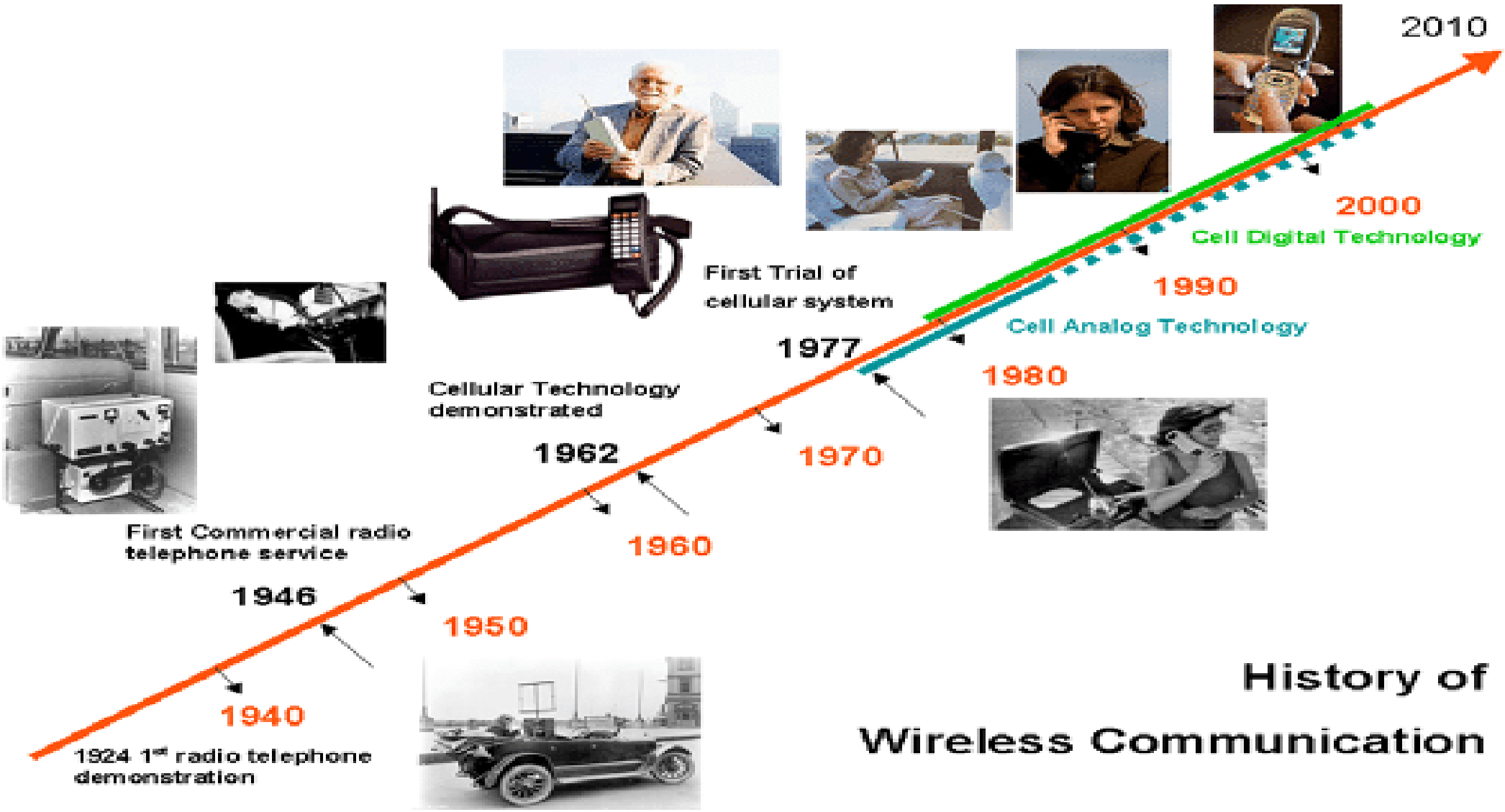
- Enable the business initiatives by supporting mobility of
  - Customers
  - Suppliers and Businesses
  - Employees
- Mobile computing applications
  - Wireless messaging (e.g., SMS)
  - Mobile ecommerce (M-Commerce) and its variants
    - Positional commerce *(p-commerce)* .
    - Voice commerce (v-commerce).
    - Television commerce (T-Commerce)
  - Mobile ebusiness applications (MEBAs), e.g., M-CRM, M-porta
  - Specialized applications
    - Location sensitive apps
    - Wireless sensor network apps
    - Mobile agent apps
- Two views:
  - Mobile applications are fundamentally new applications.
  - Mobility is another dimension of the existing applications

Applications(5)

Mobile & Wireless Computation

- Wireless & Mobile are not synonymous
- Wireless
  - Is a transmission or information transport method that enables mobile computing
  - Communication is without wires
- Mobile Computing focuses on the applications side .
  - Ability to compute no matter where the user is
  - Infrared, cellular, radio waves, microwave, satellite services

History(1)


2010
2000
Cell Digital Technology
1990
Cell Analog Technology
1980
1977
First Trial of
cellular system
Cellular Technology
demonstrated
1970
1962
1960
First Commercial radio
telephone service
1950
1946
1940
1924 1st radio telephone
demonstration
History of
Wireless Communication

History(2)

Early history of wireless communication

Many people in history used light for communication

- heliographs, flags („semaphore“), ...
- 150 BC smoke signals for communication; (Polybius, Greece)
- 1794, optical telegraph, Claude Chappe

Here electromagnetic waves are of special importance:

- 1831 Faraday demonstrates electromagnetic induction
- J. Maxwell (1831-79): theory of electromagnetic Fields, wave equations (1864)
- H. Hertz (1857-94): demonstrates with an experiment the wave character of electrical transmission through space (1886, in Karlsruhe, Germany, at the location of today’s University of Karlsruhe)

History(3)

History of wireless communication I

1895 Guglielmo Marconi
- first demonstration of wireless telegraphy (digital!)
- long wave transmission, high transmission power necessary (> 200kw)

1907 Commercial transatlantic connections
- huge base stations (30 100m high antennas)

1915 Wireless voice transmission New York - San Francisco

1920 Discovery of short waves by Marconi
- reflection at the ionosphere
- smaller sender and receiver, possible due to the invention of the vacuum tube (1906, Lee DeForest and Robert von Lieben)

1926 Train-phone on the line Hamburg - Berlin
- wires parallel to the railroad track

History(4)

- 1928 many TV broadcast trials (across Atlantic, color TV, news)
- 1933 Frequency modulation (E. H. Armstrong)
- 1958 A-Netz in Germany
  - analog, 160MHz, connection setup only from the mobile station, no handover, 80% coverage, 1971 11000 customers
- 1972 B-Netz in Germany
  - analog, 160MHz, connection setup from the fixed network too (but location of the mobile station has to be known)
  - available also in A, NL and LUX, 1979 13000 customers in D
- 1979 NMT at 450MHz (Scandinavian countries)
- 1982 Start of GSM-specification
  - goal: pan-European digital mobile phone system with roaming
- 1983 Start of the American AMPS (Advanced Mobile Phone System, analog)
- 1984 CT-1 standard (Europe) for cordless telephones

Nordic Mobile Telephone (NMT) is **an analogue system for mobile communications**

History(6)

History of wireless communication III

1986 C-Netz in Germany

- analog voice transmission, 450MHz, hand-over possible, digital signaling, automatic location of mobile device
- still in use today (as T-C-Tel), services: FAX, modem, X.25, e-mail, 98% coverage

1991 Specification of DECT

- Digital European Cordless Telephone (today: Digital Enhanced Cordless Telecommunications)
- 1880-1900MHz, ~100-500m range, 120 duplex channels, 1.2Mbit/s data transmission, voice encryption, authentication, up to several 10000 user/km^2, used in more than 40 countries

1992 Start of GSM

- in D as D1 and D2, fully digital, 900MHz, 124 channels
- automatic location, hand-over, cellular
- roaming in Europe - now worldwide in more than 100 countries
- services: data with 9.6kbit/s, FAX, voice, ...

History(5)

History of wireless communication IV

1994 E-Netz in Germany
- GSM with 1800MHz, smaller cells, supported by 11 countries
- as Eplus in D (1997 98% coverage of the *population*)

1996 HiperLAN (High Performance Radio Local Area Network)
- ETSI, standardization of type 1: 5.15 - 5.30GHz, 23.5Mbit/s
- recommendations for type 2 and 3 (both 5GHz) and 4 (17GHz) as wireless ATM-networks (up to 155Mbit/s)

1997 Wireless LAN - IEEE802.11
- IEEE-Standard, 2.4 - 2.5GHz and infrared, 2Mbit/s
- already many products (with proprietary extensions)

1998 Specification of GSM successors
- for UMTS (Universal Mobile Telecommunication System) as European proposals for IMT-2000

Iridium
- 66 satellites (+6 spare), 1.6GHz to the mobile phone

History(5)

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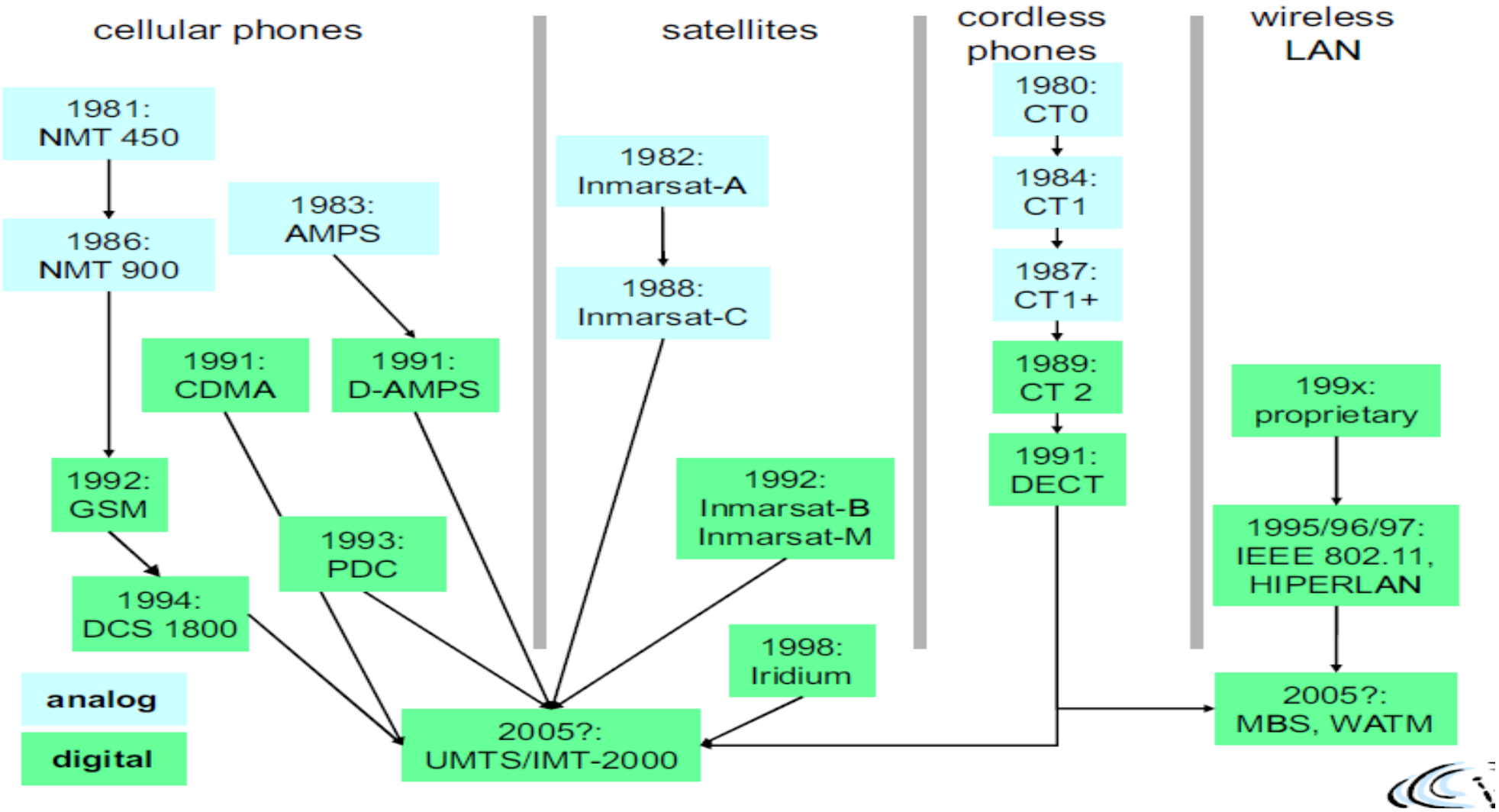
History(6)

Wireless systems: overview of the development



History(7)

The **International Telecommunication Union** (**ITU**) is the United Nations specialized agency for information and communication technologies – ICTs

The future: ITU-R - Recommendations for IMT-2000

M.687-2
- IMT-2000 concepts and goals

M.816-1
- framework for services

M.817
- IMT-2000 network architectures

M.818-1
- satellites in IMT-2000

M.819-2
- IMT-2000 for developing countries

M.1034-1
- requirements for the radio interface(s)

M.1035
- framework for radio interface(s) and radio sub-system functions

M.1036
- spectrum considerations

M.1078
- security in IMT-2000

M.1079
- speech/voiceband data performance

M.1167
- framework for satellites

M.1168
- framework for management

M.1223
- evaluation of security mechanisms

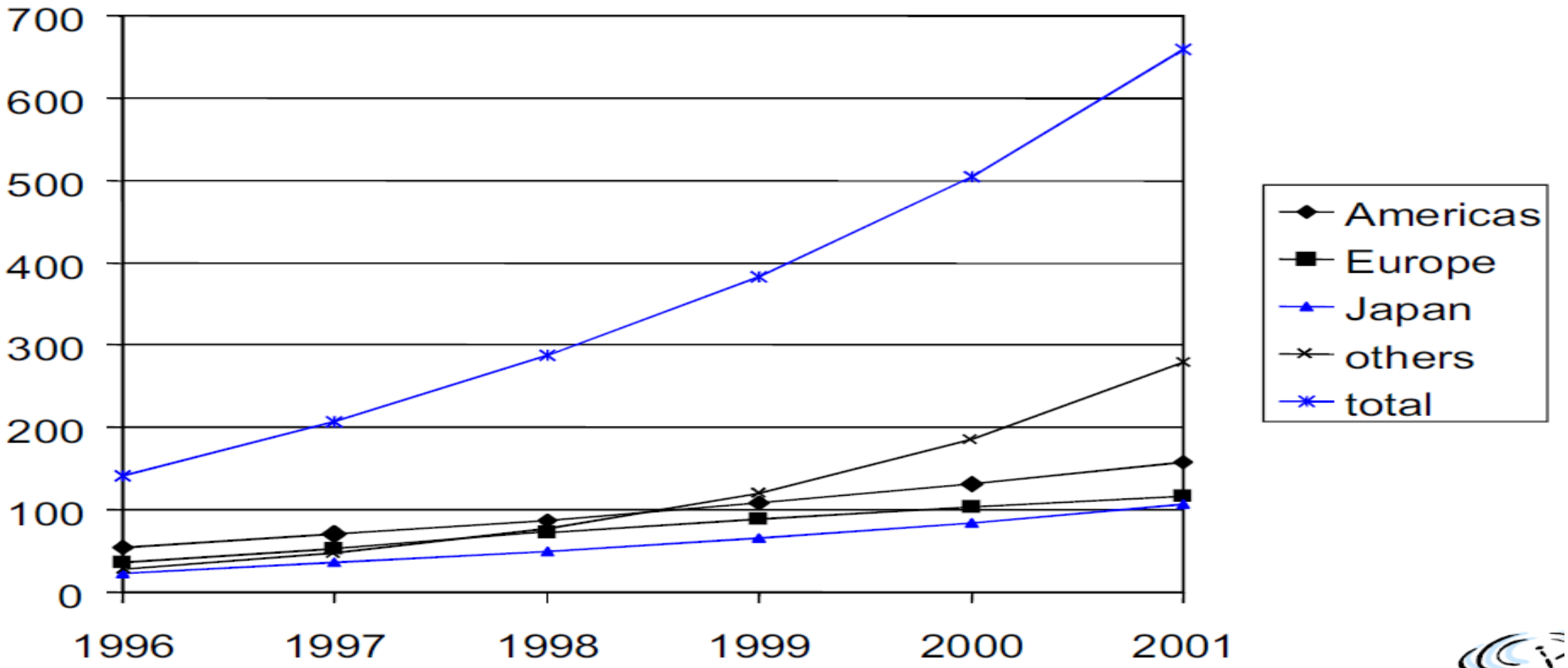
M.1224
- vocabulary for IMT-2000

M.1225
- evaluation of transmission technologies

IMT-2000 (**International Mobile Telecommunications-2000**) is the global standard for third generation (3G) wireless communications

History(8)

Worldwide wireless subscribers (prediction)



Market Scenario(1)

Areas of research in mobile communication

Wireless Communication
- transmission quality (bandwidth, error rate, delay)
- modulation, coding, interference
- media access, regulations
- ...

Mobility
- location dependent services
- location transparency
- quality of service support (delay, jitter, security)
- ...

Portability
- power consumption
- limited computing power, sizes of display, ...
- usability
- ...

Market Scenario(2)

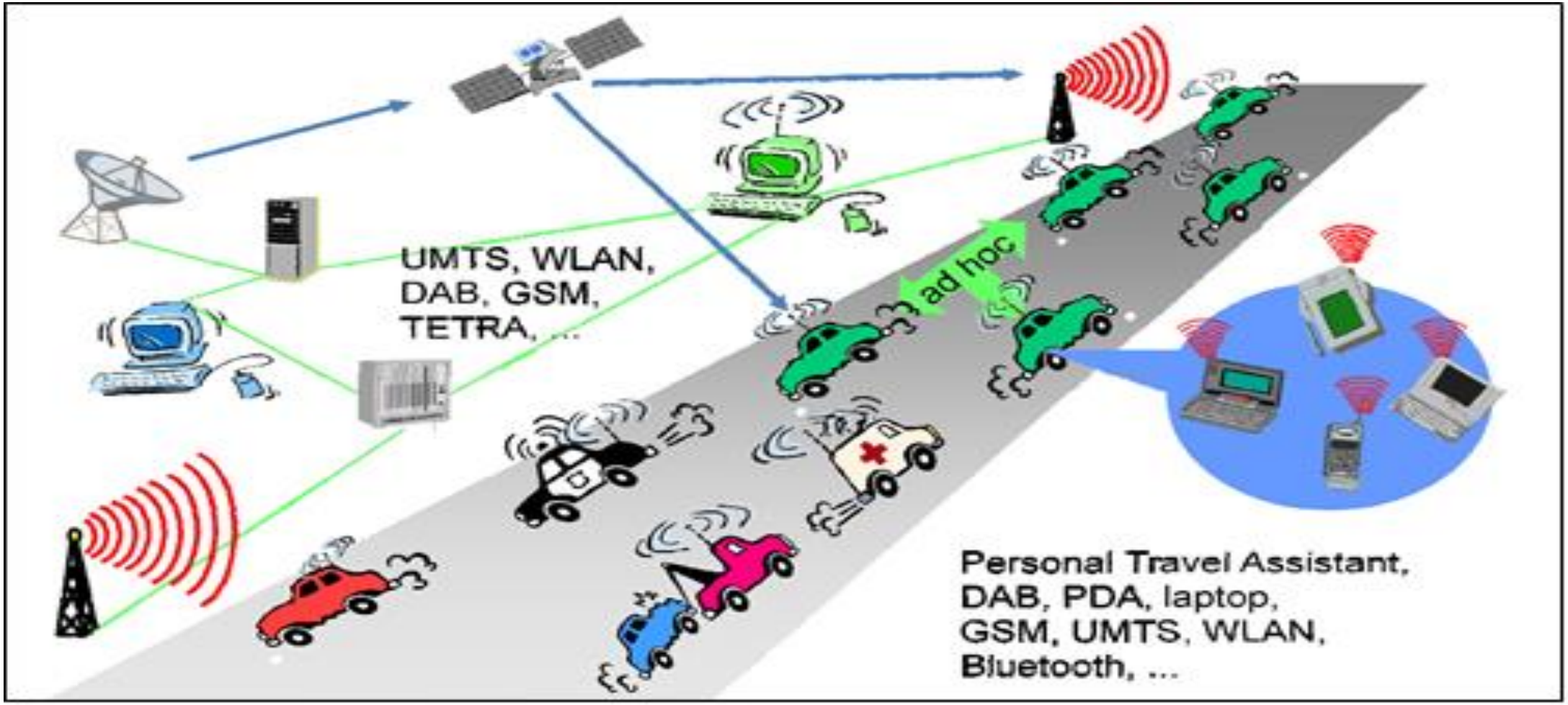
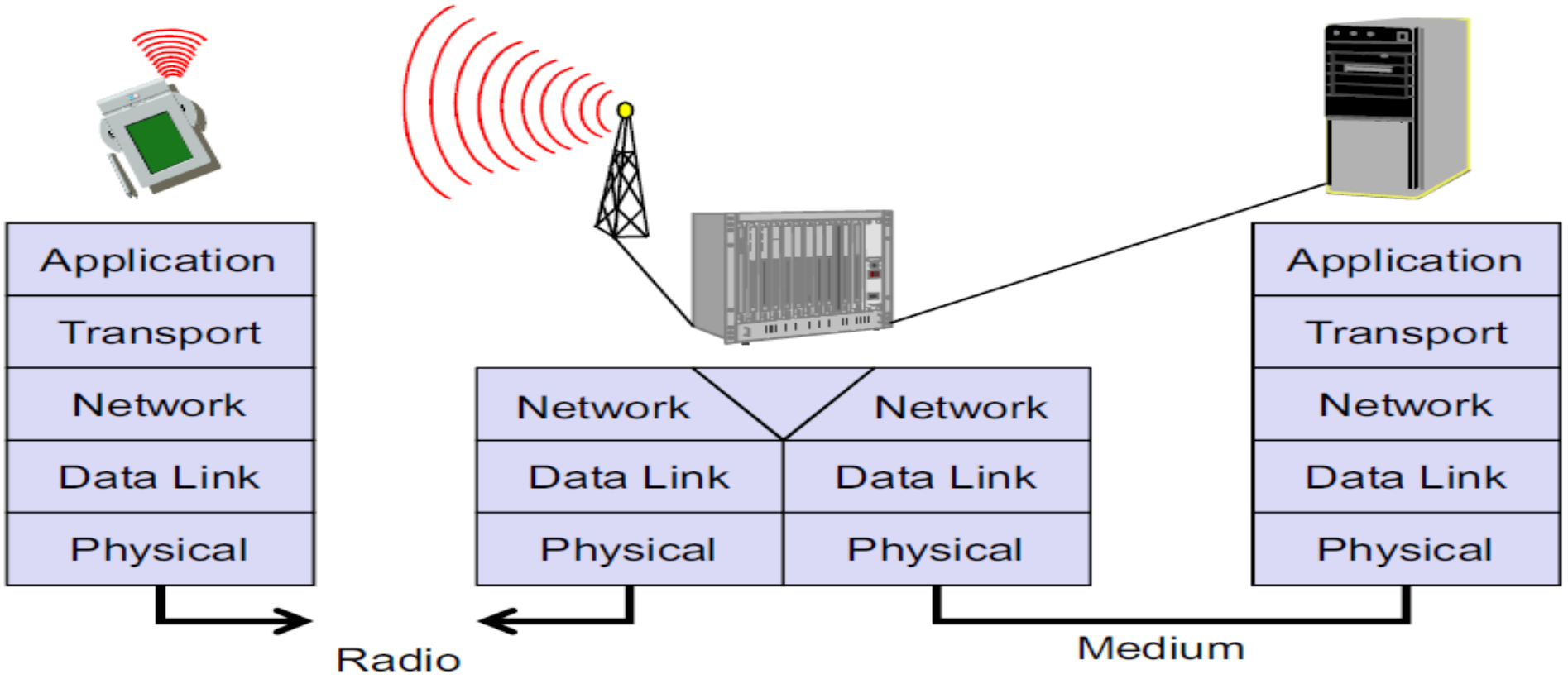


Fig: A Typical Application of Mobile Communication in Road Traffic

Reference Model & Overview (1)

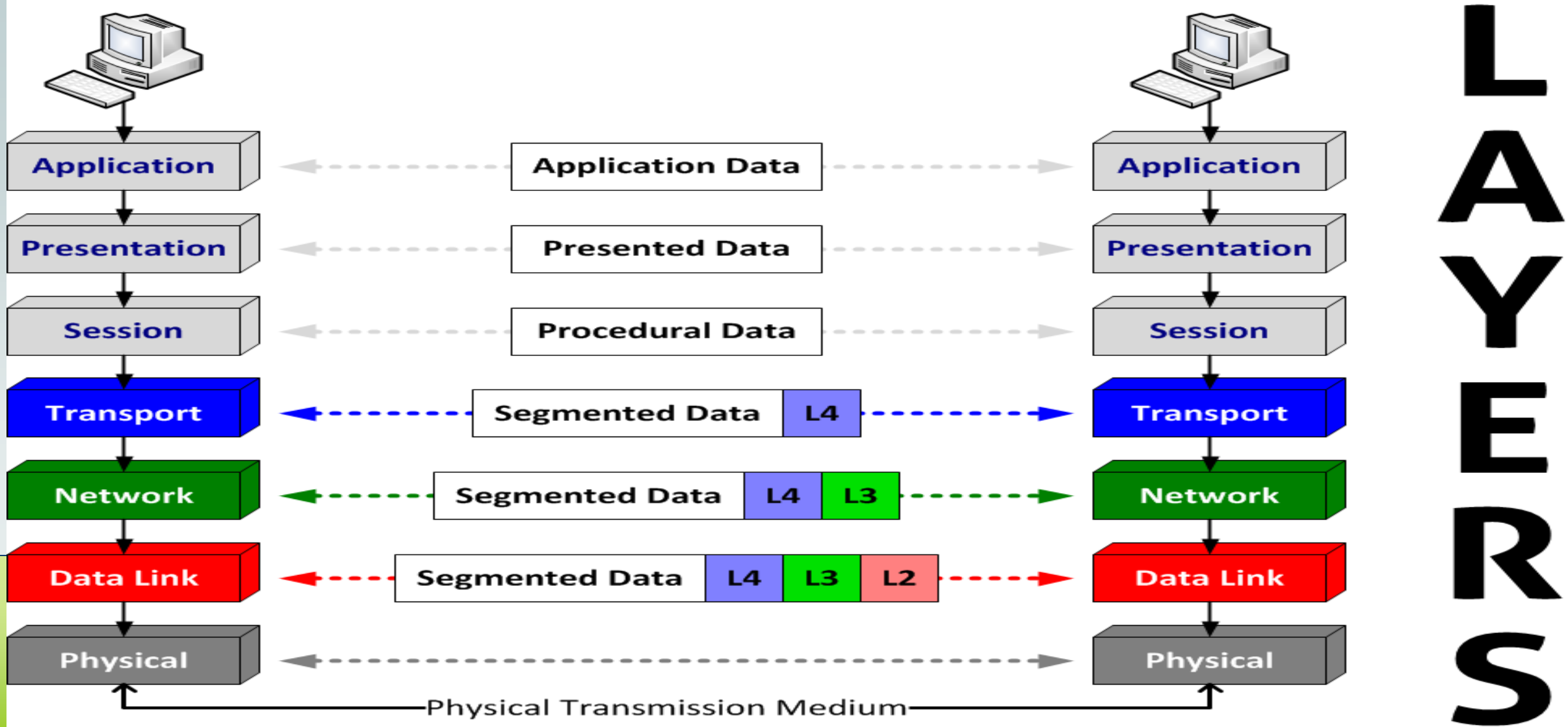
The figure shows the **protocol stack** implemented in the system according to the reference model.



End-systems, such as the PDA and computer in the example, need a full protocol stack comprising the application layer, transport layer, network layer, data link layer, and physical layer.

Applications on the end-systems communicate with each other using the lower layer services. **Intermediate systems**, such as the interworking unit, do not necessarily need all of the layers.

Reference Model & Overview (2)



Reference Model & Overview (3)

Physical layer: This is the lowest layer in a communication system and is responsible for the conversion of a stream of bits into signals that can be transmitted on the sender side. The physical layer of the receiver then transforms the signals back into a bit stream. For wireless communication, the physical layer is responsible for frequency selection, generation of the carrier frequency, signal detection (although heavy interference may disturb the signal), modulation of data onto a carrier frequency and (depending on the transmission scheme) encryption.

Data link layer: The main tasks of this layer include accessing the medium, multiplexing of different data streams, correction of transmission errors, and synchronization (i.e., detection of a data frame). Altogether, the data link layer is responsible for a reliable point-to-point connection between two devices or a point-to-multipoint connection between one sender and several receivers.

Network layer: This third layer is responsible for routing packets through a network or establishing a connection between two entities over many other intermediate systems. Important functions are addressing, routing, device location, and handover between different networks.

Transport layer: This layer is used in the reference model to establish an end-to-end connection.

Application layer: Finally, the applications (complemented by additional layers that can support applications) are situated on top of all transmission oriented layers. Functions are service location, support for multi-media applications, adaptive applications that can handle the large variations in transmission characteristics, and wireless access to the world-wide web using a portable device.

Reference Model & Overview (4)

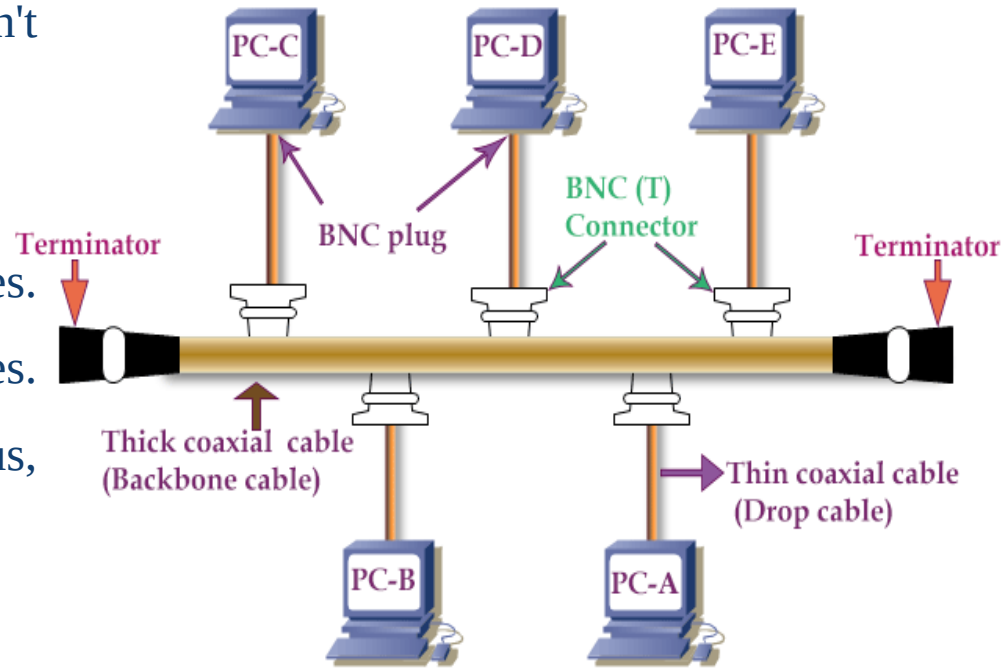
Bus
Ring
Star
Tree
Mesh

Topology in Network Design virtual shape or structure

- **Bus Topology**

A single cable, the backbone functions as a shared communication medium that devices attach or tap into with an interface connector. Ethernet bus topologies are relatively easy to install and don't require much cabling compared to the alternatives.

10Base-2 ("ThinNet") and 10Base-5 ("ThickNet") both were popular Ethernet cabling options many years ago for bus topologies. However, bus networks work best with a limited number of devices. If more than a few dozen computers are added toa network bus, performance problems will likely result



Reference Model & Overview (5)

Topology in Network Design

- **Ring Topology**

In a ring network, every device has exactly two neighbors for communication purposes. All messages travel through a ring in the same direction (either "clockwise" or "counterclockwise"). A failure in any cable or device breaks the loop and can take down the entire network.

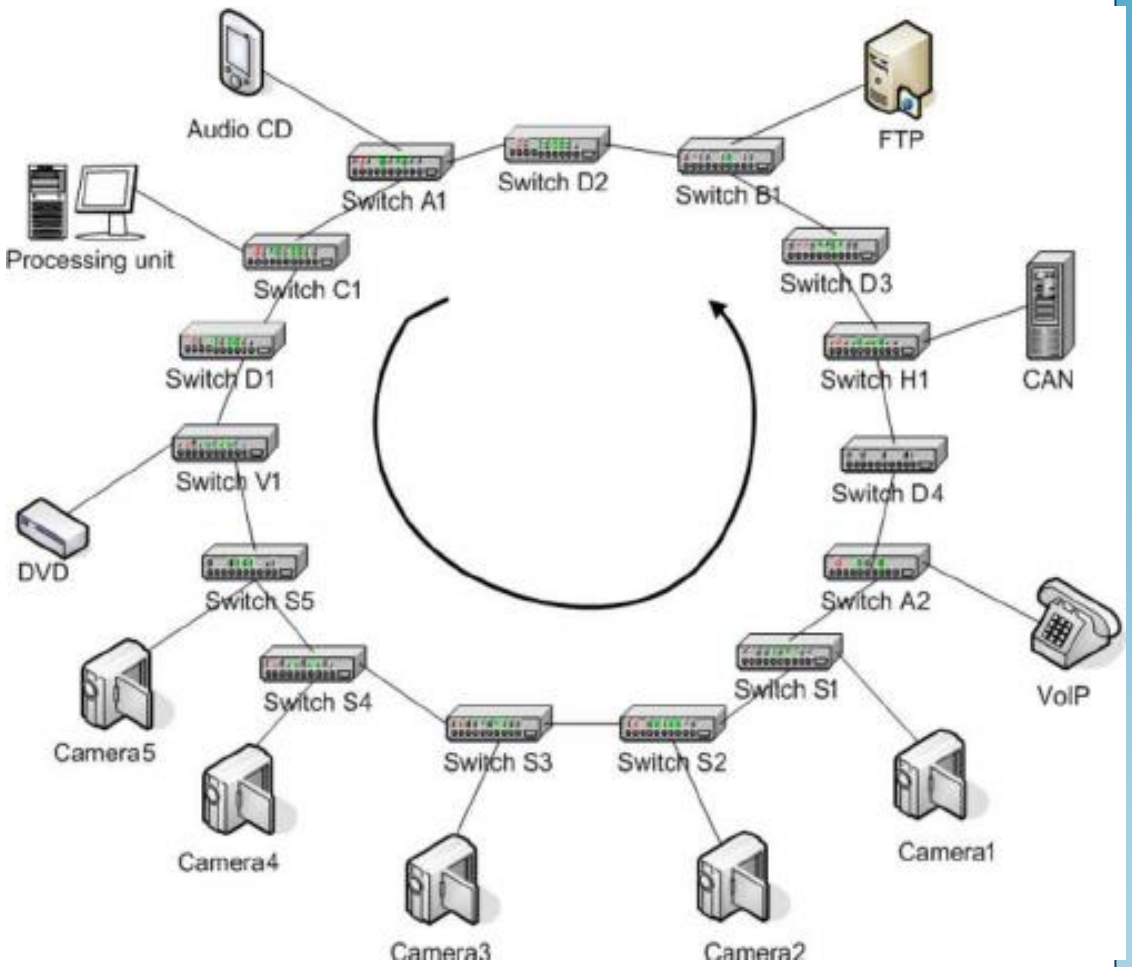
Fiber Distributed Data Interface

To implement a ring network, one typically uses **FDDI**,

Synchronous Optical Network

SONET, or Token Ring technology.

Ring topologies are found in some office buildings or school campuses.



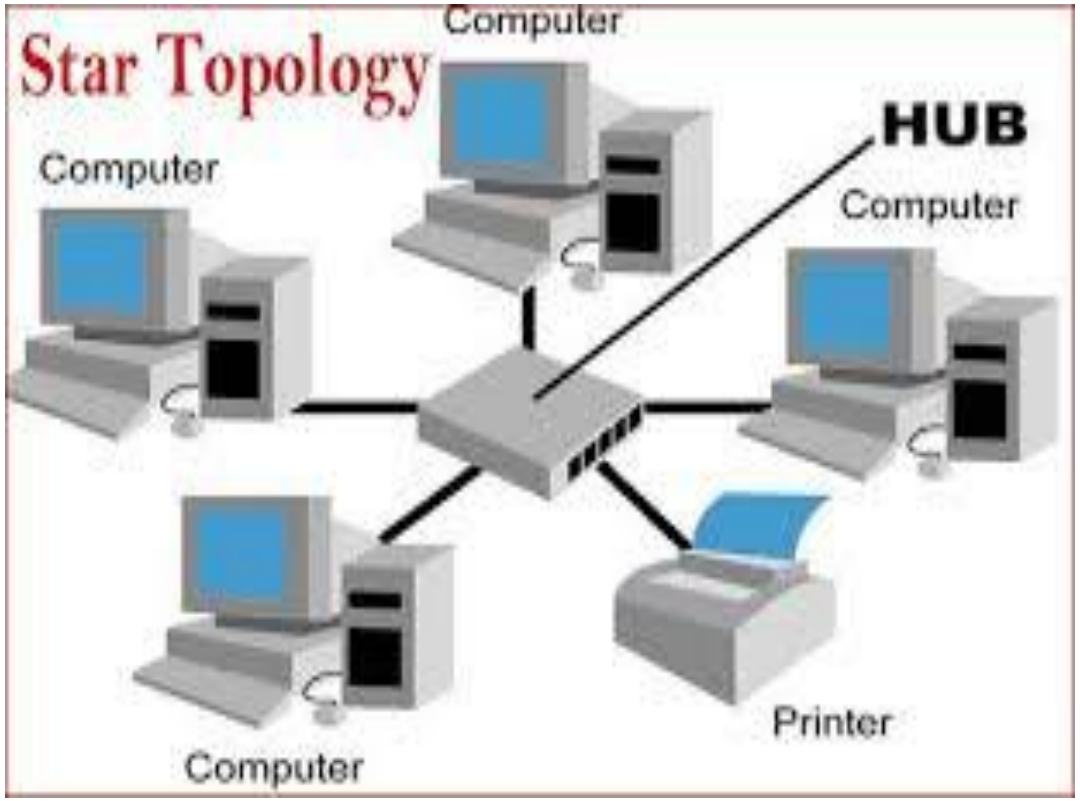
Topology in Network Design

- **Star Topology**

Many home networks use the star topology. A star network features a central connection point called a "hub node" that may be a network hub, switch or router. Devices typically connect to the hub with Unshielded Twisted Pair (UTP) Ethernet.

Compared to the bus topology, a star network generally requires more cable, but a failure in

any star network cable will only take down one computer's network access and not the entire LAN. (If the hub fails, however, the entire network also fails.)

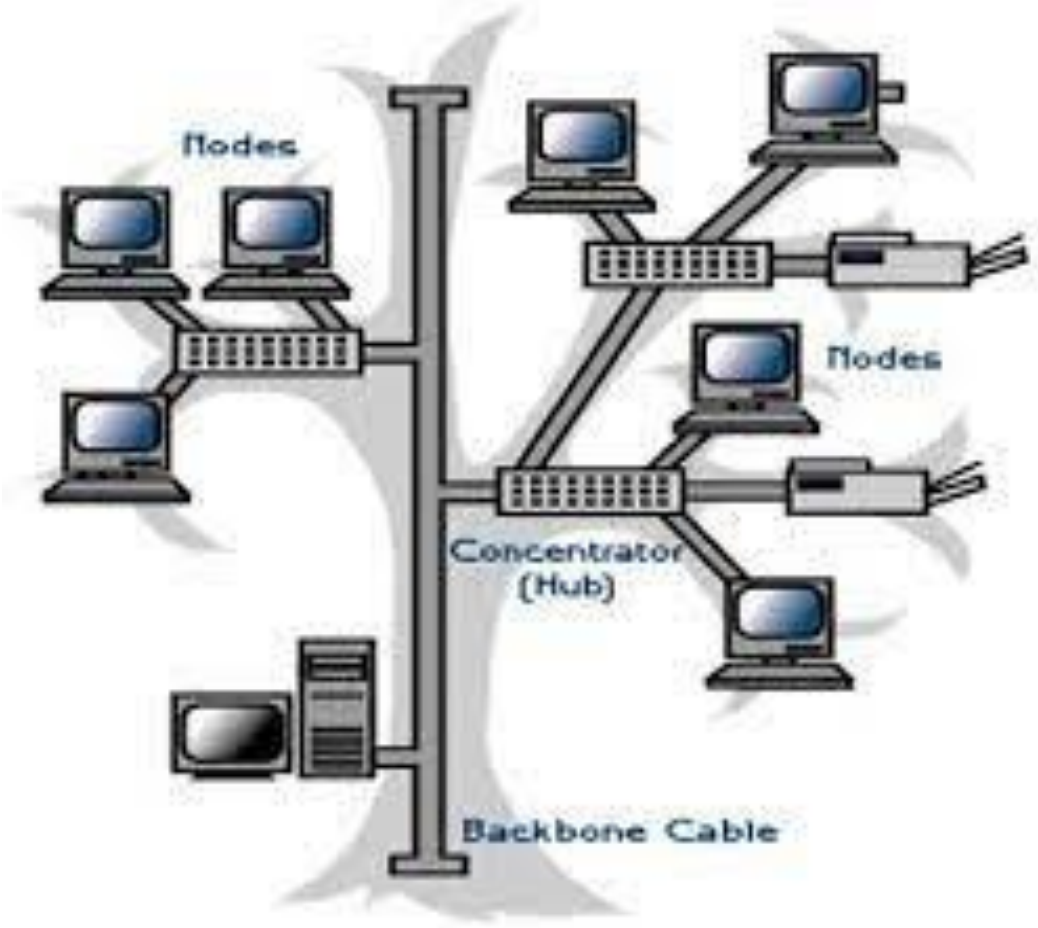


Topology in Network Design

- **Tree Topology**

A tree topology joins multiple star topologies together onto a bus. In its simplest form, only hub devices connect directly to the tree bus, and each hub functions as the root of a tree of devices.

This bus/star hybrid approach supports future expansion of the network much better than a bus (limited in the number of devices due to the broadcast traffic it generates) or a star (limited by the number of hub connection points) alone.



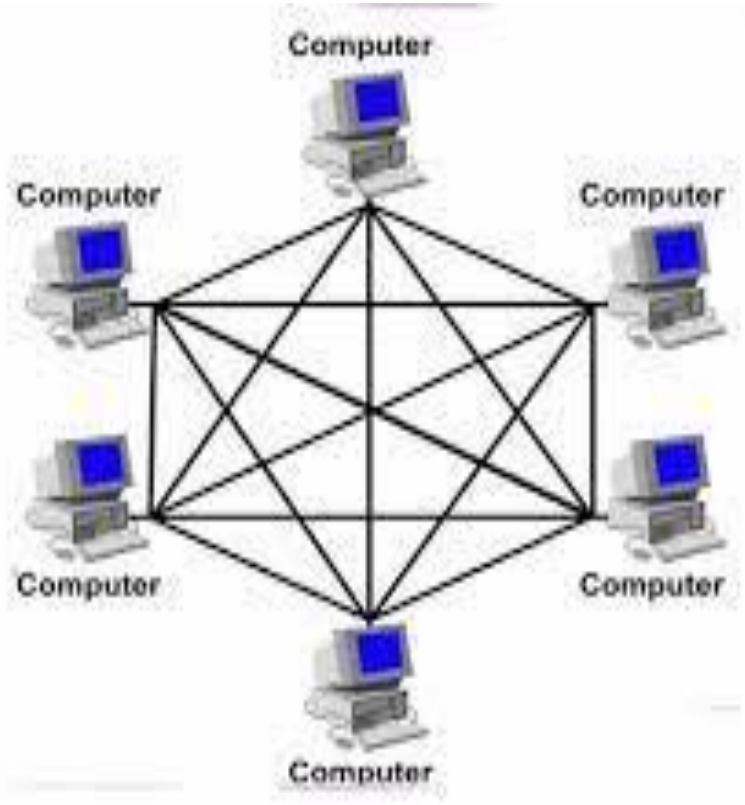
Topology in Network Design

- **Mesh Topology**

Mesh topology introduces the concept of routes. Unlike each of the previous topologies, messages sent on a mesh network can take any of several possible paths from source to destination. (Recall that even in a ring, although two cable paths exist, messages can only travel in one direction.)

Some WANs, most notably the Internet, employ mesh routing.

A mesh network in which every device connects to every other is called a full mesh. As shown in the illustration below, partial mesh networks also exist in which some devices connect only indirectly to others.



Wireless Local Loop & Cellular System (1)

Definition

What is WLL?

- **WLL is a system that connects subscribers to the local telephone station wirelessly.**

- Systems WLL is based on:
  - Cellular
  - Satellite (specific and adjunct)
  - Microcellular
- Other names
  - Radio In The Loop (RITL)
  - Fixed-Radio Access (FRA).

Wireless Local Loop & Cellular System (2)

WIRELESS LOCAL LOOP

- In the WLL system there are two concepts namely
- Narrowband WLL – offers a replacement for existing telephony services.
- Broadband WLL – provides high-speed two-way voice and data service.
- Thus, WLL is the best system to handle high data traffic in the local loop system.

TYPES OF WLL

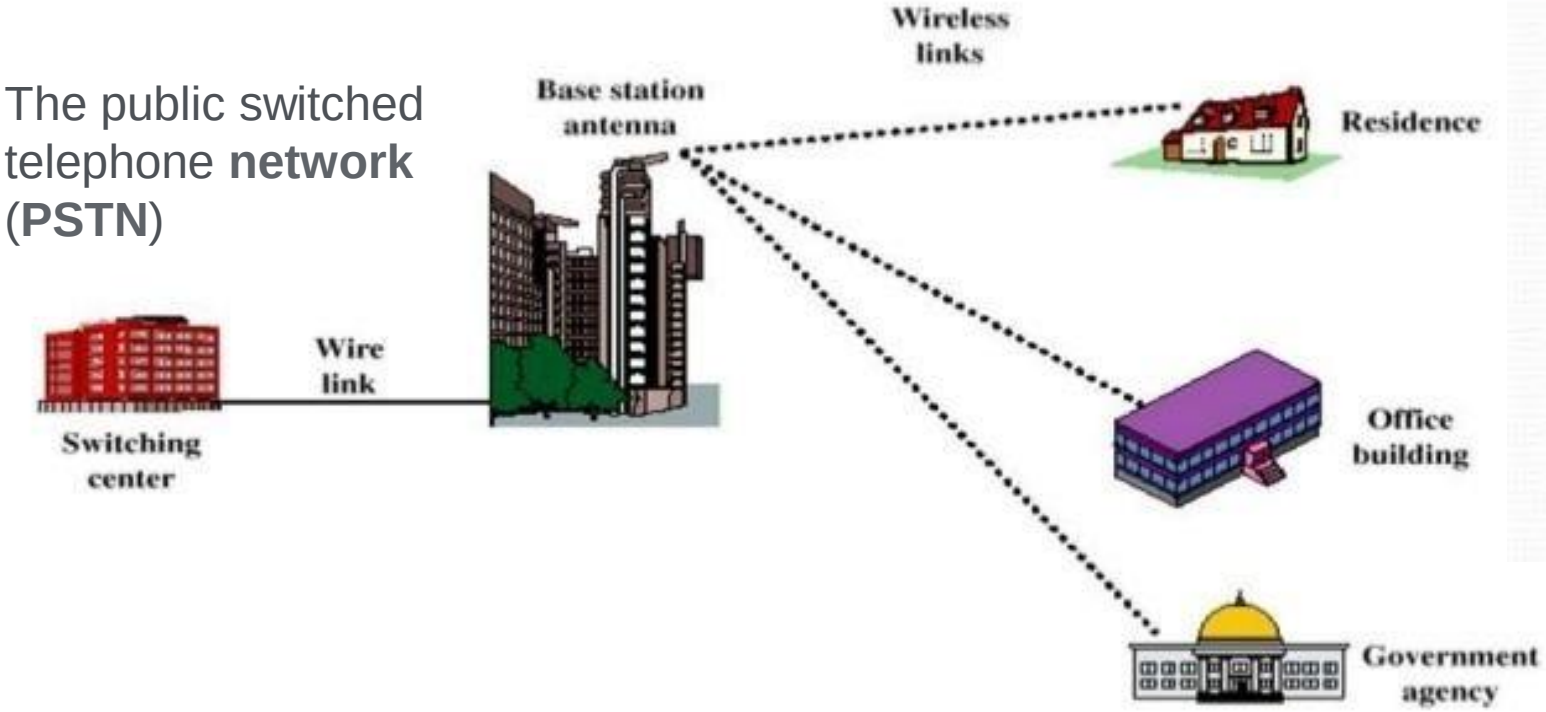
- There are two type of WLL technique available. They are

i. Local Multipoint Distribution Service (LMDS)

ii. Multichannel Multipoint Distribution Service(MMDS)

Configuration of WLL

The public switched telephone **network** (**PSTN**)



WLL Configuration

How its works

- WLL, which stands for Wireless Local Loop that connects subscribers to the PSTN using radio signals as a substitute for copper for all or part of the connection between the subscriber and the switch.
- WLL phones in homes, offices or even boats connect with a wireless system in a manner similar to that of CDMA cell phones.

Wireless Local Loop & Cellular System (4)

Advantages of WLL over Wired Approach

Cost – wireless systems are less expensive due to cost of cable installation that's avoided

- Installation time – WLL systems can be installed in a small fraction of the time required for a new wired system
- Selective installation – radio units installed for subscribers who want service at a given time
  - With a wired system, cable is laid out in anticipation of serving every subscriber in a given area

Disadvantages of wired local loop

- High cost.
- More faults occur.
- Rapid deployment is difficult
- It is expensive.

These disadvantages can be solved by using corDECT wireless local loop.

The Cellular Concept

- To utilize space division multiplexing the area covered by a cellular network is divided into **cells**.
- An idealized model of the cellular radio system consists of an array of hexagonal cells with a **base station** (BS) located at the center of each cell and a number of **mobile terminals** (MTs) communicate with each other through the base station.
  - Uplink channels for MTs to communication with the base station
  - Downlink channels for BS to communicate with MTs.
- The cells are designed for frequency reuse. Same frequency can be reused in non-nearby cells.
- A **cluster** is a group of cells which uses the entire radio spectrum.
  - The cluster size N is the number of cells in each cluster.
  - Each cell within a cluster is allocated a distinct set of frequencies (channels) and cells labeled with a given number – i.e. co-channels reuse the same channel set.
  - As the cell size decreases, traffic carrier capacity increases, and thus cells start big and split as system grows.

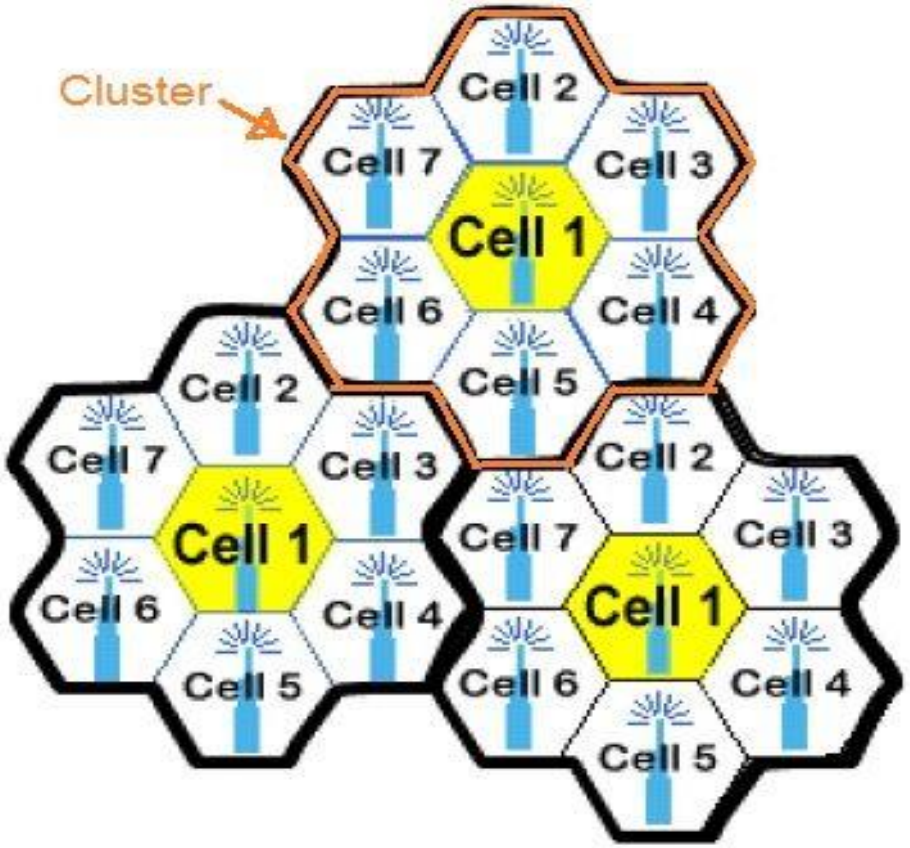
2

Cluster size and Capacity (1)

- Let a cellular system has a total of *S* duplex channels available for use.
- If each cell is allocated a group of *k* channels (*k* < *S*), and
- If the *S* channels are divided among *N* cells into unique and disjoint channel groups which each have the same number of channels,

Total number of available radio channels $S = k N$

[Rappa P-58-60]



Cellular Communication -cell splitting
Frequency reuse concept

THANKS

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