
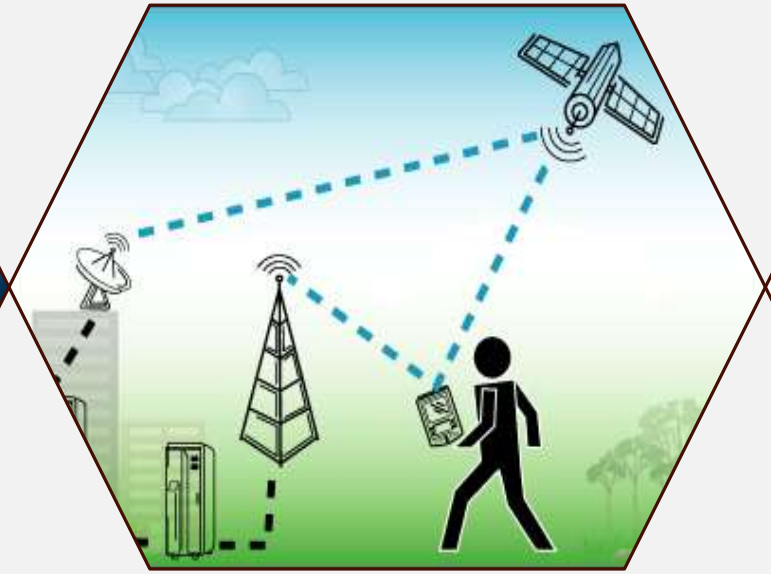


Wireless & Mobile Communication

Prepared by :
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Basic Course Information

Course Title	Wireless & Mobile Communication
Course Code	EEE 425
Credit	03
Marks	150
Semester	8th

SYNOPSIS/RATIONALE

This course is designed to develop the concepts of the Wireless communication process. This course provides a comprehensive overview and advanced knowledge of modern mobile and wireless communication systems. Building on their prior knowledge of digital communications, students develop a further understanding of the challenges and opportunities brought by the wireless medium in designing current and future wireless communication systems and networks.

OBJECTIVE

- Demonstrate basic knowledge of wireless communication.
- Understand significant limitations and conditions of wireless communication.
- Make use of algorithms and protocols for wireless communication

Course Learning Outcome (CLO)

CLO-1

Develop an understanding of the salient properties of wireless channels, channel fading, and how different statistical fading models apply in different contexts, important parameters of interest, including the level crossing rate and the fade duration, for simple statistical fading models.

CLO-2

Explain how a receiver can recover a transmitted message using optimal and suboptimal techniques in nondispersive and dispersive channels.

CLO-3

Enable the students to formulate the system model for dispersive and nondispersive wireless channels and calculate linear equalizers for narrowband and wideband systems.

CLO-4

Enable the students to analyze the concept of diversity and how it can be exploited in practice, be able to calculate the outage probability for basic diversity channels and use this to determine the diversity and coding gains of a system.

CLO-5

Develop an understanding of the main sources of interference in wireless networks and how interference is modeled for system analysis and design, diversity techniques, and design of architectures that would yield a prescribed diversity gain

ASSESSMENT PATTERN

CIE- Continuous Internal Evaluation (90 Marks)

Bloom's Category Marks (out of 90)	**Tests Mid-term (45)**		
Remember	08	**Class Test**	**15**
Understand	08	**Presentation**	**15**
Apply	08	**Attendance**	**15**
Analyze	08		
Evaluate	08		
Create	05		

ASSESSMENT PATTERN

SEE- Semester End Examination (60 Marks)

Bloom's Category	Tests
Remember	**10**
Understand	**10**
Apply	**10**
Analyze	**10**
Evaluate	**10**
Create	**10**

COURSE CONTENT

Sl. No	Course Content
1	Evolution for Mobile Networks, Evolution for Wireless Systems, Age of the Internet, Brief Introduction of 2G, 3G, 4G, and 5G, Flat Fading, Frequency, Selective Fading, Rayleigh Fading, Rician Fading, BER for different fading conditions, Definition and Model of Spread Spectrum Advantages of Spread Spectrum
2	FDMA, TDMA, CDMA, and Random Access Methods: ALOHA and CSMA, Frequency Reuse, Cell Splitting, Handoff and Roaming Procedure, The MSC, HLR and VLR, The Base Station, The Mobile Station
3	Frequency Planning, Offered Traffic, Carried Traffic, Busy Hours, Traffic Intensity, Trunking Efficiency, Number of Subscribers in a cellular system, Cell Hierarchy, Advanced Mobile Phone Service, Difference between 1st (AMPS) and 2nd (TDMA/GSM) Generation System

COURSE CONTENT

Sl. No	Course Content
4	GSM Architecture, Mobile Terminated Call, Types of Handovers, SMS, 2 cases of SMS, SMS protocol layers, Capacity of Single CDMA cells, Definition and Principle of Rake Receiver, Walsh codes for 4*4, 8*8 System, GPRS Reference Architecture, Supporting Nodes
5	Hidden Terminals, Definition and Concept of OFDM, why we use OFDM, Figure of Convolution Encoder, WEP Problems, WLAN Security, MIMO: definition, use, 802.11 a vs b vs g vs n, 802.11 n. Summary, Proposal of 802.11 ac, New Technologies of 802.11 ac
6	Network topology of Bluetooth, BT Secure simple pairing modes, Bluetooth low energy and Basic concepts of Bluetooth 4.0, Handover types in UMTS/GSM, Fast closed loop power control in UMTS, EDGE, HSDPA, HSUPA

Course Schedule

Week	Course Content	Teaching-Learning Strategy	Sources	Assessment Strategy	Aligned CLOs
1	Introduction to wireless communication, characteristics of sinusoidal functions, and basics of wireless networks	Lectures, discussions, visual aids	Slides, textbooks	Quiz, participation, short exercises	CLO1, CLO2
2	Overview of current wireless systems: cellular, WLAN, Bluetooth, and satellite systems	Demonstrations, problem-solving	Slides, practical examples	Hands-on activities, worksheet	CLO1, CLO2
3	Wireless applications in vehicles and emergencies	Case studies, visual aids	Slides, textbooks	Quiz, group discussions	CLO2, CLO3
4	Wireless applications in business, education, and entertainment	Interactive problem-solving	Textbooks, slides	Worksheet, participation	CLO1, CLO3
5	Signal propagation, path loss, and effects of mobility	Problem-solving exercises	Slides, textbooks	Problem-solving exercises	CLO2, CLO4

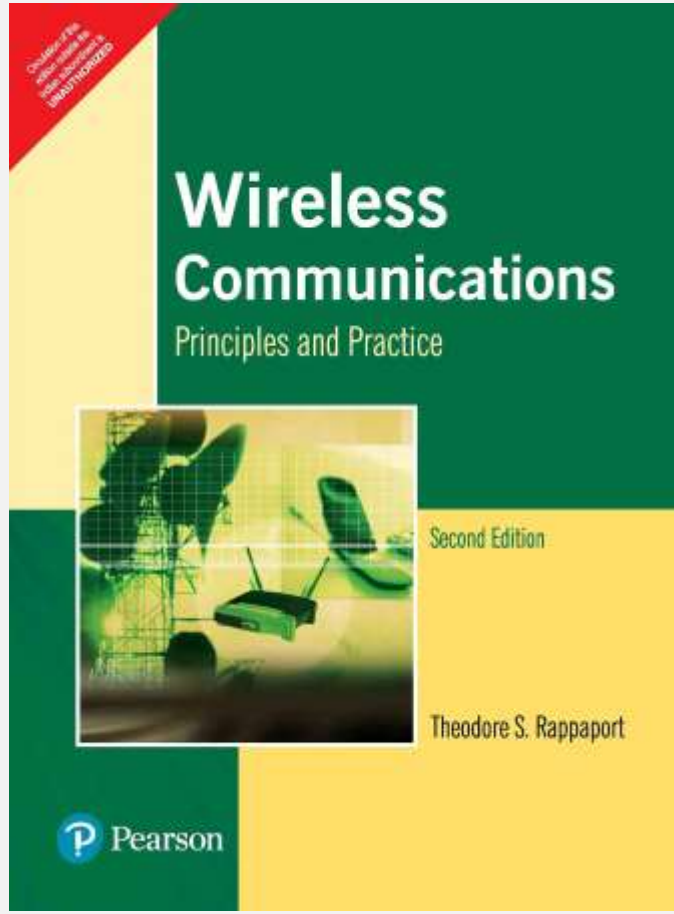
Course Schedule

6	Frequencies and modulation techniques for wireless communication	Lectures, group activities	Textbooks, slides	Quiz, participation	CLO2, CLO3
7	Antennas: isotropic radiators, simple dipoles, and diversity techniques	Experiments, discussions	Reference books, slides	Case study analysis	CLO1, CLO4
8	Medium access control techniques: SDMA, FDMA, TDMA, and CDMA	Interactive discussions, hands-on	Slides, textbooks	Group presentation	CLO2, CLO4
9	Ad-hoc and infrastructure wireless network configurations	Debates, research-based learning	Slides, textbooks	Essay, participation	CLO1, CLO3
10	Wireless LAN standards: IEEE 802.11a/b/g/n, components, and SSID	Lectures, problem-solving exercises	Textbooks, slides	Problem-solving exercises	CLO2, CLO3
11	Roaming in wireless communication and load balancing between access points	Discussions, practical activities	Slides, textbooks	Lab report, short presentation	CLO1, CLO2
12	Cellular networks: components, databases, and call procedures	Case studies, visual aids	Textbooks, slides	Worksheet, participation	CLO1, CLO4

Course Schedule

13	Medium access control: hidden and exposed terminal problems, near-far issues	Lectures, interactive sessions	Slides, textbooks	Participation, problem-solving	CLO2, CLO4
14	Applications of Bluetooth and wireless personal area networks (WPAN)	Interactive problem-solving	Slides, textbooks	Group presentation	CLO1, CLO3
15	Advances in wireless communication technologies and future trends	Summary lectures, brainstorming	Slides, textbooks	Comprehensive test	CLO1, CLO2, CLO3, CLO4
16	Capstone project: design and analysis of a wireless communication system	Capstone project, discussions	All previous materials	Final project evaluation	CLO2, CLO3, CLO4
17	Course review and final assessment	Summary lectures, Q&A	All previous materials	Comprehensive assessment	CLO1, CLO2, CLO3, CLO4

Reference Books




Week-01
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WHAT IS WIRELESS ?

- The word wireless is dictionary defined “having no wires ” .

- In networking terminology , wireless is the term used to describe any computer network where there is no physical wired connection between sender and receiver,
- but rather the network is connected by radio waves and or microwaves to maintain communications.
- Wireless networking utilizes specific equipment such as NICs and Routers in place of wires (copper or optical fiber).

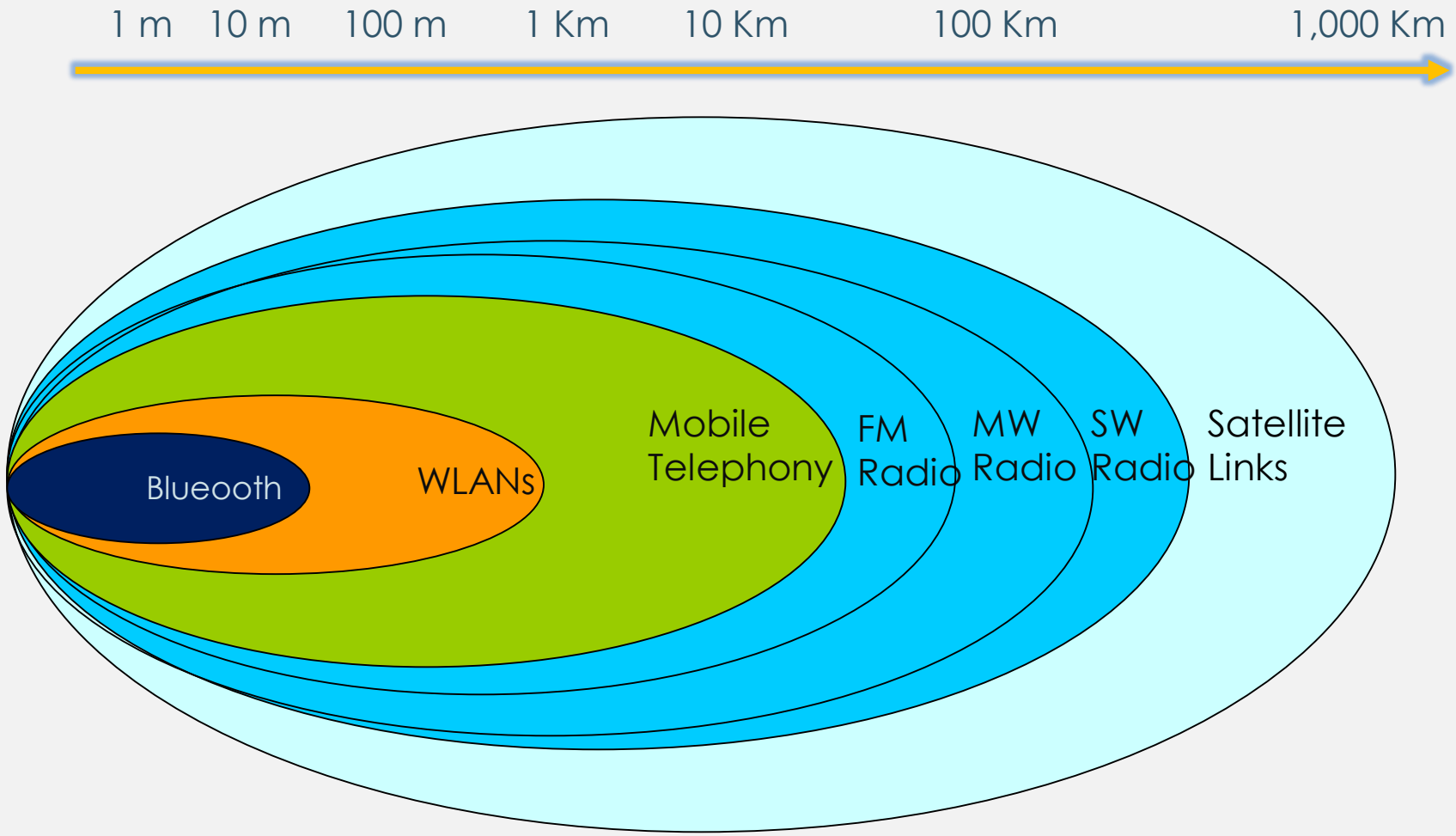
Wireless Communications

- It is a communication while moving with wireless transmission medium.
- It refers to the transfer of info. b/n two or more points that are not physically connected.
  - e.g. Cellular Networks/Mobile networks

Current Wireless Systems

- Cellular systems
- Wireless LANs
- Satellite Systems
- Paging Systems
- Bluetooth
- Ultra wideband Radios
- Zigbee Radios

Wireless Systems: Range Comparison



Computers for the next decades?

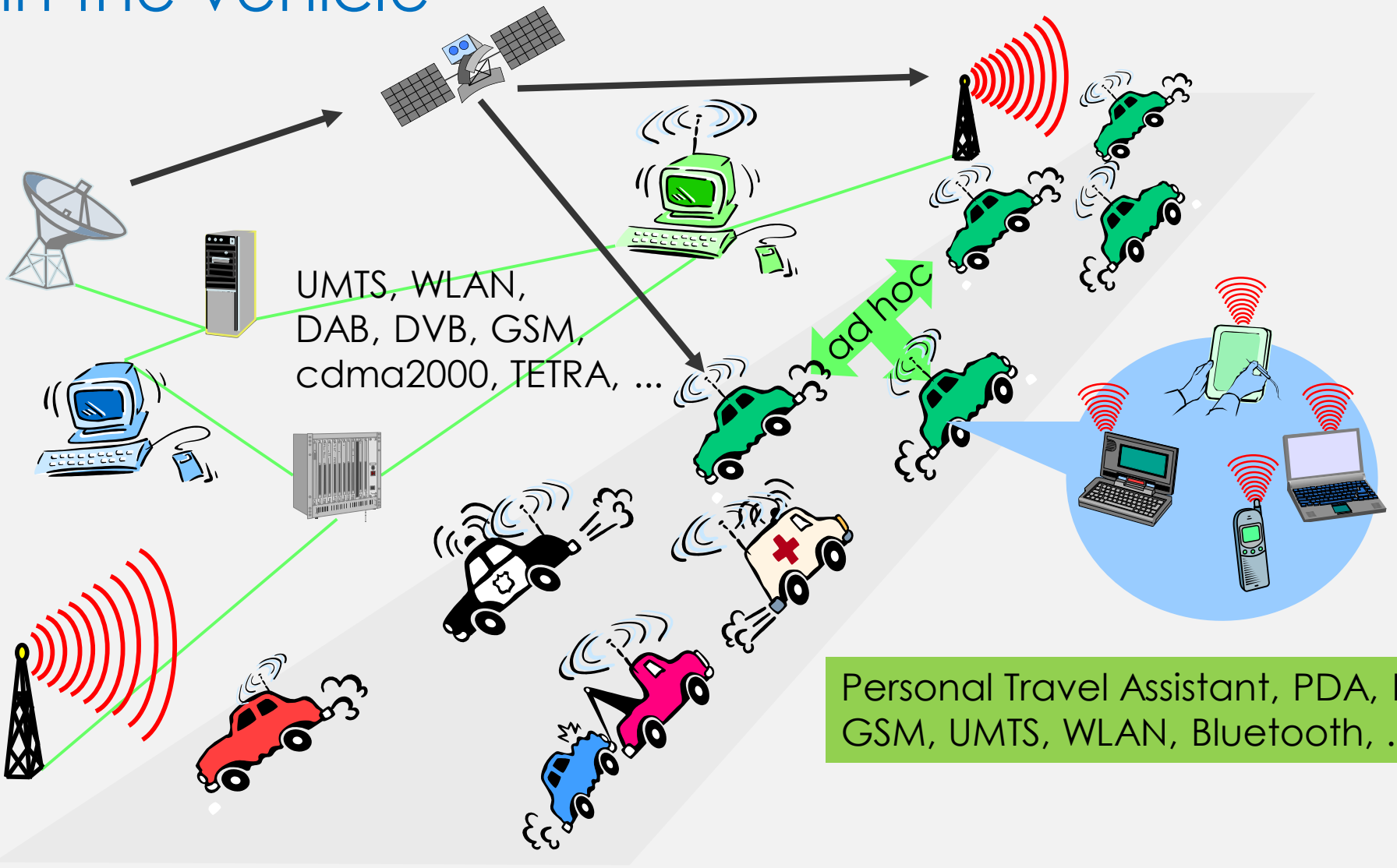
- **Computers are integrated**
  - small, cheap, portable, replaceable - no more separate devices
- **Technology is in the background**
  - computer are aware of their environment and adapt (“location awareness”)
  - computer recognize the location of the user and react appropriately (e.g., call forwarding, fax forwarding, “context awareness”))
- **Advances in technology**
  - more computing power in smaller devices
  - flat, lightweight displays with low power consumption
  - new user interfaces due to small dimensions
  - more bandwidth per cubic meter
  - multiple wireless interfaces: wireless LANs, wireless WANs, regional wireless telecommunication networks etc. („overlay networks“)

Wireless Applications

A. Vehicles

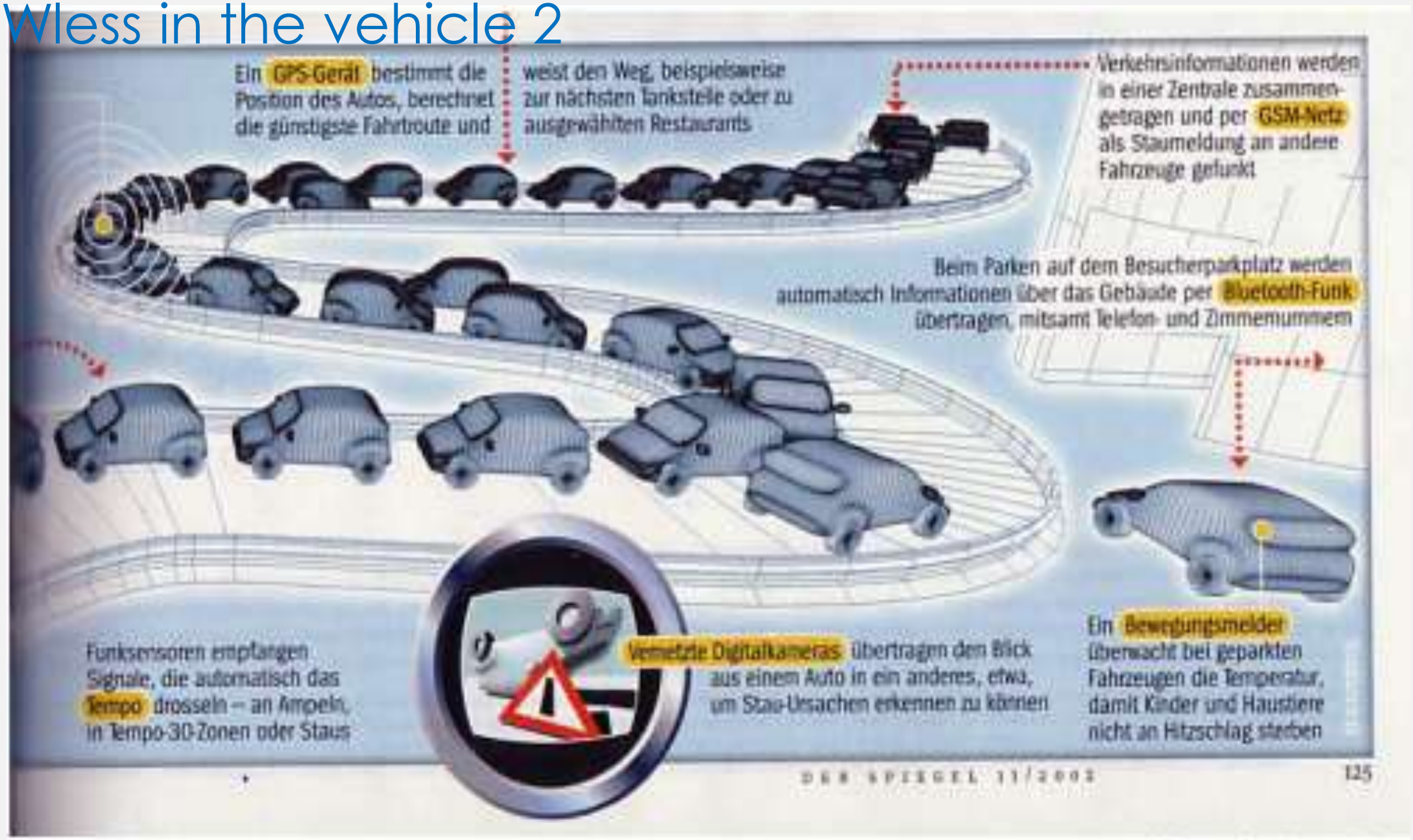
- transmission of news, road condition, weather, music via DAB
- personal communication using GSM
- position via GPS
- local ad-hoc network with vehicles close-by to prevent accidents, guidance system, redundancy
- vehicle data (e.g., from busses, high-speed trains) can be transmitted in advance for maintenance

Wless in the vehicle



Personal Travel Assistant, PDA, Laptop, GSM, UMTS, WLAN, Bluetooth, ...

Wless in the vehicle 2



Wireless Applications

B. Emergencies

- Just imagine the possibilities of an ambulance with a high-quality wireless connection to a hospital.
- Vital information about injured persons can be sent to the hospital from the scene of the accident.
  - early transmission of patient data to the hospital, current status, first diagnosis
- All the necessary steps for this particular type of accident can be prepared and specialists can be consulted for an early diagnosis.
- Wireless networks are the only means of communication in the case of natural and unnatural disasters such as hurricanes or earthquakes.
  - replacement of a fixed infrastructure in case of earthquakes, hurricanes, fire etc.
  - crisis, war, ...
- In the worst cases, only decentralized, wireless ad-hoc networks survive.
- The breakdown of all cabling not only implies the failure of the standard wired telephone system, but also the crash of all mobile phone systems requiring base stations!

Wireless Applications

C. Business

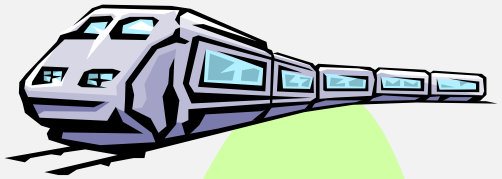
- Travelling salesmen
  - direct access to customer files stored in a central location/company's database:
    - to ensure that files on his or her laptop reflect the current situation,
    - to enable the company to keep track of all activities of their travelling employees,
    - to keep databases consistent etc.
- consistent databases for all agents
- mobile office
  - With wireless access, the laptop can be turned into a true mobile office, but efficient and powerful synchronization mechanisms are needed to ensure data consistency

Wless in the Business

DSL/ WLAN
3 Mbit/s

GSM/GPRS 53 kbit/s
Bluetooth 500 kbit/s

UMTS, GSM
115 kbit/s

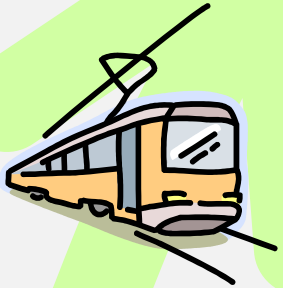


LAN
100 Mbit/s,
WLAN
54 Mbit/s

GSM/EDGE 384 kbit/s,
DSL/WLAN 3 Mbit/s

GSM 115 kbit/s,
WLAN 11 Mbit/s

UMTS, GSM
384 kbit/s



UMTS
2 Mbit/s

Wireless Applications

D. Replacement of wired networks

- Replacement of fixed networks
  - remote sensors, e.g., weather, earth activities(earthquake detection, or to provide environmental information.)
  - flexibility for trade shows
  - LANs in historic buildings

E. Education, ...

- outdoor Internet access(E-Learning)
- intelligent travel guide with up-to-date location dependent information
- ad-hoc networks for multi user games(Hallo)

Wireless Applications

F. Entertainment and more

- Internet everywhere? Not without wireless networks!
- Imagine a travel guide for a city.
- Static information might be loaded via CD-ROM, DVD, or even at home via the Internet.
- But wireless networks can provide up-to-date information at any appropriate location.
- The travel guide might tell you something about the history of a building (knowing via GPS, contact to a local base station, or triangulation where you are) downloading information about a concert in the building at the same evening via a local wireless network.
- You may choose a seat, pay via electronic cash, and send this information to a service provider (Cheverst, 2000).
- Another growing field of wireless network applications lies in entertainment and games to enable, e.g., ad-hoc gaming networks as soon as people meet to play together.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Location independent Wless services

- **Location aware services**
  - what services, e.g., printer, fax, phone, server etc. exist in the local environment
- **Follow-on services**
  - automatic call-forwarding(If someone wanted to reach you using a multimedia conferencing system, this call would be forwarded to your current location.), transmission of the actual workspace to the current location
- **Information services**
  - „push“: e.g., current special offers in the supermarket, Ethio Gebeta
  - „pull“: e.g., where is the Langano entertainment, Ednamol?
- **Support services**
  - caches, intermediate results, state information etc. „follow“ the mobile device through the fixed network
- **Privacy**
  - who should gain knowledge about the location

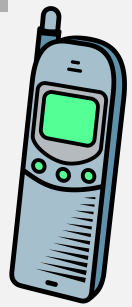
Mobile/Wireless devices

Pager
- receive only
- tiny displays
- simple text messages

PDA
- graphical displays
- character recognition
- simplified WWW

Laptop/Notebook
- fully functional
- standard applications

Sensors, embedded controllers



Mobile phones
- voice, data
- simple graphical displays

Palmtop
- tiny keyboard
- simple versions of standard applications

Effects of device portability on wless communication

- **Power consumption**
  - limited computing power, low quality displays, small disks due to limited battery capacity
  - **CPU: power consumption ~ CV2f**
    - C: internal capacity, reduced by integration
    - V: supply voltage, can be reduced to a certain limit
    - f: clock frequency, can be reduced temporally
- **Loss of data**
  - higher probability, has to be included in advance into the design (e.g., defects, theft)
- **Limited user interfaces**
  - compromise between size of fingers and portability
  - integration of character/voice recognition, abstract symbols
- **Limited memory**
  - limited value of mass memories with moving parts
  - flash-memory or ? as alternative

Wless nets in comparison to fixed nets

- **Higher loss-rates due to interference**
  - emissions of, e.g., engines, lightning
- **Restrictive regulations of frequencies**
  - frequencies have to be coordinated, useful frequencies are almost all occupied
- **Low transmission rates**
  - local some Mbit/s, regional currently, e.g., 53kbit/s with GSM/GPRS
- **Higher delays, higher jitter**
  - connection setup time with GSM in the second range, several hundred milliseconds for other wireless systems
- **Lower security, simpler active attacking**
  - radio interface accessible for everyone, base station can be simulated, thus attracting calls from mobile phones
- **Always shared medium**
  - secure access mechanisms important

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
  - ...

- **Reading assignment** on History of Wireless Communication
- Next session Wireless Transmission

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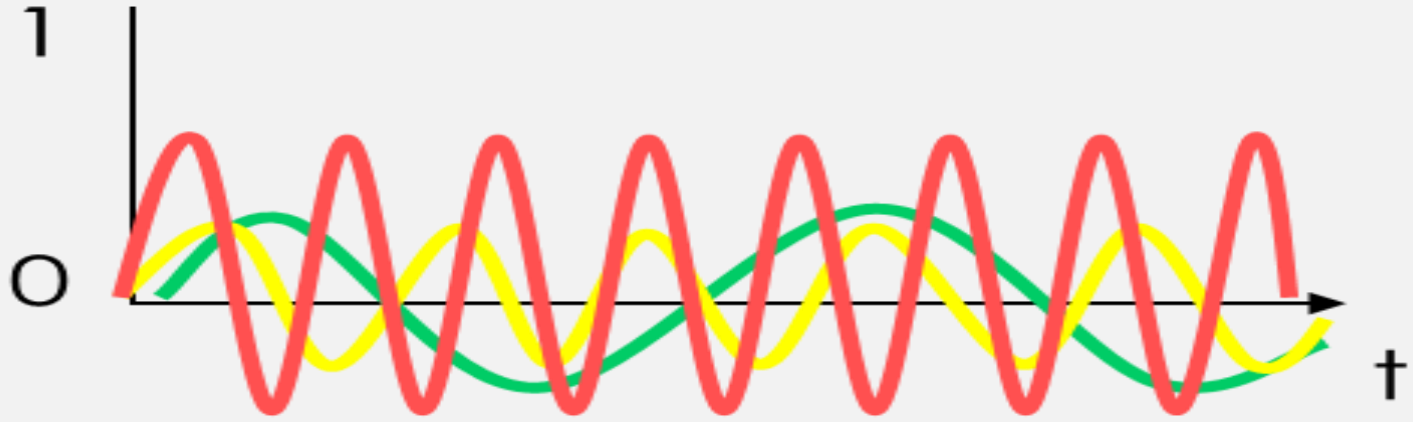
Wireless transmission/Wireless radio



objectives

- **At the end of this session students should be able to:-**
  - Explain transmission medium
  - Explain and categorize frequencies for wireless communication
  - Define signal and wireless radio
  - Discuss media accessing techniques(multiplexing)
  - Present spread spectrum and modulations

Wireless radio

- Radio is the radiation (wireless transmission) of electromagnetic signals through the atmosphere or free space.
- Information, such as sound, is carried by systematically changing (modulating) some property of the radiated waves, such as their amplitude, frequency, phase, or pulse width.
- When radio waves strike an electrical conductor, the oscillating fields induce an alternating current in the conductor.
- The information in the waves can be extracted and transformed back into its original form.
- Radio systems need a transmitter to modulate (change) some property of the energy produced to impress a signal on it.

Wireless radio…2

- Some types of modulation include amplitude modulation and frequency modulation.
- Radio systems also need an antenna to convert electric currents into radio waves, and vice versa.
- An antenna can be used for both transmitting and receiving. The electrical resonances of tuned/regulated circuits in radios allow individual stations to be selected.
- A radio receiver receives its input from an antenna and converts it into a form usable for the consumer,
  - such as sound, pictures, digital data, measurement values, navigational positions, etc.
- A radio communication system sends signals by radio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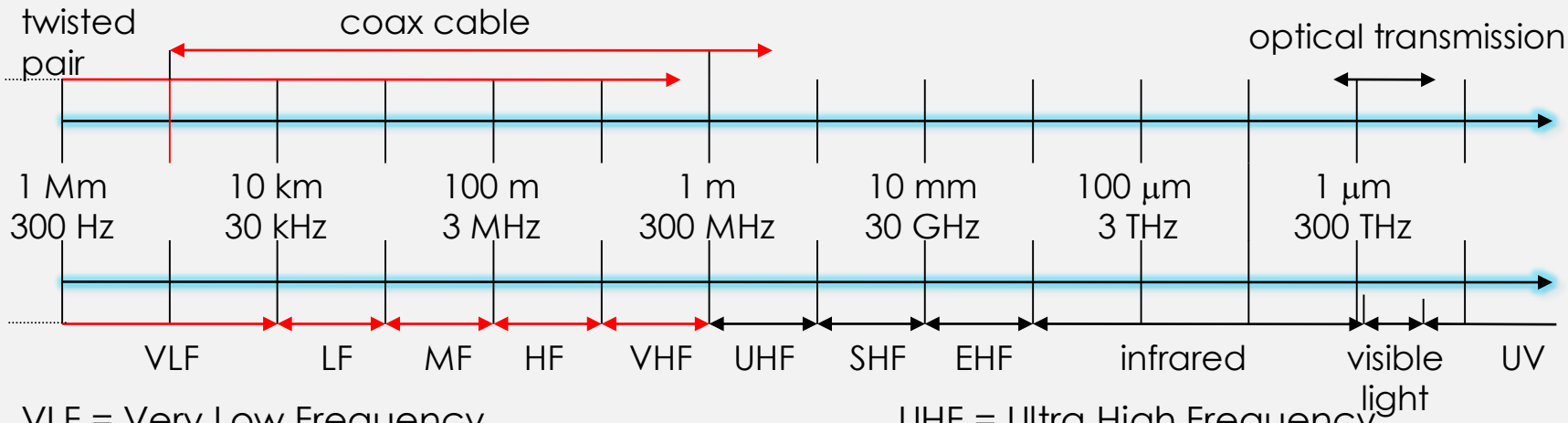
Frequencies for communication



VLF = Very Low Frequency
LF = Low Frequency
MF = Medium Frequency
HF = High Frequency
VHF = Very High Frequency

UHF = Ultra High Frequency
SHF = Super High Frequency
EHF = Extra High Frequency
UV = Ultraviolet Light

Frequency and wave length:

$$\lambda = c/f$$

wave length λ, speed of light c $\cong 3 \times 10^8$ m/s, frequency f

Frequencies for mobile communication

- **VHF-/UHF-ranges for mobile radio**
  - simple, small antenna for cars
  - deterministic propagation characteristics, reliable connections
- **SHF and higher for directed radio links, satellite communication**
  - small antenna, beam forming
  - large bandwidth available
- **UHF - SHF range for Wireless LANs use frequencies**
  - some systems planned up to EHF
  - limitations due to absorption by water and oxygen molecules (resonance frequencies)
    - weather dependent fading, signal loss caused by heavy rainfall etc.

Frequencies and regulations

- ITU-R holds auctions for new frequencies, manages frequency bands worldwide (WRC, World Radio Conferences)

	Europe	USA	Japan
Cellular Phones	**GSM** 450-457, 479-486/460-467,489-496, 890-915/935-960, 1710-1785/1805-1880 **UMTS** (FDD) 1920-1980, 2110-2190 **UMTS** (TDD) 1900-1920, 2020-2025	**AMPS**, **TDMA**, **CDMA** 824-849, 869-894 **TDMA**, **CDMA**, **GSM** 1850-1910, 1930-1990	**PDC** 810-826, 940-956, 1429-1465, 1477-1513
Cordless Phones	**CT1+** 885-887, 930-932 **CT2** 864-868 **DECT** 1880-1900	**PACS** 1850-1910, 1930-1990 **PACS-UB** 1910-1930	**PHS** 1895-1918 **JCT** 254-380
Wireless LANs	**IEEE 802.11** 2400-2483 **HIPERLAN 2** 5150-5350, 5470-5725	902-928 **IEEE 802.11** 2400-2483 5150-5350, 5725-5825	**IEEE 802.11** 2471-2497 5150-5250
Others	**RF-Control** 27, 128, 418, 433, 868	**RF-Control** 315, 915	**RF-Control** 426, 868

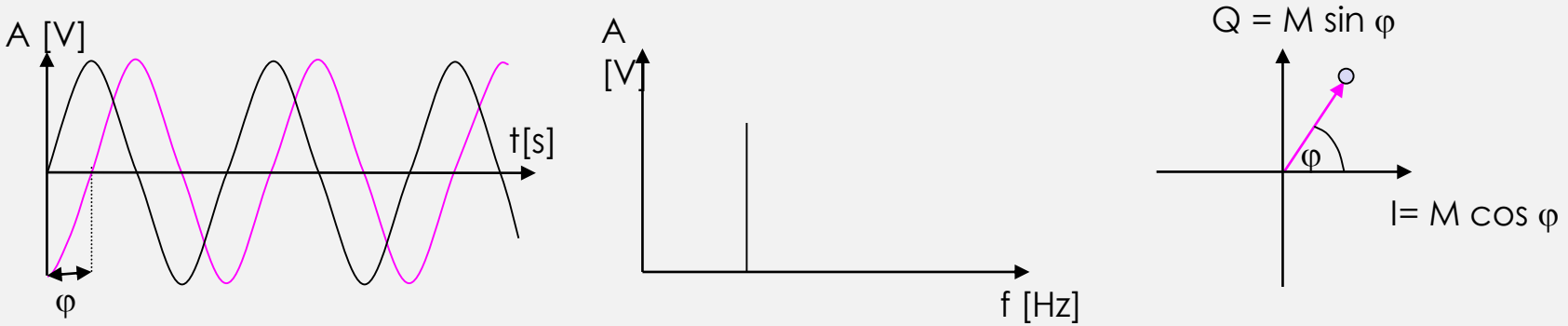
Signals

- physical representation of data
- function of time and location
- signal parameters: parameters representing the value of data
- classification
  - continuous time/discrete time
  - continuous values/discrete values
  - analog signal = continuous time and continuous values
  - digital signal = discrete time and discrete values
- signal parameters of periodic signals:
  period T, frequency f=1/T, amplitude A, phase shift φ
  - sine wave as special periodic signal for a carrier:

$$s(t) = A_t \sin(2 \pi f_t t + \varphi_t), \varphi=2\pi ft$$

Signals

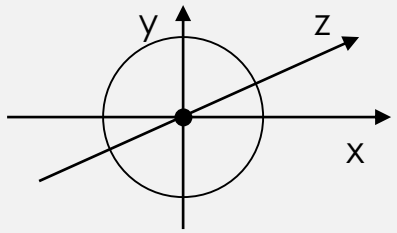
- Different representations of signals
  - amplitude (amplitude domain)
  - frequency spectrum (frequency domain)
  - phase state diagram (amplitude M and phase □ in polar coordinates)

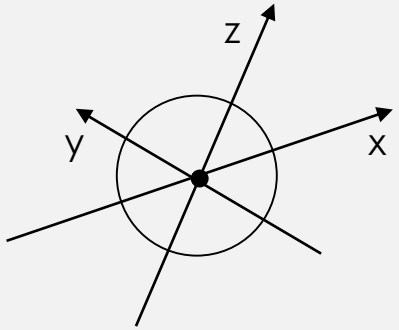


- Composed signals transferred into frequency domain using Fourier transformation
- Digital signals need
  - infinite frequencies for perfect transmission
  - modulation with a carrier frequency for transmission (analog signal!)

Antennas: isotropic radiator

- Antennas couple electromagnetic energy to and from space to and from a wire or coaxial cable (or any other appropriate conductor)
- Radiation and reception of electromagnetic waves, coupling of wires to space for radio transmission
- Isotropic radiator: equal radiation in all directions (three dimensional) - only a theoretical reference antenna
- Real antennas always have directive effects (vertically and/or horizontally)
- Radiation pattern: measurement of radiation around an antenna and is symmetric in all directions

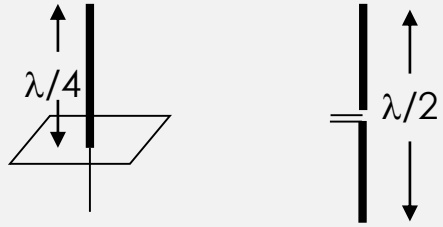




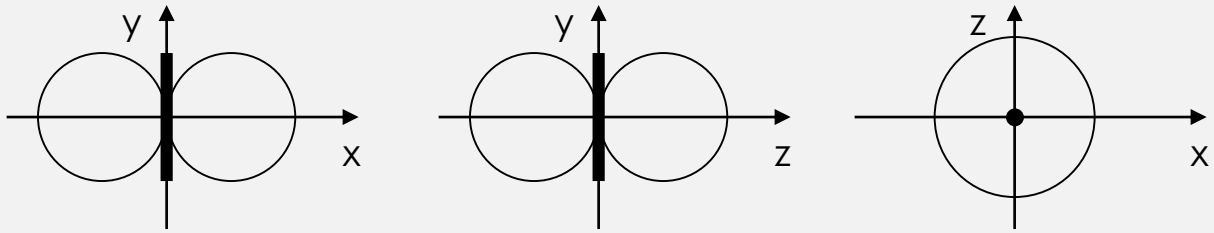
Ideal isotropic radiator

Antennas: simple dipoles

- Real antennas are not isotropic radiators but, e.g., dipoles with lengths λ/4 on car roofs or λ/as Hertzian dipole
  - shape of antenna proportional to wavelength



- Example: Radiation pattern of a simple Hertzian dipole



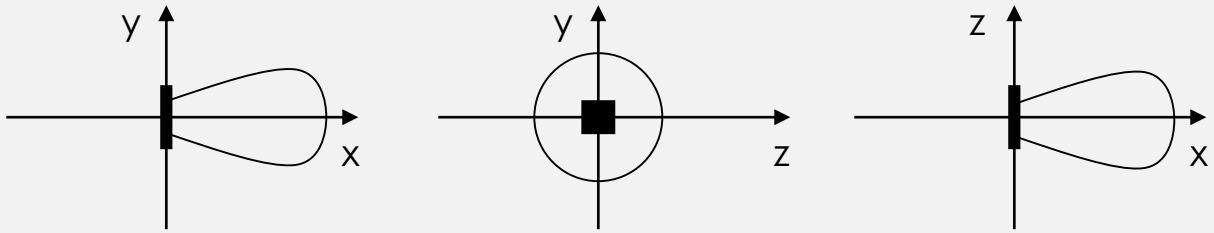
side view (xy-plane) side view (yz-plane) top view (xz-plane)

Simple dipole

- Gain: maximum power in the direction of the main lobe/section compared to the power of an isotropic radiator (with the same average power)

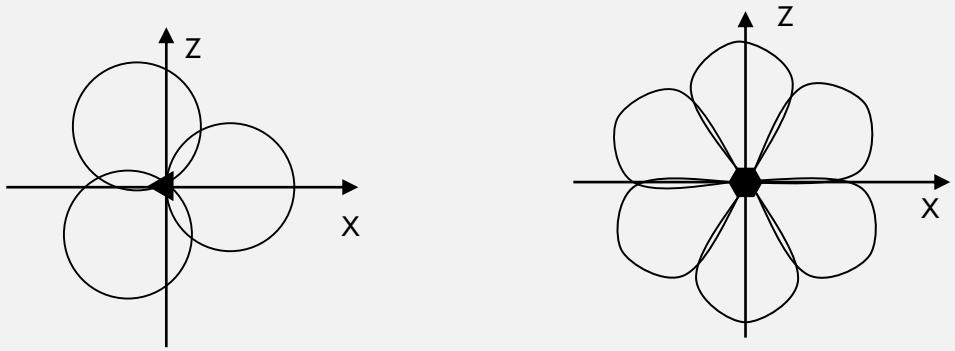
Antennas: directed and sectored

- Often used for microwave connections or base stations for mobile phones (e.g., radio coverage of a valley)



side view (xy-plane) side view (yz-plane) top view (xz-plane)

Directed antenna

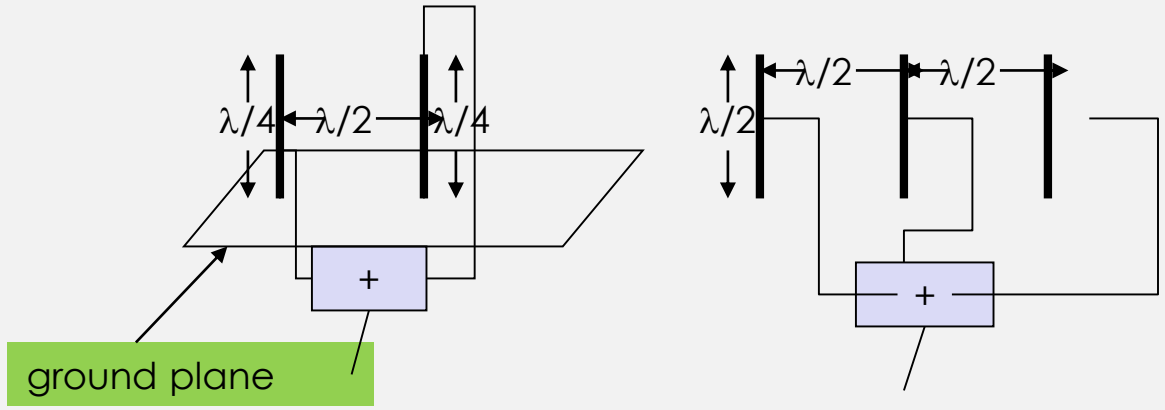


top view, 3 sector top view, 6 sector

Sectored antenna

Antennas: diversity

- Grouping of 2 or more antennas
  - multi-element antenna arrays
- Antenna diversity
  - switched diversity, selection diversity
    - receiver chooses antenna with largest output
  - diversity combining
    - combine output power to produce gain
    - The phase is first corrected/cophasing needed to avoid cancellation




Week-04
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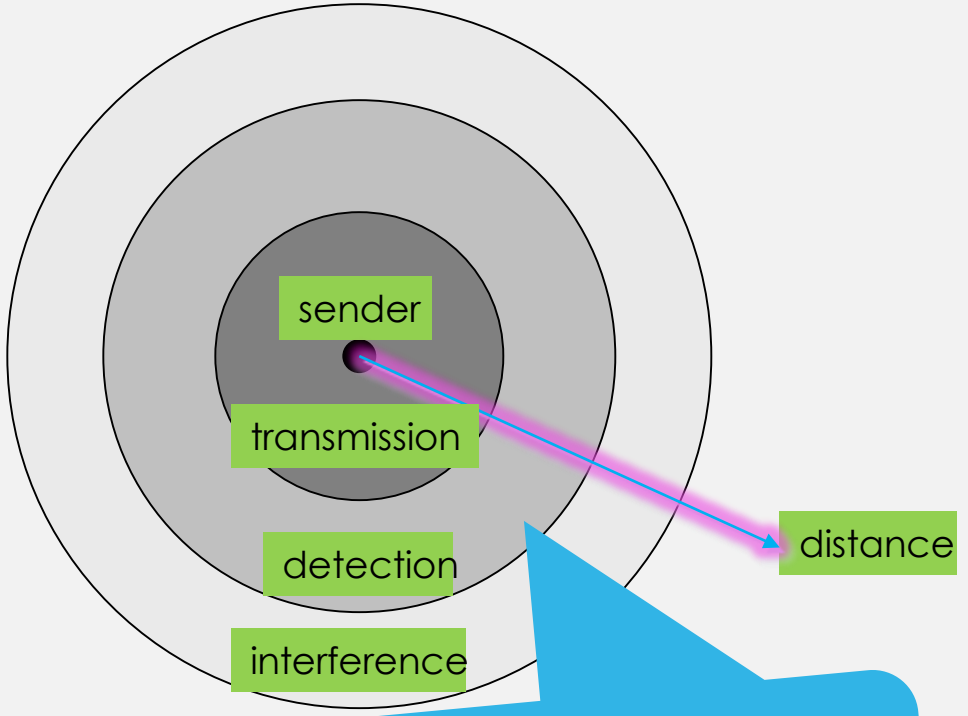
Signal propagation(ranges)

- Transmission range a receiver receives the signals with an error rate low enough to be able to communicate and can also act as sender.
  - communication possible
  - low error rate
- Detection range
  - detection of the signal is possible
  - no communication possible
- Interference range
  - signal may not be detected
  - signal adds to the background noise
  - the signals may disturb other signals.



Path loss of radio signals

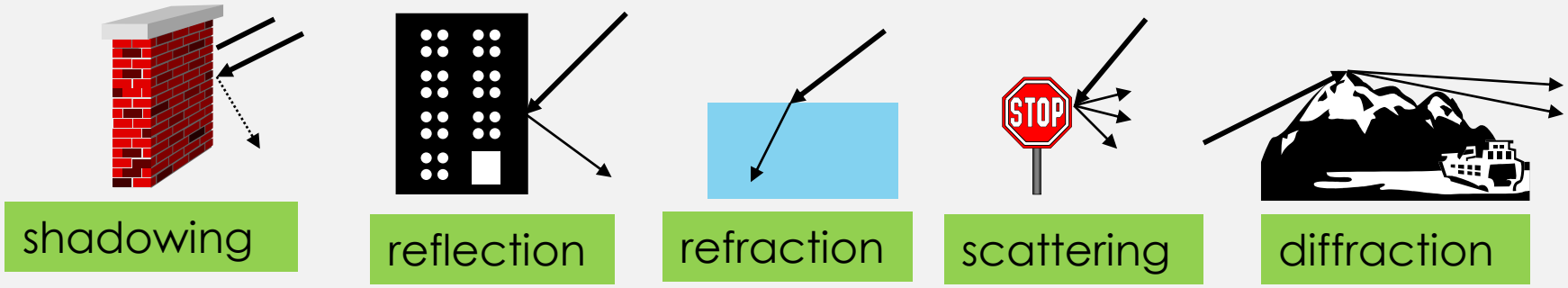
- If such a straight line exists between a sender and a receiver it is called line-of-sight(LOS).
- Even if no matter exists between the sender and the receiver (i.e., if there is a vacuum), the signal still experiences the free space loss.
- The received power also depends on the wavelength and the gain of receiver and transmitter antennas
- Most radio transmission takes place through the atmosphere – signals travel through air, rain, snow, fog, dust particles, smog etc.
- While the path loss or attenuation does not cause too much trouble for short distances.

Path loss of radio signals

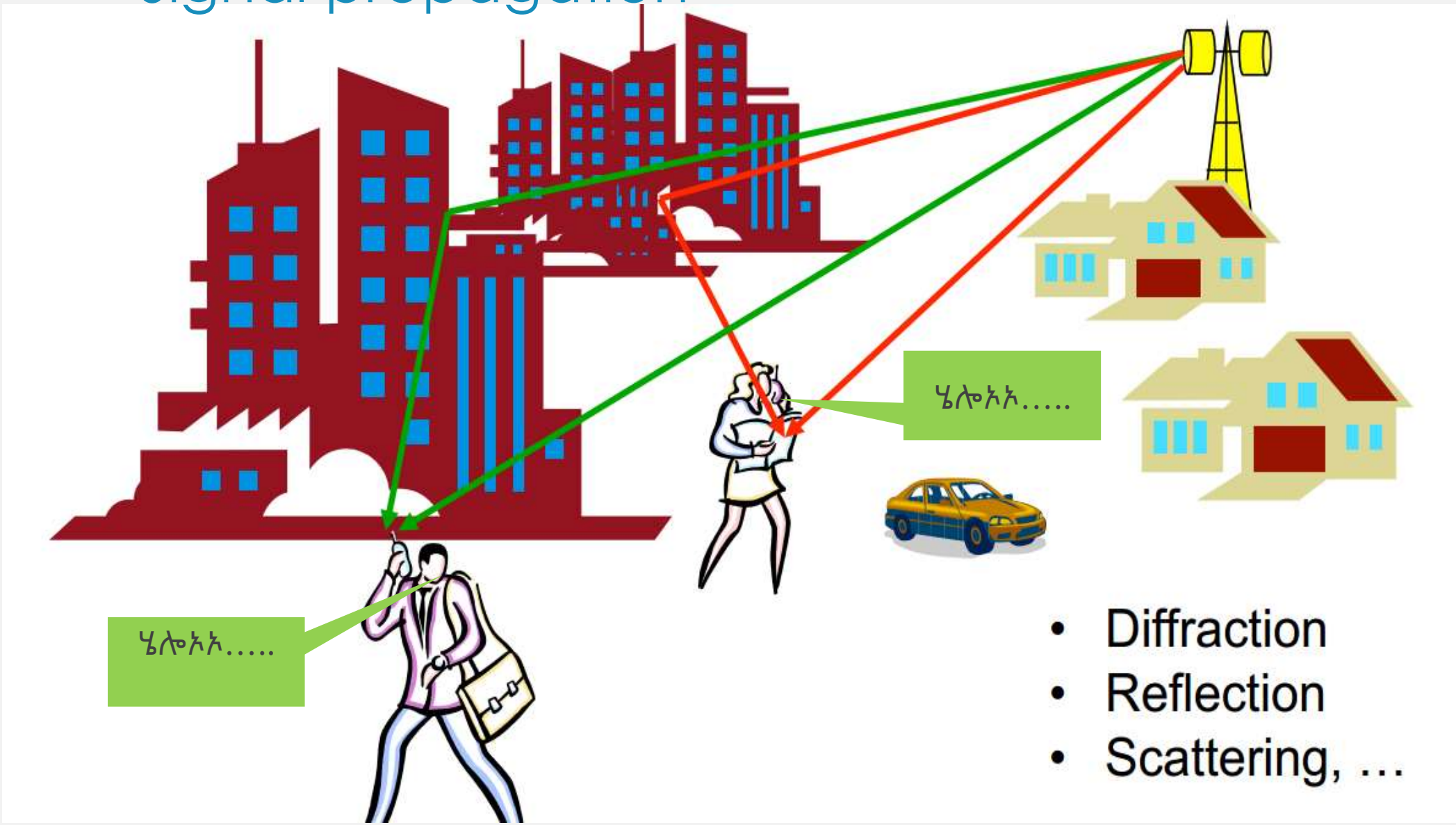
- Radio waves can exhibit three fundamental propagation behaviors depending on their frequency:
  - **Ground wave** (<2 MHz): Waves with low frequencies follow the earth's surface and can propagate long distances. These waves are used for, e.g., submarine communication or AM radio.
  - **Sky wave (2–30 MHz):** Many international broadcasts and amateur radio use these short waves that are reflected at the ionosphere. This way the waves can bounce back and forth between the ionosphere and the earth's surface, travelling around the world.
  - **Line-of-sight (>30 MHz**): Mobile phone systems, satellite systems, cordless telephones etc. use even higher frequencies. The emitted waves follow a (more or less) straight line of sight.
    - This enables direct communication with satellites (no reflection at the ionosphere) or microwave links on the ground.
    - However, an additional consideration for ground-based communication is that the waves are bent by the atmosphere due to refraction

Signal propagation

- Propagation in free space always like light (straight line)
  - Receiving power proportional to $1/d^2$ in vacuum – much more in real environments (d = distance between sender and receiver)
  - Receiving power additionally influenced by
    1. fading (frequency dependent)
    2. shadowing
    3. reflection at large obstacles
    4. refraction depending on the density of a medium
    5. scattering at small obstacles
    6. diffraction at edges

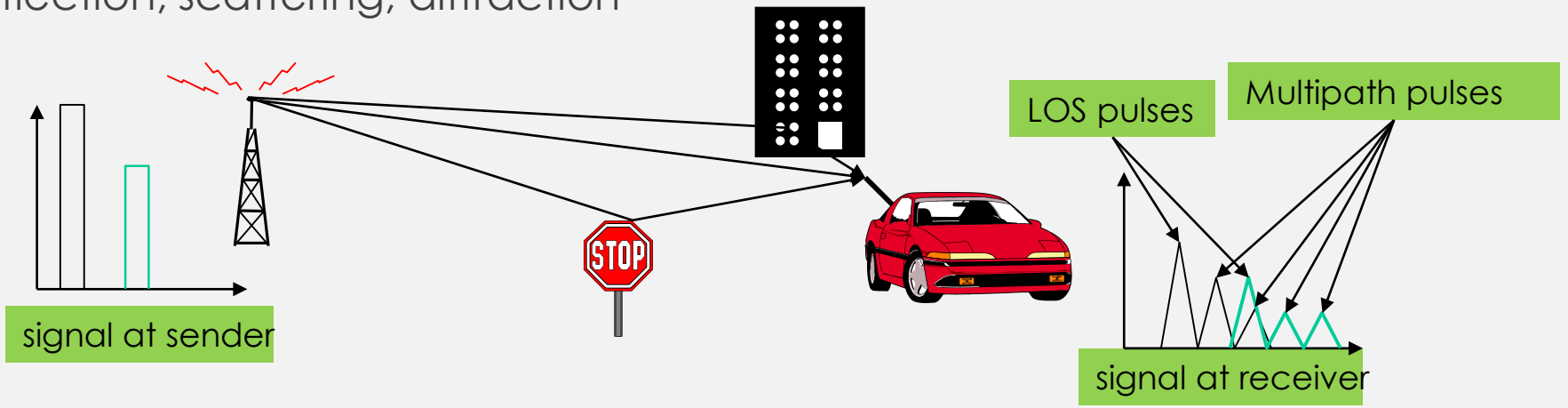


Signal propagation



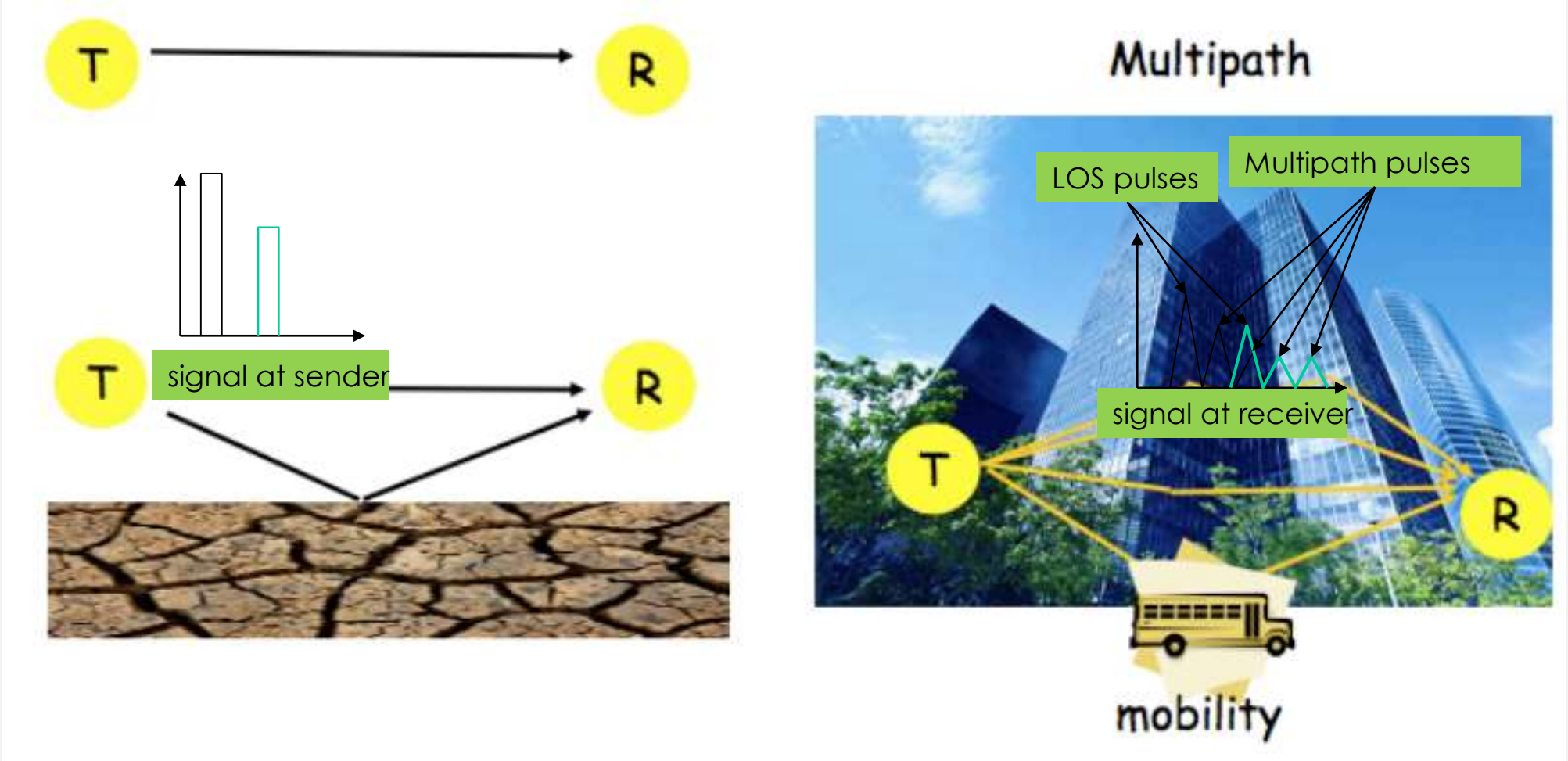
Multipath propagation

- Signal can take many different paths between sender and receiver due to reflection, scattering, diffraction



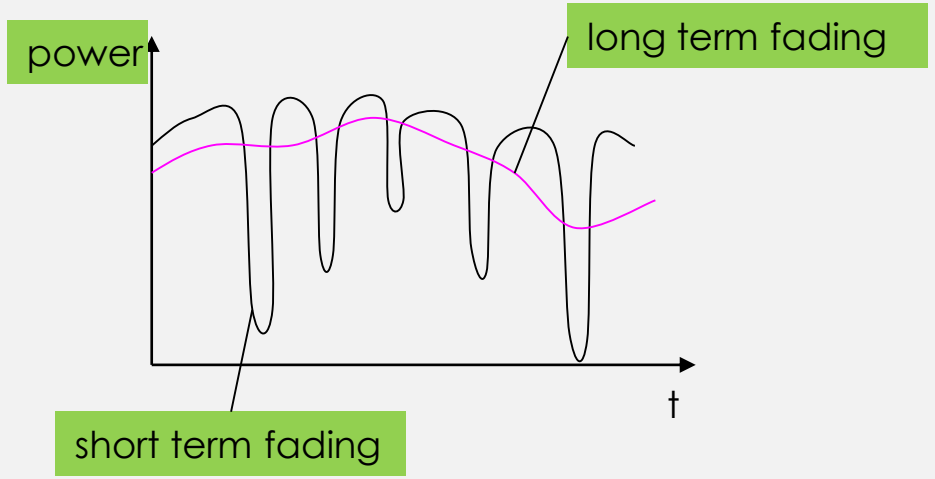
- Time dispersion: signal is detach over time
  - interference with "neighbor" symbols, Inter Symbol Interference (ISI)
- The signal reaches a receiver directly and phase shifted
  - distorted signal depending on the phases of the different parts

Multipath propagation



Effects of mobility

- Channel characteristics change over time and location
  1. signal paths change
  2. different delay variations of different signal parts
  3. different phases of signal parts
  4. quick changes in the power received (short term fading)
     - Additional changes in
       - distance to sender
       - obstacles further away
  5. slow changes in the average power received (long term fading)



Next session

Media accessing technique in wireless communication environment at physical layer

Multiplexing …..

Medium access control at layer2...

Questions welcome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WLAN Media accessing technique Multicast Routing

At the Physical layer, Layer 1

Objectives

At the end of this session, students will be able to:

- Define physical layer
- Discuss the different medium accessing techniques at the physical layer (layer 1)
- Explain multiplexing in accessing layer1 as a shared medium
- Compare and contrast accessing railway/highway with that of layer 1 in communication
- List advantages of multiplexing having a characteristics of guard space.
- List and discuss types of multiplexing and advantages and disadvantages of each scheme
- Determine if the organizations are at risk while exchanging information either using shared medium or private network(VPN)

Accessing shared Medium

- Group discussion
  - Prepare a short note on physical layer and present for your educator
    - Responsibilities
    - Functions

Motivation Questions

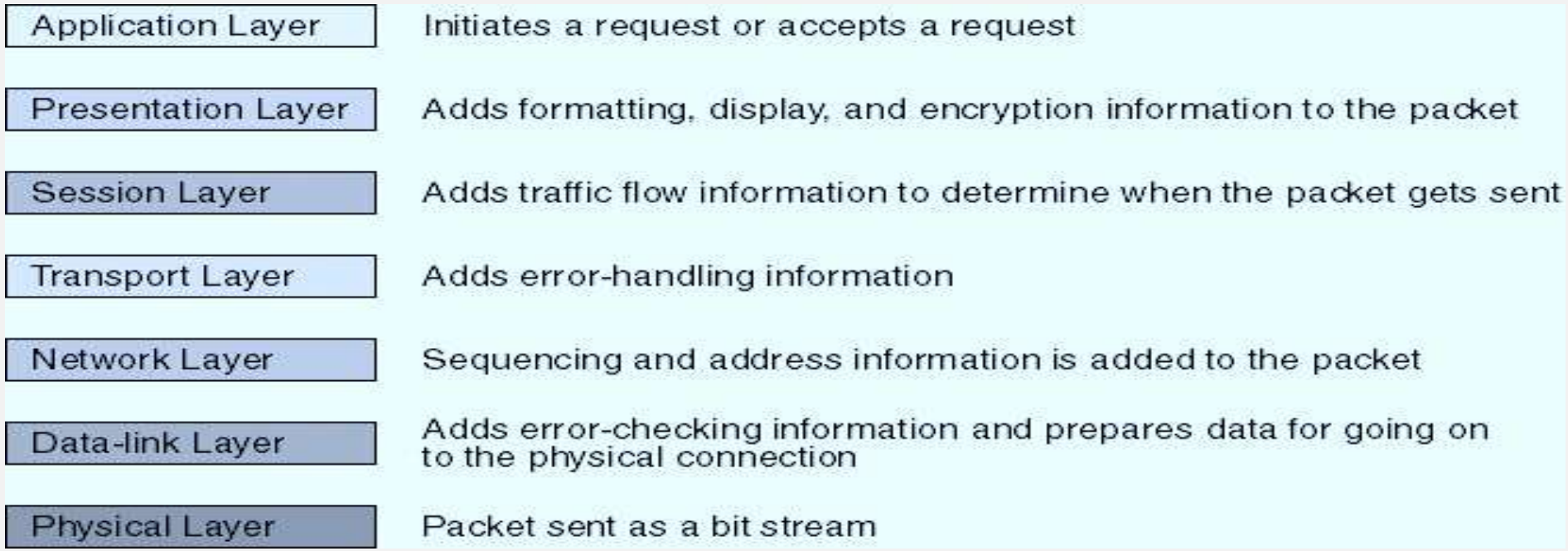
1. How to access the shared madia?
2. Is it possible to access the public medium individulally?
3. If(your answer is yes for Q2),Is there a mechanism? Or if NO why?
4. If yes for Q3, what mechanism is it?
5. What do you think in accessing highway? Is the same as public medium?

Multiplexing

- Goal: multiple use of a shared medium
- Important: guard spaces needed!

Physical Layer—Layer 1

The OSI physical layer defines specifications such as the electrical and mechanical conditions necessary for activating, maintaining, and deactivating the physical link between devices. Specifications include voltage levels, maximum cable lengths, connector types, and maximum data rates. The physical layer is concerned with the binary transmission of data. This binary data is represented as *bits* (which is short for *binary digits*). A bit has a single binary value, either 0 or 1.

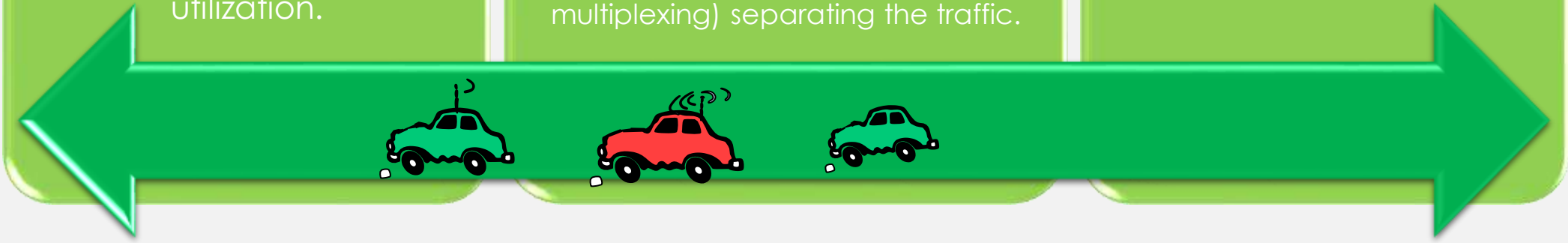


Accessing a shared medium through Multiplexing

describes how several users can share a medium with minimum or no interference and a maximum of medium utilization.

Many users (car drivers) use the same medium (the highways) with hopefully no interference (i.e., accidents)- due to the provision of several lanes (space division multiplexing) separating the traffic.

In addition different cars use the same medium (i.e., the same lane) at different points in time (time division multiplexing).



Types of Multiplexing technique

Space division

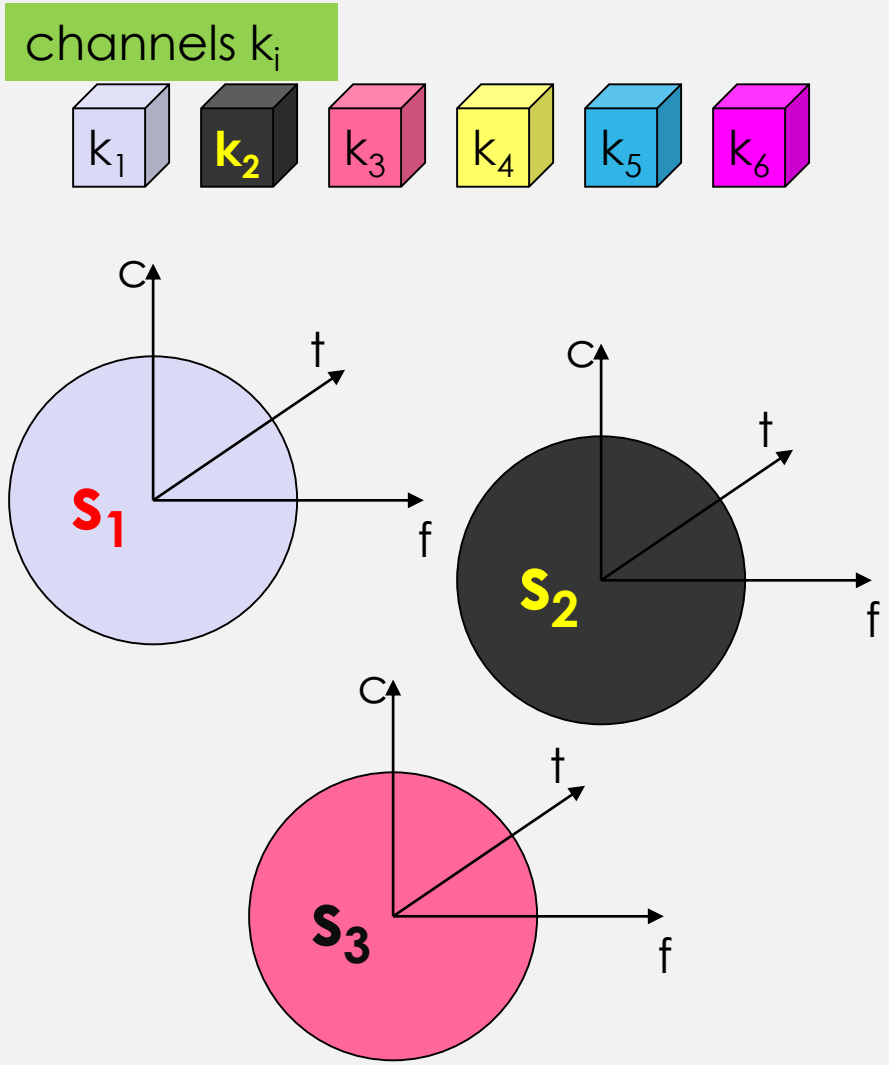
Time division

Frequency division

Code division

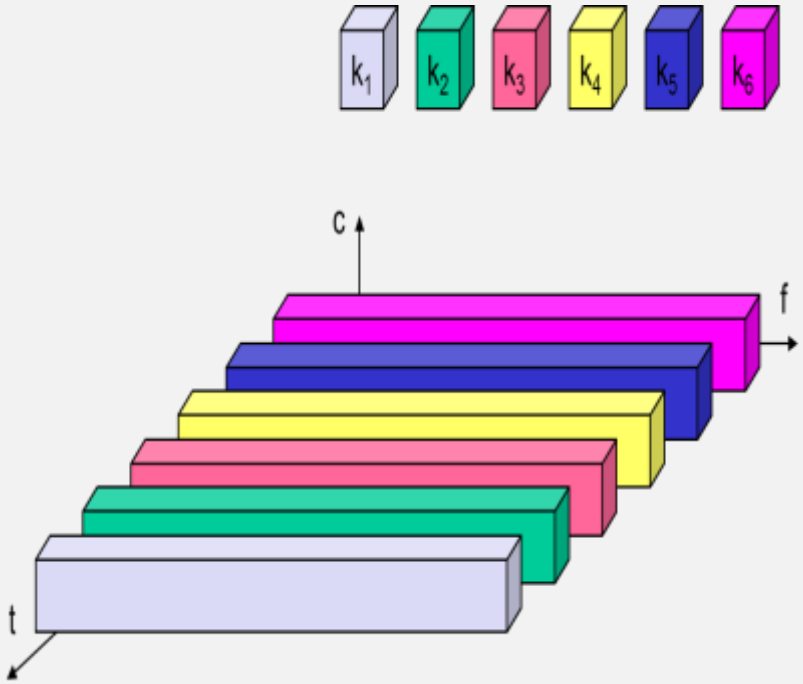
Space division Multiplexing

- The channels(k1 to k3) - spaces(s1 to s3) ratio
  - which clearly separate the channels and
  - prevent the interference ranges from overlapping.
  - The space between the interference ranges is sometimes called guard space.
- In wireless transmission, SDM implies a separate sender for each communication channel with a wide enough distance between senders.
- The term communication channel here only refers to an association of sender(s) and receiver(s) who want to exchange data.
- Although this procedure clearly represents a waste of space, this is exactly the principle used by the old analog telephone system



Eg. FM radio stations where the transmission range is limited to a certain region

Frequency Division Multiplexing



Eg. radio stations within the same region

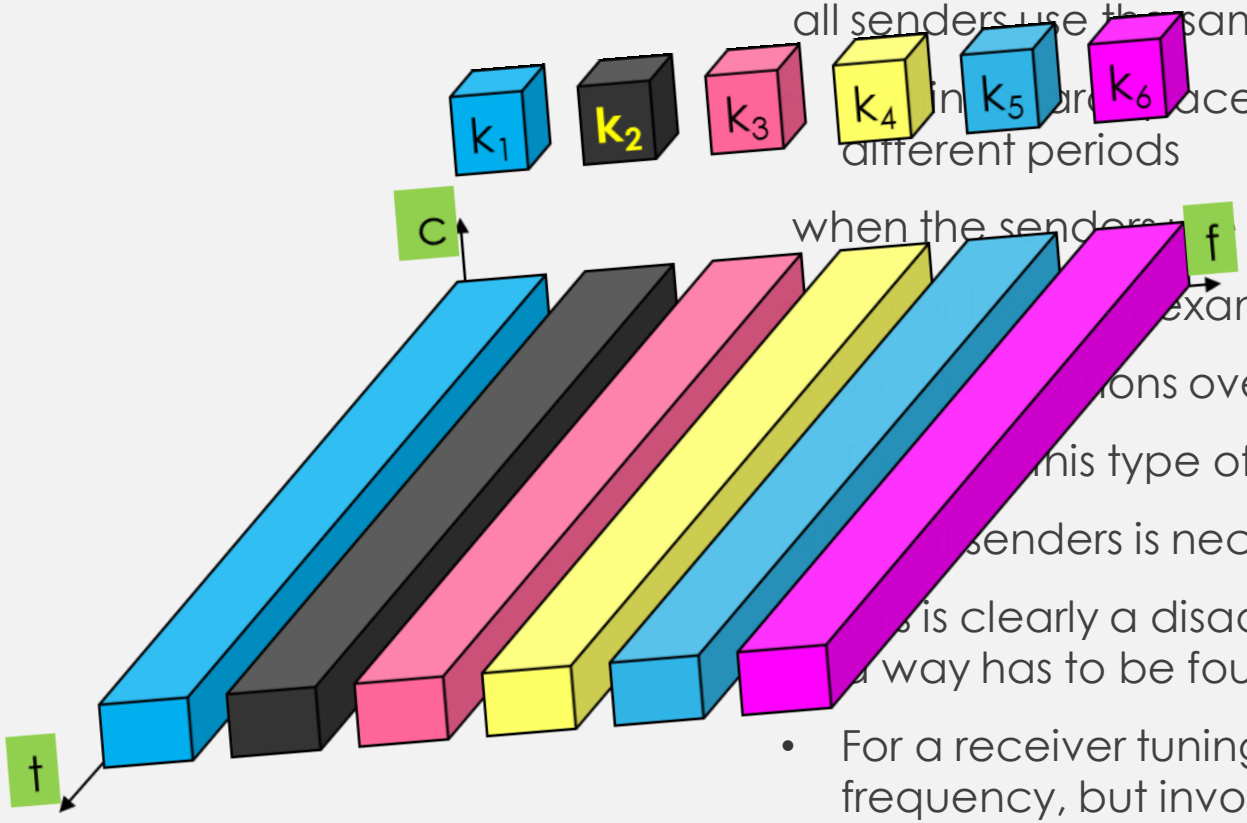
- describes schemes to subdivide the frequency dimension into several non-overlapping frequency bands
- The channels(k1 to k3) - frequency band ratio
- Senders using a certain frequency band can use this band continuously.
- Again, guard spaces are needed to avoid frequency band overlapping (also called adjacent channel interference).

➨ However, this scheme also has **disadvantages**.

- While radio stations broadcast 24 hours a day, mobile communication typically takes place for only a few minutes at a time -> **wastage of bandwidth**
- Additionally, the fixed assignment of a frequency to a sender makes the scheme very **inflexible and limits** the number of senders.

→ Very simple multiplexing scheme **does not need complex coordination** between sender and receiver: the receiver only has to tune in to the specific sender.

Time Division Multiplexing



- channel ki is given the **whole bandwidth** for a certain amount of time, i.e.,

all senders use the same frequency but at different points in time

in guard spaces, which now represent time gaps, have to separate the different periods

when the senders use the medium.

example, this would refer to the gap between two cars.

ions overlap in time, this is called co-channel interference.

his type of interference, precise synchronization between

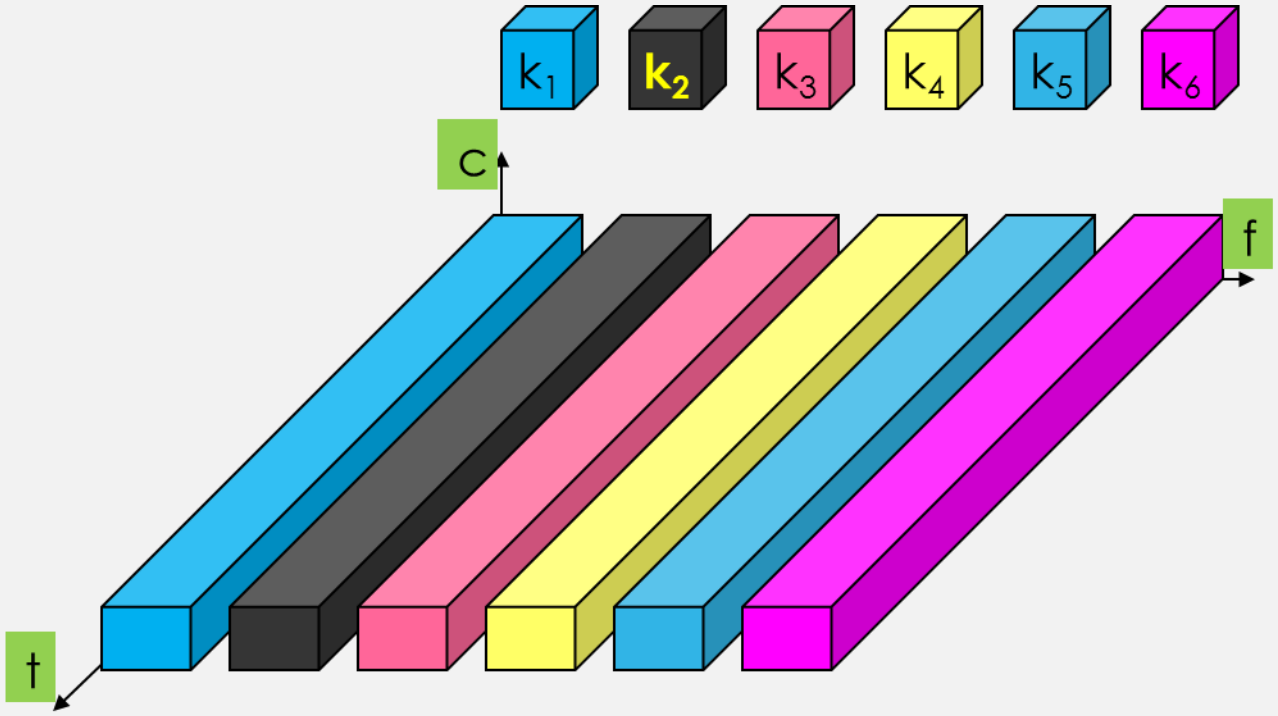
senders is necessary.

is clearly a disadvantage, as all senders need precise clocks or, alternatively, a way has to be found to distribute a synchronization signal to all senders.

- For a receiver tuning in to a sender this does not just involve adjusting the frequency, but involves listening at exactly the right point in time.

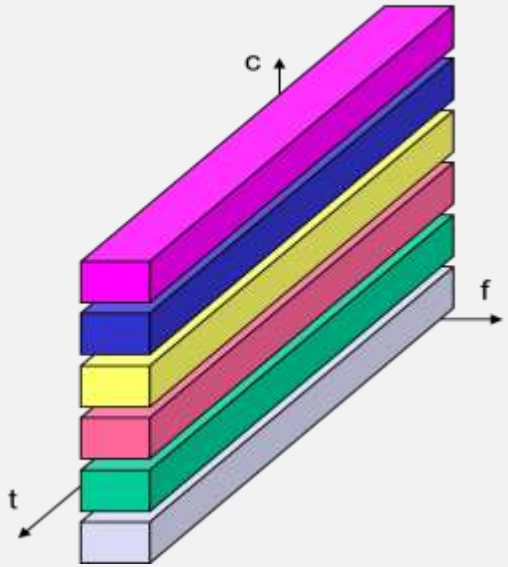
→ However, this scheme is **quite flexible** as one can assign more sending time to senders with a heavy load and less to those with a light load.

Eg. EBC, Ethiopian Broadcasting Corporation


k1
k2
k3
k4
k5
k6
c
f
t

Code Division Multiplexing

- (CDM) is a relatively new scheme in commercial communication systems.
- First used in military applications due to its inherent security features
- All channels use the same spectrum at the same time.
- Different codes have to be assigned, but code space is huge compared to the frequency space-Each channel has a unique code.



→ The main disadvantage of this scheme is the relatively high complexity of the receiver. A receiver has to know the code and must separate the channel with user data from the background noise composed of other signals and environmental noise.

→ Additionally, a receiver must be precisely synchronized with the transmitter to apply the decoding correctly.

- → lower user data rates
- → more complex signal regeneration
- → To apply CDM, precise power control is require

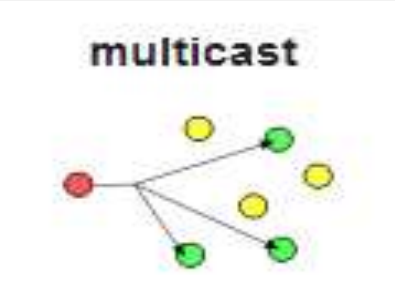
→ The main advantage of CDM for wireless transmission is that it gives good protection against interference and tapping.

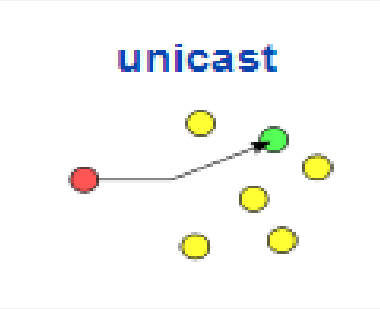
- → Good in bandwidth efficient
- → no coordination and synchronization necessary

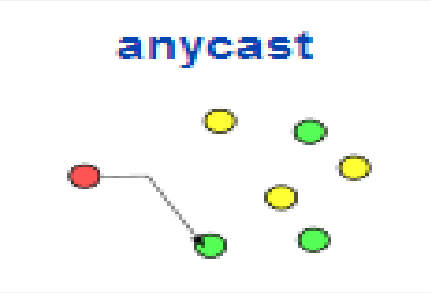
Eg. party with many participants from different countries around the world who establish communication channels, i.e., they talk to each other, using the same frequency range (approx. 300–6000 Hz depending on a person's voice) at the same time.

Multicast Routing->Routing Algorithm

- Sending a message to a group is called multicasting, and its routing algorithm is called multicast routing.
- Multicasting requires group management. Some way is needed to create and destroy groups, and to allow processes to join and leave groups. How these tasks are accomplished is not of concern to the routing algorithm. What is of concern is that when a process joins a group, it informs its host of this fact.
- It is important that routers know which of their hosts belong to which groups through
- One the host must inform their routers about changes in group membership, Second routers must query their hosts periodically as an alternative .
- Either way, routers learn about which of their hosts are in which groups. Routers tell their neighbors, so the information propagates through the subnet. To do multicast routing, each router computes a spanning tree covering all other routers.







How to determining if an organization is at risk

- **To check whether an organization is secured or not you should have to bear in mind such questions!**
  - Does the power has a protection mechanism?
  - Is the system free from computer viruses?
  - Is there a security programs/mechanism in the organization?
  - Is there a backup program?
  - Is it better to use external drives as alternative like backup?
  - Is there data recovery center?
  - Is it possible to backing up PDAS, smart phones,…?
  - Is there data transfer between users of an organization? If yes in what way this can be handled? What is/ are the security issue/s during data transferring?

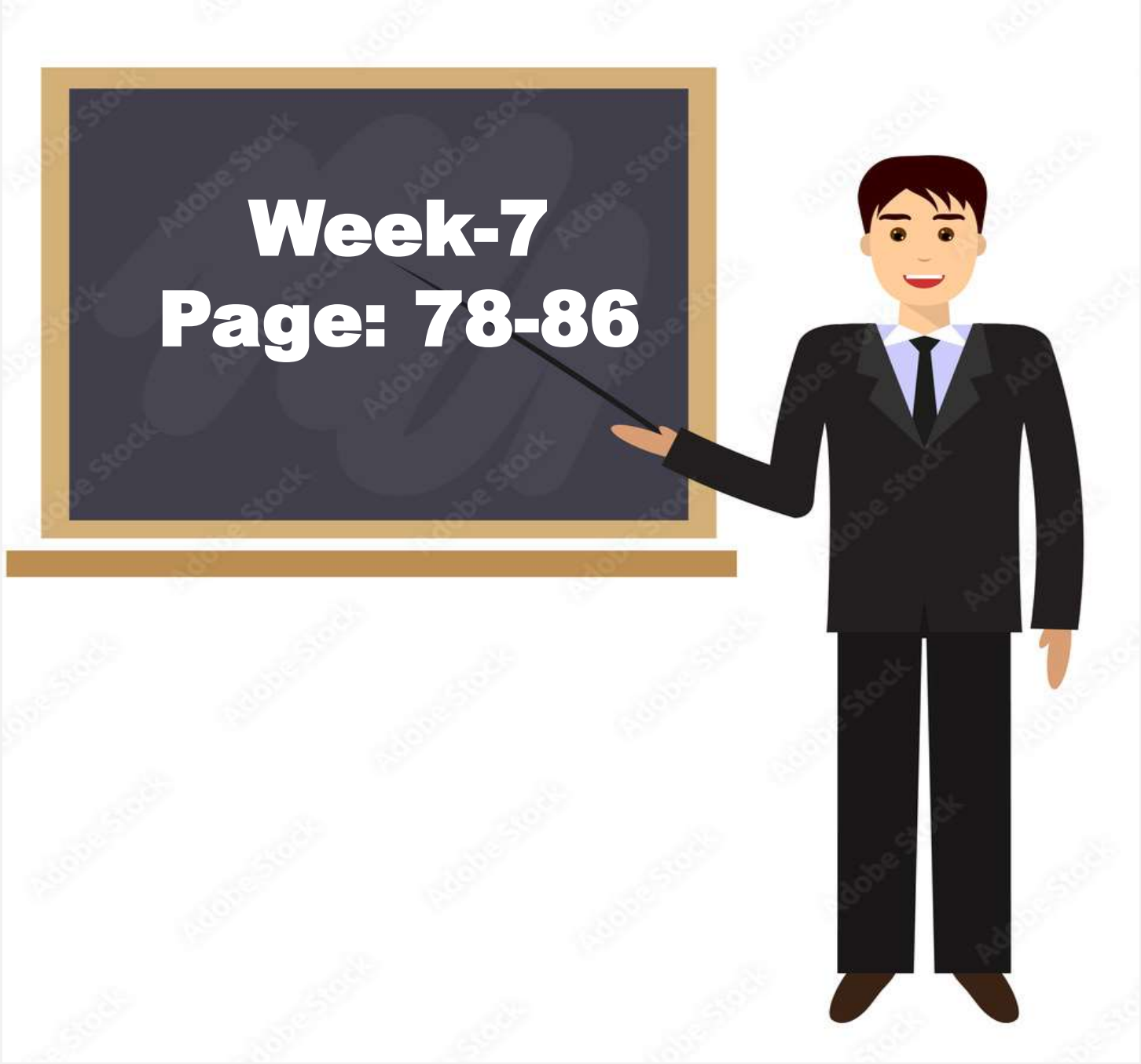
Preventive mechanisms

1. physical security: locks and cases(hardware)
2. cellular phone safety
3. securing equipment and premises remotely
4. practices for safe computing
5. cataloging equipment: the specifics
6. hardware and software setups
7. security setups
8. …what else

Next session chapter 2

Reading assignment:- Combination of frequency and time Multiplexing, and Modulation and Modulation techniques

Questions welcome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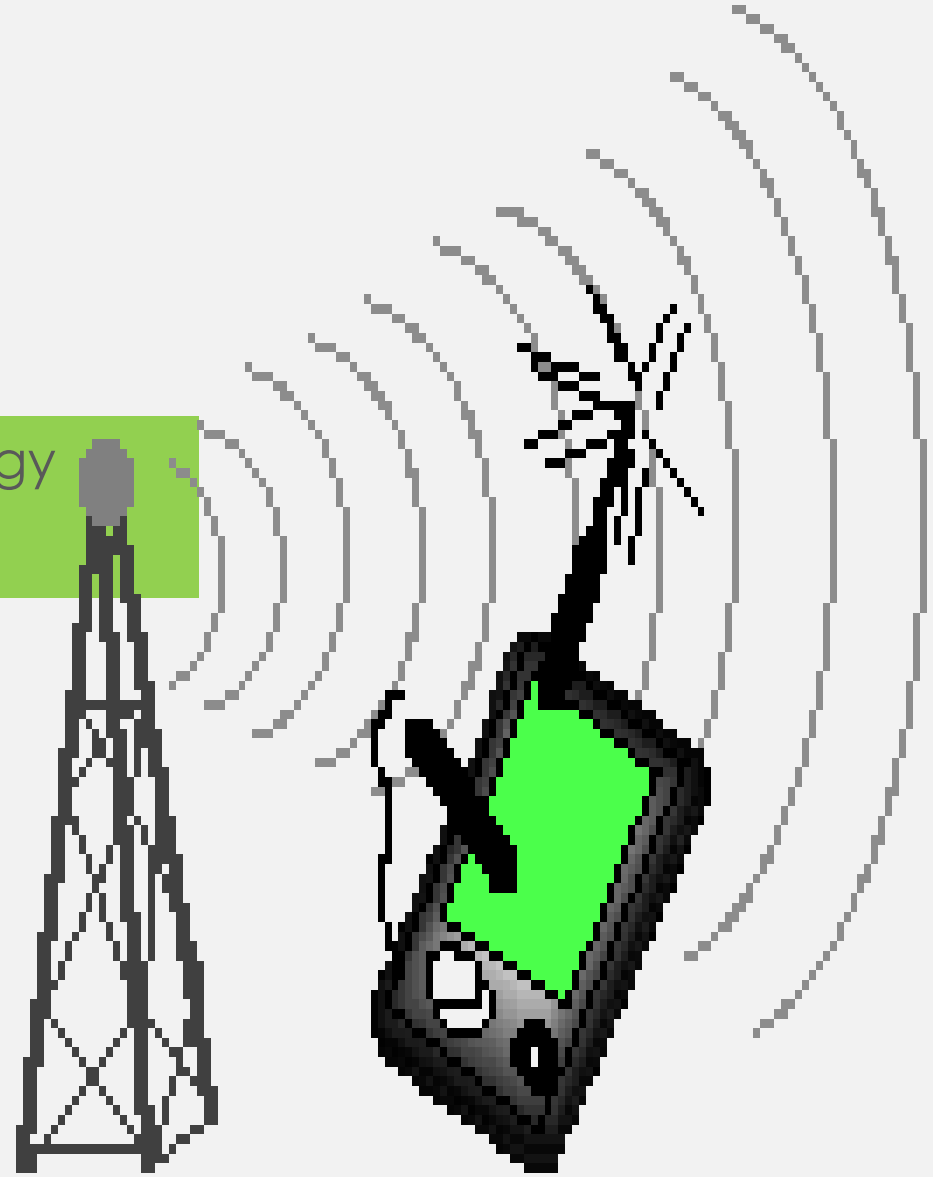
Chapter two

Wireless communication as a cost effective strategy

Notice

Submit your assignment, Please



Objectives

At the end of this session, students will be able to:-

- Know wireless implementation issues
- Identify Wireless Network Technologies and Service Providers
- Differentiate Packet Data Networks and circuit switching
- Understand and discuss Choosing an Architecture and Access Method for wireless implementation
- Choose Wireless Applications for agent, and email based systems
- Choose wireless products

Introduction

- Most organizations have some mobile field activities involving sales representatives, field service technicians, telecommuting employees, traveling managers, route-based personnel, or even mobile health care providers.
- Organizations with significant numbers of mobile field activities require a well-synchronized exchange of information between central information systems and mobile users.
- Many organizations are investing in portable computers and software to provide mobile users with the tools they need to accomplish their daily tasks.
- Some organizations have begun to look at emerging wireless technologies to further enhance communications and streamline information exchange by providing anytime, anywhere access.
- Automating business processes through wireless technology offers organizations many benefits, including improved productivity and increased competitive advantage.
- To achieve these benefits, organizations must thoroughly consider several implementation issues..

Implementation issues

- To achieve such benefits, organizations must thoroughly consider several implementation issues that fall into three broad categories:
  1. **Communications architecture and access methods.**
  2. **Application appropriateness.**
  3. **Wireless service products.**

Wireless Network Technologies and Service Providers

- There are two prevalent technologies for wireless applications:
  1. **Circuit-switched networks.**
  2. **Packet data networks**
- Circuit-Switched Networks:-
- Circuit-switched networks involve establishing a dedicated connection (or circuit) between two points and then transmitting data over the connection, much like a **typical telephone conversation**.
- They can be either analog or digital.

Wireless Network Technologies and Service Providers

Analog Circuit-Switched (Cellular) Networks

- Two-way analog Circuit-Switched Cellular technology has existed since the advent of cellular phones.
- To use circuit-switched cellular (CSC) service, the user requires a cellular phone with a cellular modem.
- Sending wireless data over a circuit-switched cellular (CSC) connection offers several advantages, including:
  - Wide on-street coverage and availability.
  - Suitability for sending and receiving large data files such as long E-mail messages or reports.
  - Per-minute (as opposed to per-packet) charges.
  - Implementation through standard communications software Analog Circuit-Switched (Cellular) Networks.
- The disadvantages of using circuit-switched cellular (CSC) technology include:
  - Increased relative cost of sending short messages, because call setup time may become a large percentage of cost.
  - Security concerns involving unencrypted files.
  - Lack of cellular error-correction or enhancement standards.

Wireless Network Technologies and Service Providers

Digital Circuit-Switched (Cellular) Networks

- Digital communications technology is inherently more reliable for sending data than is analog technology.
- Examples of digital circuit-switched wireless network implementations in the US are Code Division Multiple Access (CDMA) and time division multiple access (TDMA).
- Because the availability of both code division multiple access (CDMA) and TDMA is limited, it will be some time before most US organizations will be able to take advantage of digital circuit-switched technologies for wireless data applications.

Packet Data Networks

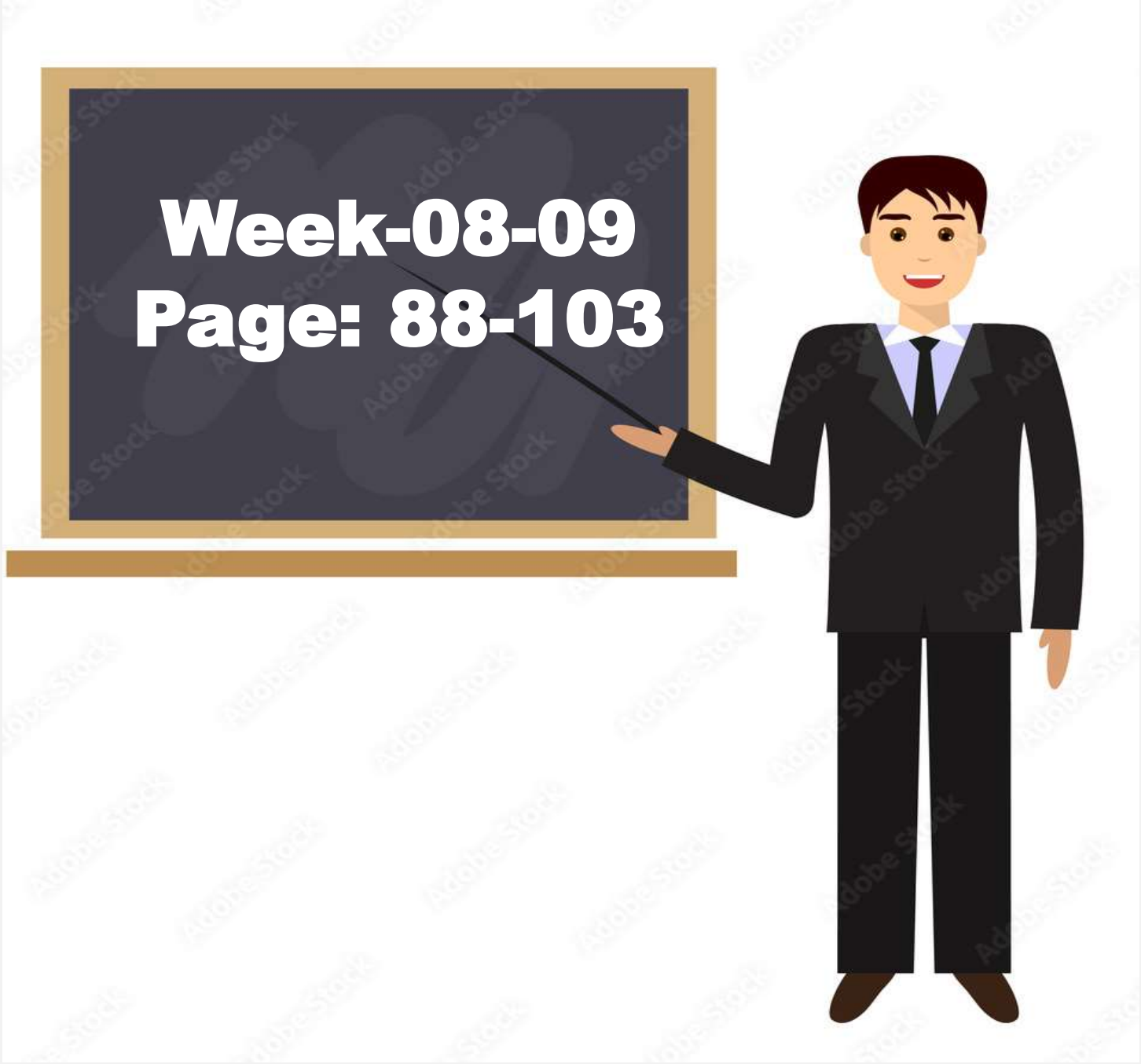
- Packet data networks have been designed for effective and reliable transfer of data rather than voice.
- They use a method that is comparable to sending a document one page at a time.
- The document is first broken into pages, and each page (or packet) is sent in its own envelope.
- The network determines the most appropriate transmission path, and once each page reaches its destination, the document is reassembled (if appropriate).
- Packet data networks **use radio frequency channels** to connect the portable computing device to a network backbone and, ultimately, to the company's host system.
- The major networks (e.g., Ardis and RAM Mobile Data) use packet radio technology.
- Packet cellular technology (e.g. CDPD) is now emerging.

Reading assignment on Ardis & RAM if needed

Packet Data Networks con…

- What are Packet Radio Technologies? discuss
- Packet Cellular Technology(more on chapter 4)
- Cellular digital packet data (CDPD) technology is being developed and implemented by a consortium of 10 major cellular carriers, including McCaw Cellular and Air Touch.
- cellular digital packet data claims a bandwidth of 19.2K bps, although typical user rates are closer to 9.6K bps.
- As a digital overlay of the existing analog cellular network that utilizes unused bandwidth in the cellular voice channel, cellular digital packet data is a logical extension of cellular data communications.

Assignment, must be submitted to your educator, Packet data networks offer several advantages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A. Choosing an Architecture and Access Method

- The first step in implementing wireless technology is to choose an appropriate communications architecture and access methodology.
- Many wireless and connectivity access methods available generally fall into three categories:
  1. Continuous extensions of desktop or local area network (LAN) systems.
  2. E-mail-based systems.
  3. Agent-based messaging systems.

1. Continuous-Connection Architectures

- A continuous-connection architecture establishes and maintains a wireless connection so that a user can perform work while online to central computing resources, such as a desktop PC or LAN -based PC.
- This work is accomplished through remote access and file synchronization utilities.
- Although there are unique variations on how these utilities are implemented, organizations generally use one of two methods: remote node or remote control.
- Remote node technology makes mobile users a node on the LAN network and allows them to perform work as if they were locally logged into the LAN, albeit usually more slowly.
- Remote control technology allows mobile users to connect and see a virtual copy of the remote PC's screen or hard drive so that files can be accessed and applications can be run remotely.

1. Continuous-Connection Architectures

- Continuous-connection technologies offer the basic advantage of providing mobile users with access to their central LAN -based PCs and servers; the mobile computing device looks and acts as if it were the user's local desktop PC.
- Unfortunately, this strategy is inappropriate for the majority of large mobile implementations for several reasons:
  - Most field professionals are mobile or remote all of the time. They may not need LAN resources, understand local area networks or logically redirected disk drives, or have a dedicated PC at the central site.
  - Even when the complexity of establishing connections is hidden from the remote user, communication time is lengthy and communication costs are high.
  - Before performing work online, the user must leave the task at hand to initiate and establish a connection.
  - Continuous-connection systems do not provide for communications management or for general systems management; as a result support costs are likely to increase.

2. E-Mail Based Systems

- E-mail based systems use E-mail as both the messaging application and as a general communications transport for other message types or transactions.
- The basic advantage of using E-mail as the access method for all communications is that it is a predominant application that users understand.
- However, use of E-mail as an access method for other applications is less than optimum because E-mail based systems:
- Lack integral systems management capabilities such as software distribution.

  - Involve users with the information delivery process, which is not provided automatically by the application.
  - Do not support applications that require queries into data bases.

3. Agent-Based Messaging Systems

- Agent-based messaging systems provide a communications architecture built on a client/server platform; a server at the central site acts as an agent on behalf of the mobile users.
- Software distribution, posting of forms-based data into central data bases, querying of data from central data bases, E-mail delivery, and many other tasks can be automated by agents capable of handling these functions on behalf of mobile users.
- Wireless or land-line connections can be established automatically and efficiently to synchronize information between the client and the server, with all of the work (e.g., data entry to book an order) being performed offline.

3. Agent-Based Messaging Systems

- Agent-based messaging systems provide many benefits in extending client/server systems to large field organizations, including:
  - Minimized connect times, which yields significant savings in communications costs.
  - Minimized user involvement in communications.
  - More-efficient applications performance resulting from the tight coupling of applications with the mechanism of information delivery.
  - More-efficient management control of system resources and communications.
  - High scalability with support for hundreds of remote users per server.
  - Capability for more and different types of work (e.g., messaging and transactions) to be accomplished.

B. Choosing Wireless Applications

- The next step in implementing wireless technology involves assessing which applications provide mobile workers with the most benefits.
- Application requirements vary among different classes of users, who may require different products and service providers.
- Four basic classes of applications are discussed:
  1. Wireless E-mail and fax systems.
  2. Remote access and file synchronization utilities.
  3. Single-transaction based applications.
  4. Mobile enterprise applications.

B. Choosing Wless Apps:-Wless E-Mail and Fax Systems

- A survey of telecommunications and IS managers conducted by the Hartford CT based Yankee Group revealed that the two primary drivers behind mobile data networks are customer satisfaction and revenue generation
- Similarly, a study by Link Resources Corp. revealed that wireless data solutions were implemented mainly to decrease or control costs and to attain competitive advantage.
- Users who believe that E-mail and fax will achieve customer satisfaction and generate revenue generally do so for three reasons:
  1. Wireless E-mail systems are being marketed as the next killer application that mobile users must have for the real-time communications necessary to support continuous sales.
  2. Personal productivity applications like E-mail and calendaring are believed to be as necessary to mobile users as they are to headquarters-based users.
  3. E-mail is thought to be the appropriate transport for routing forms, updating data bases, and performing other critical business functions.

B. Cho.. Wless Apps:-Remote Access and File Synchronization Utilities

- Personal productivity utilities facilitating wireless remote access and file synchronization functionality are basic utilities that give the mobile user access to local hard drives on a desktop PC or on a LAN drive at corporate headquarters
- Generally, the applications perform this function by providing either a wireless remote node connection to a central LAN, a remote control function to a local desktop PC, or a distributed file system that mirrors the remote drives locally and accesses remote files whenever needed.
- The general idea is to extend the same personal productivity applications and files found in the Central Office to the mobile user.
- Although these utilities provide important functionality for end users temporarily away from their LAN -connected desktop systems, they do little for the requirements of large field organizations involving hundreds of mobile users who rarely, if ever, use a desktop PC.
- As discussed previously, wireless remote access and file synchronization systems offer solutions that scale poorly and involve high support costs and connection charges.
- They provide few capabilities for systems management, application management, or connect-time and communications session management—all of which are critical issues for large wireless data implementations.

B. Cho.. Wless Apps:-Single-Transaction Based Applications

- Single-transaction based applications use wireless technology to perform one function (and sometimes a few functions) extremely well over a wireless connection.
- They tend to be oriented toward a large user community.
  - A single-transaction based application is used, for example, by a rental car employee to enter a returning car's ID number as well as other customer information on a handheld computer that prints a receipt. Another example is a job assignment dispatch application used by an organization with a large field service operation.
- To date, these types of systems have produced acceptable rates of return because the applications implemented increase customer satisfaction and generate revenue.
- However, single-transaction based systems are most appropriate for a small, distinct set of highly repetitive functions. Most mobile users, including salespeople, should not be limited to a single application like order entry.
- They need a variety of applications to help them perform many functions well. Also, unless additional functionality is custom-built into these systems, single-transaction based application systems do not address application management, update, and maintenance issues.

B. Cho.. Wless Apps:-Mobile Enterprise Applications

- Mobile enterprise applications provide solutions to a large mobile user community that needs to exchange information with centrally located systems and users.
- These applications include transaction-based applications, information distribution applications, and E-mail and messaging-based applications.
- Mobile enterprise application systems provide the most utility and payback of all the wireless solutions for the following reasons:
  - They allow an organization to automate within one system many key line-of-business functions that focus on increasing revenue, improving customer satisfaction, and decreasing costs.
  - They provide a client/server framework in which to implement a mobile client/server system that is highly scalable because it was designed for hundreds of users.
  - They allow for efficient use of land-line, LAN, and wireless networks, so that users can choose the protocol or transport most appropriate to such conditions as the time of the connection or the application type.
  - They provide sophisticated application services including posting into central data bases, querying from central data bases, routing and sharing of transactional information, and automatic and efficient updating of messaging-based applications

Issues & Decision Criteria By Type of Wless App

Wireless Issue and/or Decision Criteria	Wireless E-mail and FAX	Remote Access and File Synchronization Utilities	Single Transaction-based Applications	Tools to Build Mobile Enterprise Applications
Examples of software application or tool	RadioMail	Wireless cc:MailAirsoft's AirAccess	MobileWareOracle Mobile Agents	In-house developed applicationsXcelleNet
Connectivity available	Wireless focus with some landline capability.	Wireless focus with some landline capability.	Wireless focus with some landline capability.	Mixed mode supports wireless, landline and LAN.
System architecture	Peer-to-peer and client/server.	Peer-to-peer focus.	Some client/server.Client/server-based architecture.	Client/server-based architecture, such as client/agent/server.
Application focus	E-mail and fax.	Messaging applications.File transfer and remote access.	Transaction applications, typically vertical in nature.	Messaging-based, transaction-based, and info exchange applications.
Number of applications available	Limited to e-mail and fax	Many	A few applications	Unlimited
End-user profile	Knowledgeable LAN-based PC professional, which occasionally goes mobile.	Knowledgeable LAN-based PC professional, which occasionally goes mobile.	Field professionals who do not have to be computer literate and focus on a single line-of-business task.	Field professionals who do not have to be computer literate and focus on many line-of business tasks.
End-user community	Single user or small department	Single-user or small department	Large field force	Large field force with potentially multiple end-

C. Choosing Wireless Products

- Much of the infrastructure for certain wireless technologies is either immature or under construction, and some wireless service providers require that an application be developed to a nonstandard protocol or application programming interface (API).
- As a result, organizations should develop a communications and applications strategy that provides the most flexibility regardless of which technologies or services ultimately gain widespread marketplace acceptance.
- There are two basic ways to do this:
  - Use middleware APIs or developer kits to develop wireless applications.
  - Use a system for communications management that provides an interface based on a high-level Graphical User Interface to set up and maintain multiple wireless technologies.

C. Cho.. Wless Prod:- Using Middleware APIs & Developer Kits

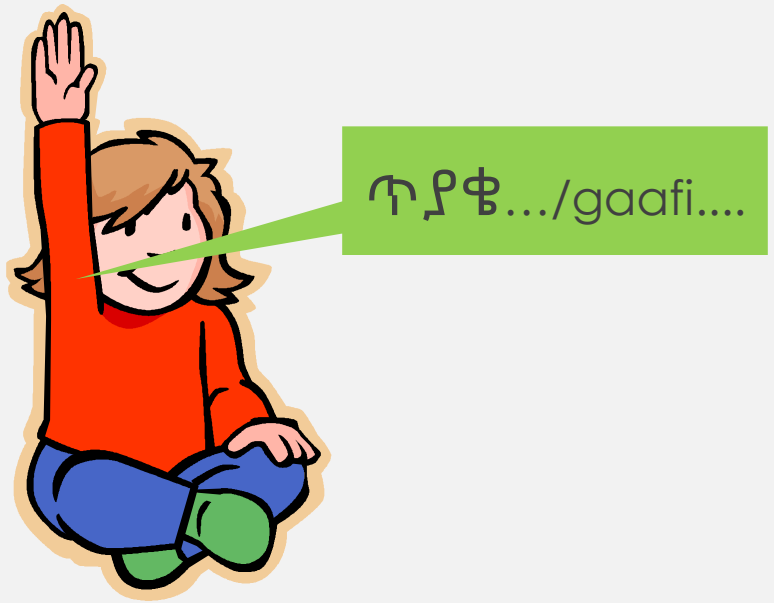
- Some vendors offer middleware APIs that shelter organizations from having to learn how to connect over RAM, Ardis, Cellular Digital Packet Data, or analog cellular networks.
- By developing to the vendor's API set, organizations can choose different wireless providers or switch from one to another through a simple programming change.
- Vendors of middleware APIs claim to provide anywhere, any-protocol access.
- The basic advantage to using middleware APIs is they allow organizations to skip the details of understanding, testing, and debugging communications.
- Many APIs also provide communications capabilities for land-line and local area networks.
- Middleware APIs also have disadvantages, some of which are:
  - Many of them are not based on industry standard messaging APIs, so organizations must develop and maintain applications using a nonstandard API.
  - They require organizations to program (i.e., custom build) functionality that is already available in various systems for communications management.
  - Many of the companies that offer middleware APIs are new and small; their long-term stability may be less certain than that of existing wireless service providers

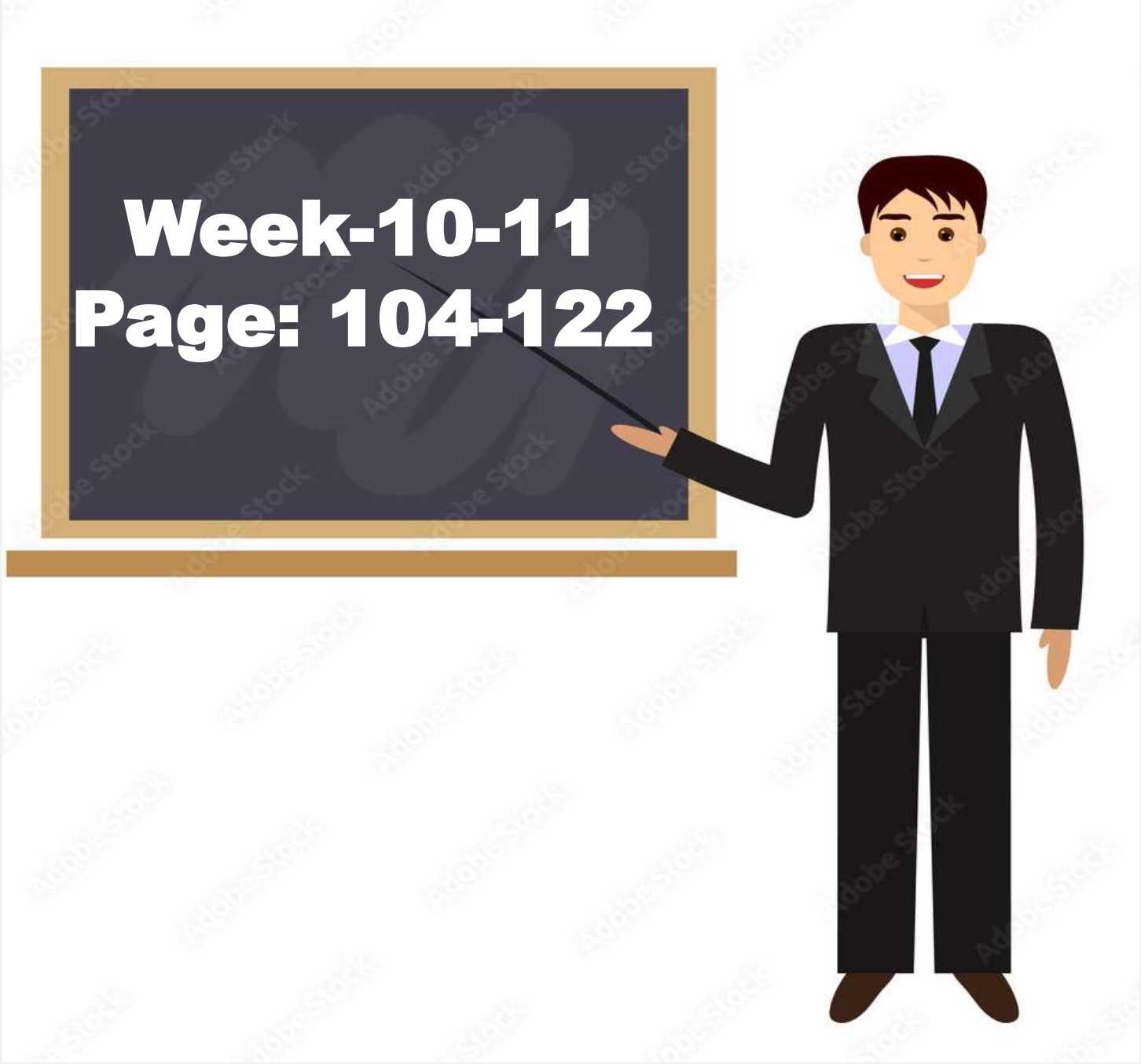
C. Cho.. Wless Prod:- Systems for Communications Mangnt

- A system for communications management can provide an organization with support for many wireless technologies.
- A comprehensive system for communications management can also provide functionality in the area of systems management, software updates, file transfer, E-mail and messaging, and scheduling of tasks to take place over any of the various wireless services.
- The major benefits of a system for communications management include:
  - Provision of capabilities that organizations would otherwise have to develop for themselves using middleware APIs.
  - Powerful functionality in the setup and maintenance of mobile users.
  - The benefits of an API set or developer kit, because most systems provide interfaces and APIs.
- Systems for communications management also ensure that the **messaging layer** on **which applications are built can support future anticipated** wireless services or APIs.
- In this way, an application can take advantage of future wireless services without additional development.

Next session chapter 3

Questions welcome

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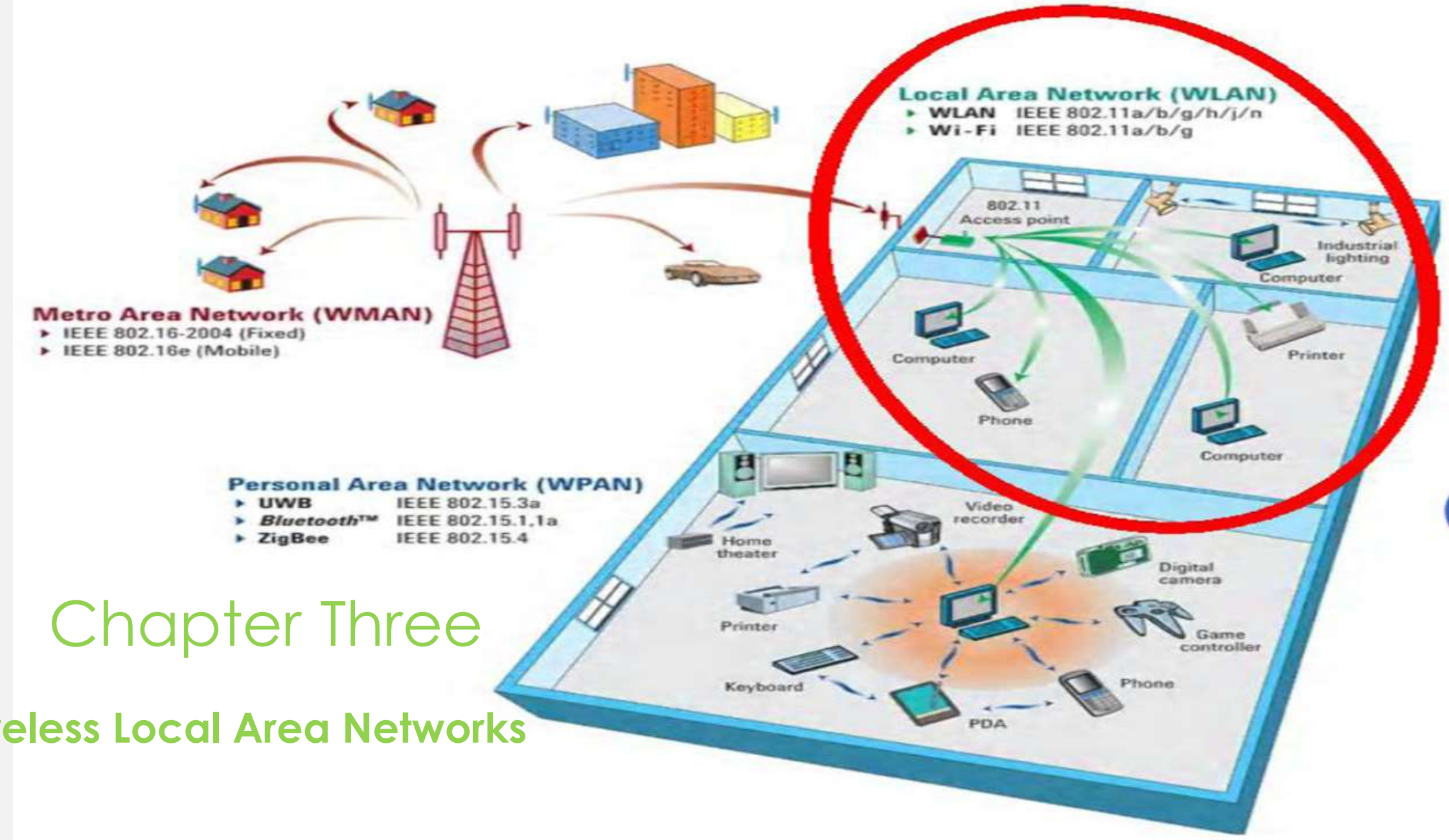
Chapter Three

Wireless Local Area Networks



Objectives

- At the end of this session students will be able to:
  - Demonstrate spread spectrum for wireless communication
  - Illustrate current wireless standards in the world, and in Ethiopia
  - Identify wireless LAN Components
  - Discuss on AP and compare and list the functions of access point
  - List wireless LAN installation forms and beyond each form of installation

Introduction

- No cables
- They use the electromagnetic spectrum
- Generally they are integrated within wired LANs

Why?

- Allow mobility
- Allow installation in places where cables can't be installed (or are expensive)

Introduction

Advantages:

- Allow the same features as wired LANs, but without cable limitations.
- Mobility
- Reduce installation time/cost
- Flexibility
- May work inside buildings or between buildings

Disadvantages:

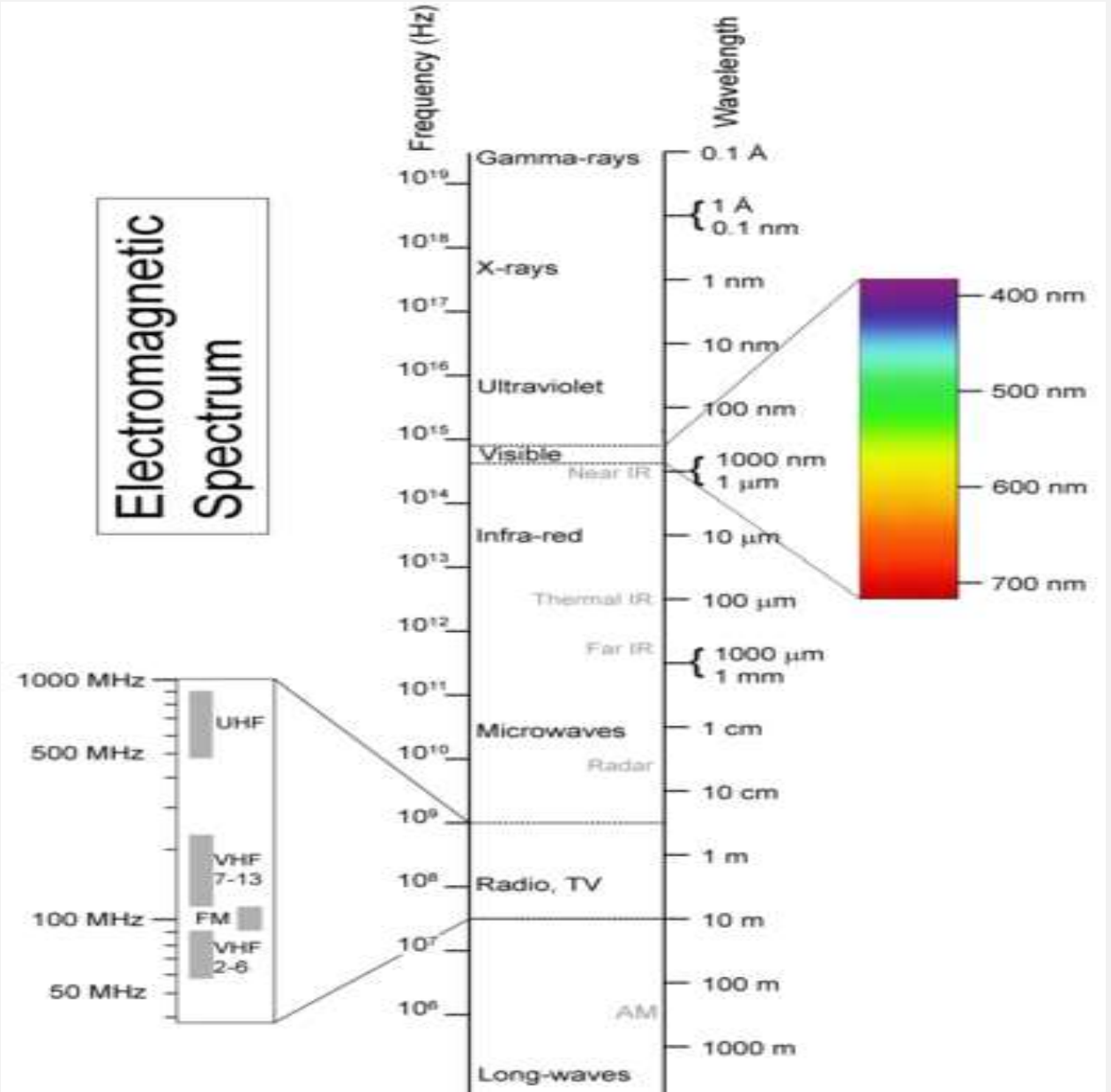
- Need a transmission medium based on radio frequency (RF) -> Electromagnetic spectrum is limited
- Transmission rates are slower than in wired LANs
- Security problems

Electromagnetic spectrum

- Use of electromagnetic spectrum
  - 0-200 MHz: Radio, television, remote controls, wireless phones, etc.
  - 200 MHz- 1GHz: alarms, medical implants, walkie-talkies, television, mobile phones.
  - 1- 2 GHz: GPS, medical telemetry, phone mobiles
  - 2.4 GHz: free band… satellite radio, satellite phones, microwave ovens, weather radars, WI-FI, BLUETOOTH.
  - 2.5- 5 GHz: satellite communications (e.g, TV)
  - 5-50 GHz: Wi-Fi, police radars
  - 50-300 GHz: short-distance signals.

Electromagnetic spectrum

- ISM frequency bands:
  - 900 – 928 MHz
  - 2,400 – 2,4835 GHz
  - 5,725 – 5,850 GHz



Wireless LAN Standards

Standards

- They specify the RF spectrum used, data rates, how the information is transmitted, and more.
- The main organization responsible for the creation of wireless technical standards is the IEEE.
- Standardization of WLANs is in charge of IEEE & WIFI Alliance.
- IEEE in standard 802.11 is in charge of:
  - Define specifications of high performance WLANs
  - Ensures Interoperability
  - Security
  - Quality of Service.

Wireless LAN Standards

- WIFI Alliance is in charge of:
  - Certificates that a manufacturer's product may interoperate with another manufacturer's one.
  - is responsible for testing wireless LAN devices from different manufacturers.
  - The Wi-Fi logo on a device means that this equipment meets standards and should interoperate with other devices of the same standard.
  - Promote the use of WLANs

IEEE 802.11 standard

- The IEEE 802.11 standard governs the WLAN environment.
- There are four amendments to the IEEE 802.11 standard that describe different characteristics for wireless communications.
- The currently available amendments are
  1. **802.11a**,
  2. **802.11b**,
  3. **802.11g** and
  4. **802.11n**. (**802.11n** is ratified on Sept 14, 2009)

802.11a

- Uses 5 GHz RF spectrum
- Not compatible with 2.4 GHz spectrum, i.e. 802.11b/g/n devices
- Range is approximately 33% that of the 802.11 b/g
- Supports data rates of 6, 9, 12, 18, 24, 36, 48, and 54 Mbps
- Relatively expensive to implement compared to other technologies.
- Increasingly difficult to find 802.11a compliant equipment
- Has 12 to 23 clean channels depending on the country

802.11b and 802.11g

802.11b:

- Operate on 2.4GHz to 2.4835GHz radio band
- Supports data rates of 1, 2, 5.5, and 11 Mbps.
- Range of approximately 46 m (150 ft) indoors/96 m (300 ft.) outdoors

802.11g:

- 2.4 GHz technologies
- Maximum data-rate increase to 54 Mbps
- Same range as the 802.11b
- Backward compatible with 802.11b

802.11n and 802.11i

802.11n:

- uses multiple-input, multiple-output (MIMO) technology
- 2.4 GHz technologies (draft standard specifies support for 5 GHz)
- Extends the range and data throughput because it uses multiple receiving & transmitting antenna
- Backward compatible with existing 802.11g and 802.11b equipment (draft standard specifies support for 802.11a)
- Read about 802.11i

Differences between standards

Common IEEE WLAN Standards

Standard	Release Date	Frequency	Data Rate (Max)	Maximum Range*
802.11	July 1997	2.4 GHz	2 Mbps	undefined
802.11a	October 1999	5 GHz	54 Mbps	50 m
802.11b	October 1999	2.4 GHz	11 Mbps	100 m
802.11g	June 2003	2.4 GHz	54 Mbps	100 m
**802.11n	Draft - Nov 2006 Release - Jan 2007 Approval - April 2007	2.4 GHz or 5 GHz	540 Mbps	250 m

*Maximum Range - This value can vary widely. ~ The 802.11n standard is still in draft and values may change.

Wireless LAN Components

- Once a standard is adopted, it is important that all components within the WLAN adhere to the standard, or are at least compatible with the standard.
- There are various components that must be considered in a WLAN including: a wireless client or STA, an Access Point, a Wireless Bridge and an antenna.
-

WLAN Components:-Wireless Client

- Any host device that can participate in a wireless network.
- Most devices that can be connected to a traditional wired network can be connected to a WLAN if equipped with the proper wireless NIC and software.
- Can either be stationary or mobile
- Commonly referred to as a STA, short for station.
- Examples include: laptops, PDAs, printers, projectors, storage devices and digital cameras.

WLAN Components:-Access Point

- Controls access between a wired and a wireless network,

i.e. allows wireless clients to gain access to a wired network and vice versa.

- Acts as a media converter accepting the Ethernet frames from the wired network and converting them to 802.11 compliant frames before transmitting them on the WLAN.
- Accepts 802.11 frames from the WLAN and converts them into Ethernet frames before placing them onto the wired network.
- APs support wireless connections within a limited area, known as a cell or
- Basic Service Set (BSS)

WLAN Components:-Wireless Bridge

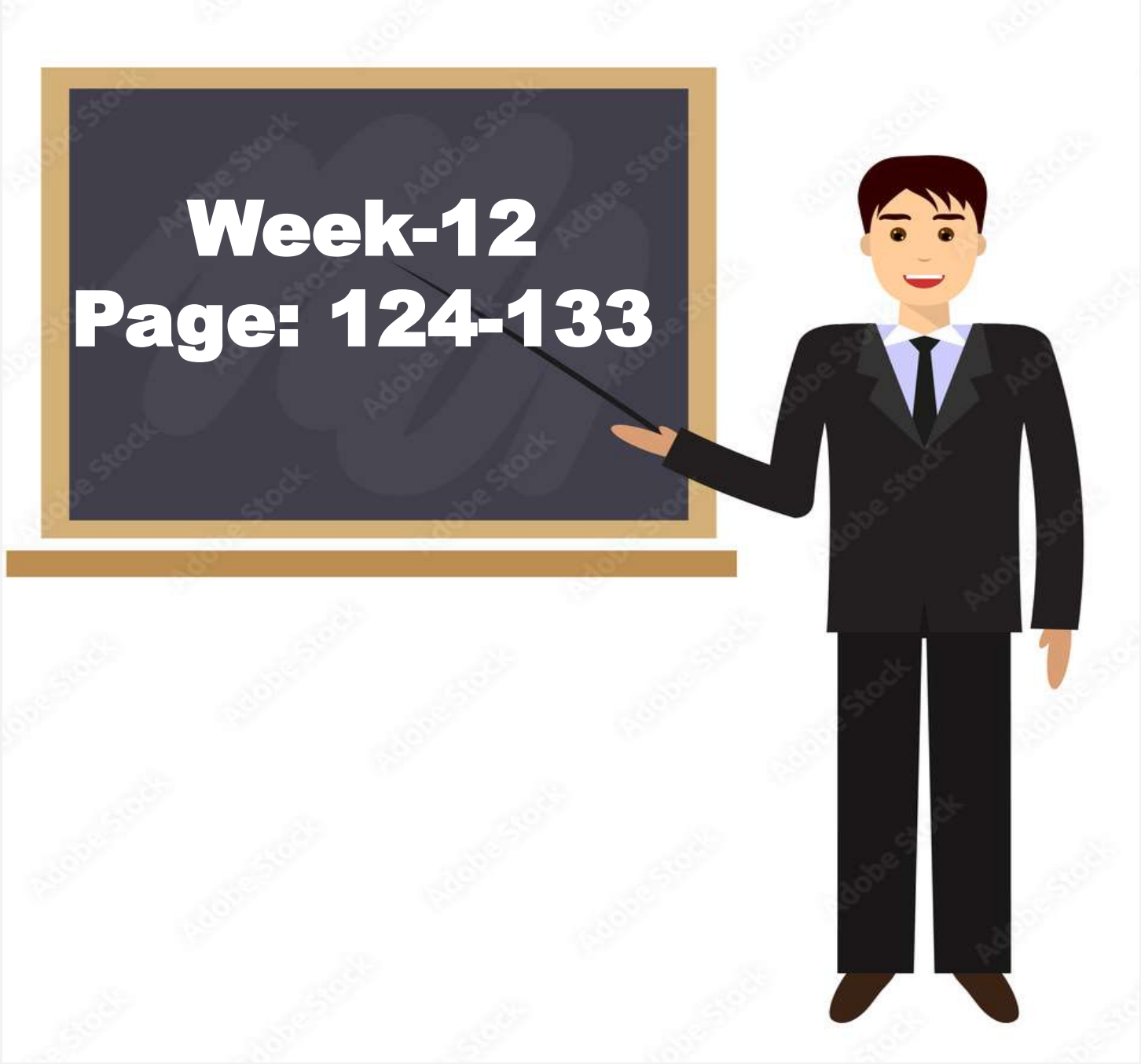
- Used to connect two wired networks through a wireless link
- Allows long-range point-to-point connections between networks
- Using the unlicensed RF frequencies, networks 40km(25miles) or more apart can be connected without the use of wires

WLAN Components:-**Antennas**

- Used on APs and Wireless bridges
- Increases the output signal strength from a wireless device
- Receives wireless signals from other devices such as STAs
- Increase in signal strength from an antenna is known as the gain
- Higher gains usually translate into increased transmission distances
- Antennas are classified according to the way they radiate the signal.
- Directional antennas concentrate the signal strength into one direction.
- Omni-directional antennas are designed to emit equally in all directions.
- By concentrating the entire signal into one direction, directional antennas can achieve great transmission distances.
- Directional antennas are normally used in bridging applications while Omni-directional antennas are found on APs.

WLANs and the SSID(Service Set Identifier)

- When building a wireless network, it is important to make sure that the wireless components connect to the appropriate WLAN.
- The SSID is a case-sensitive, alpha-numeric string that is up to 32-characters.
- It is sent in the header of all frames transmitted over the WLAN.
- Tells wireless devices which WLAN they belong to and with which other devices they can communicate.
- Regardless of the type of WLAN installation, all wireless devices in a WLAN must be configured with the same SSID in order to communicate.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Forms of WLAN installations

- Ad-hoc/Self Organized
- Infrastructure Mode

Forms of WLAN installations:-Ad-hoc

- An ad-hoc network is a collection of mobile nodes(ad hoc means "for this‟ or "for this purpose only."), that :
  - Connect over the wireless/wired medium
  - without the need of any pre-deployed existing infrastructure
- Nodes in a MANET can dynamically self-organize into temporary and arbitrary and network topologies
- Multi-hop flexible low cost last mile-extensions of wired infrastructure
- The simplest form of a wireless network is created by connecting two or more wireless clients together in a peer-to-peer network.
- A wireless network established in this manner is known as an ad-hoc network and does not include an AP.
- All clients within an ad-hoc network are equal.
- The area covered by this network is known as an Independent Basic Service Set (IBSS).
- A simple ad-hoc network can be used to exchange files and information between devices without the expense and complexity of purchasing and configuring an AP.

Forms of WLAN installations:-Ad-hoc

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Why Ad Hoc Networks ?

- Ease and Speed in deployment
- Decreased dependence on infrastructure
- Only possible solution to interconnect a group of nodes
- Many Commercial Products available today

Mobile Ad-Hoc network Applications

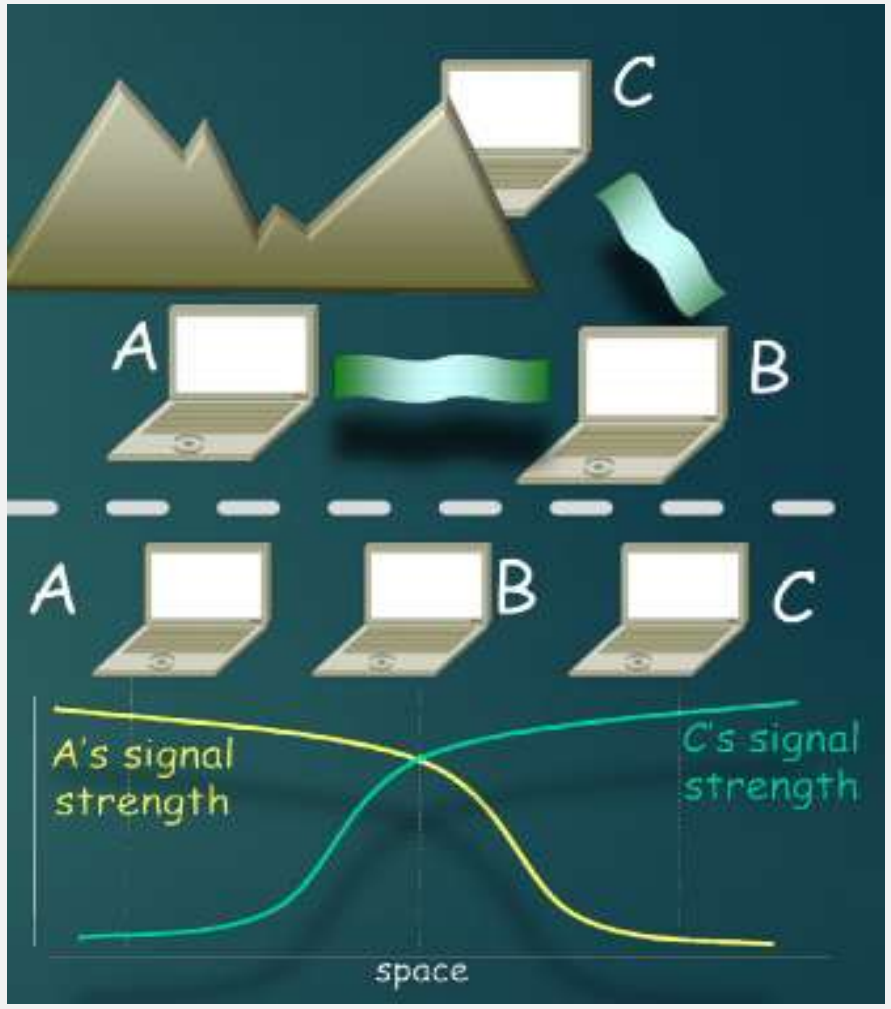
- Body Area Networking
  - body sensors network,
- Personal area Networking
  - cell phone, laptop, ear phone, wrist watch
- Disaster Recovery Areas
- Emergency operations
  - search-and-rescue (earthquakes, boats, airplanes…)
  - Policing and fire fighting
- Military environments
  - soldiers, tanks, planes, battlefield
- Civilian environments
  - vehicle networks
  - meeting rooms
  - sports stadiums
  - boats, small aircraft
- E-Health/M-Health/U-Health

What's unique about a mobile ad-hoc network ?

- Traffic characteristics may differ in different ad hoc networks
  - various and volatile wireless link quality
  - bit rate, reliability requirements, unicast, multicast,
  - host-based/ content-based/ capability-based addressing
- Co-exist and Co-operate with infrastructure-based networks
- Mobility characteristics may be different
  - speed, direction of movement, pattern of movement
- Symmetric vs. Asymmetric (nodes' capabilities and responsibilities)
- Pervasive (cheap) devices: Power constraints
- Security/Confidentiality issues

Issues in Mobile Ad-hoc Networks

- Limited wireless transmission range
- Broadcast nature of the wireless medium
  - Hidden terminal problem
- Packet losses due to transmission errors
- Mobility-induced route changes
- Mobility-induced packet losses
- Battery constraints
- Potentially frequent network partitions
- Ease of snooping on wireless transmissions (security hazard)

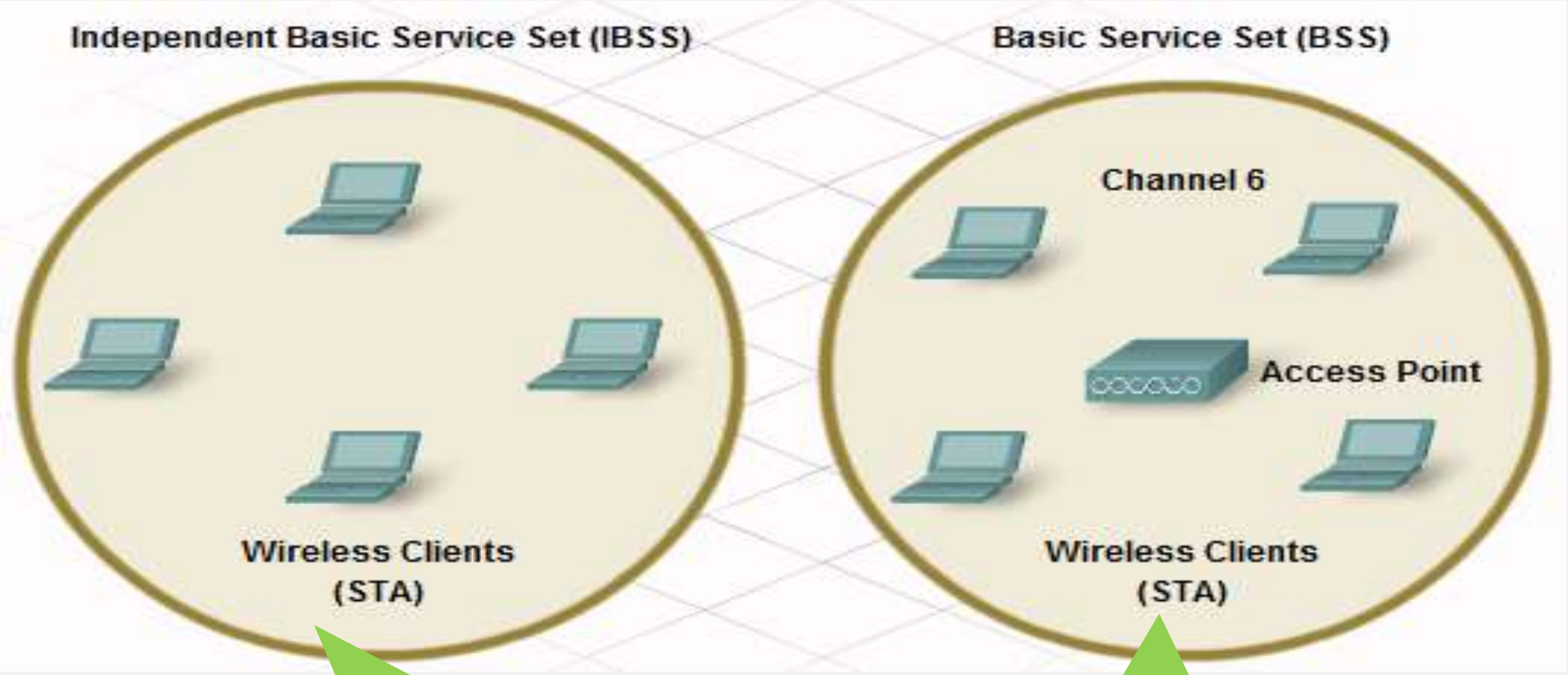


Reading assignment Routing in MANET

Forms of WLAN installations:- Infrastructure Mode

- Although an ad-hoc arrangement may be good for small networks, larger networks require a single device that controls communications in the wireless cell.
- If present, an AP will take over this role and control who can talk and when.
- This is known as infrastructure mode and is the mode of wireless communication most often used in the home and business environment.
- In this form of WLAN, individual STAs cannot communicate directly with each other.
- To communicate, each device must obtain permission from the AP.
- The AP controls all communications and ensures that all STAs have equal access to the medium. The area covered by a single AP is known as a Basic Service Set (BSS) or cell.

Exercise:- Individual Participation Mandatory

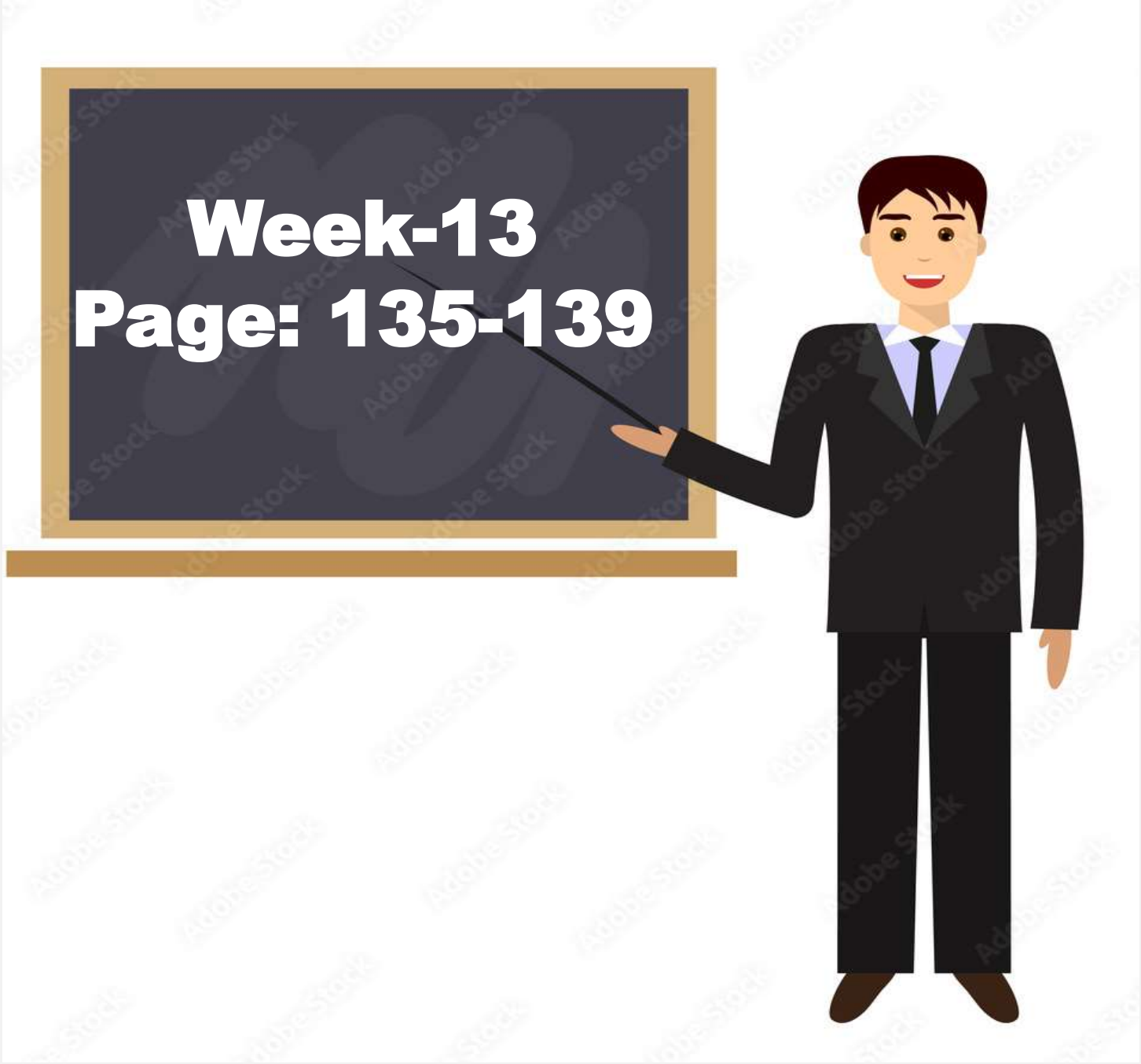


Ad-hoc Network

Infrastructure Network

What are BSS,ESS

- The Basic Service Set (BSS) is the smallest building block of a WLAN.
- The area of coverage of a single AP is limited.
- To expand the coverage area, it is possible to connect multiple BSSs through a Distribution System (DS). This forms an Extended Service Set (ESS).
- An ESS uses multiple APs. Each AP is in a separate BSS.
- In order to allow movement between the cells without the loss of signal, BSSs must overlap by approximately 10%.
- This allows the client to connect to the second AP before disconnecting from the first AP.
- Most home and small business environments consist of a single BSS.
- However, as the required coverage area and number hosts needed to connect increases it becomes necessary to create an ESS.
- **What is the difference between BSSID and SSID?**
- BSSID (MAC of its wireless interface) and a SSID (configured by the network administrator).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Roaming in Wireless Communication environment

Roaming

- Typically, wireless networks within buildings require more than just one access point to cover all rooms.
- Depending on the solidity and material of the walls, one access point has a transmission range of 10–20 m if transmission is to be of decent quality.
- Each story of a building needs its own access point(s) as quite often walls are thinner than floors.
- If a user walks around with a wireless station, the station has to move from one access point to another to provide uninterrupted service.
- Moving between access points is called roaming.

The steps for roaming between access points

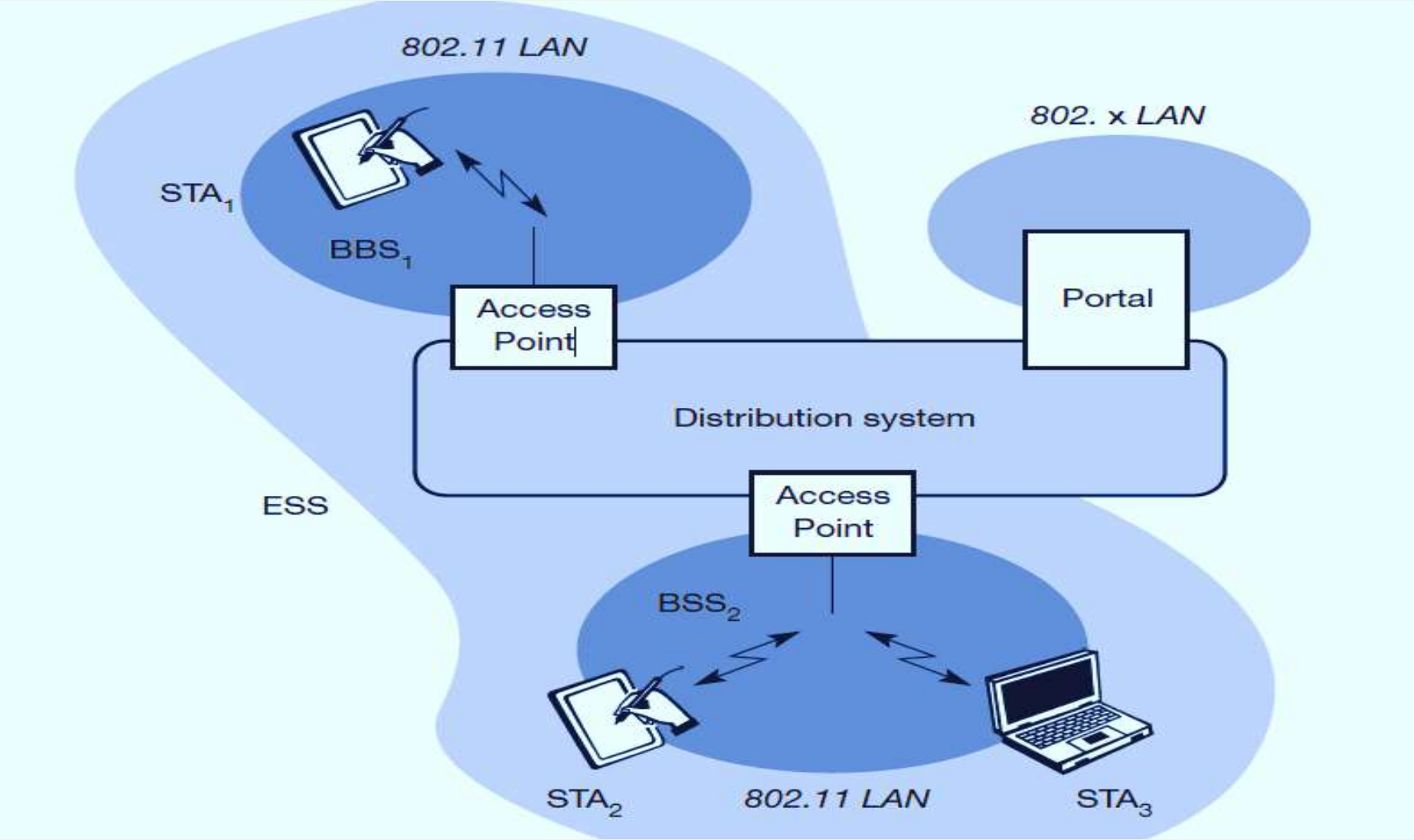
1. A station decides that the current link quality to its access point AP1 is too poor. The station then starts scanning for another access point.
2. Scanning involves the active search for another BSS and can also be used for setting up a new BSS in case of ad-hoc networks.
   - IEEE 802.11 specifies scanning on single or multiple channels (if available at the physical layer) and differentiates between passive scanning and active scanning.
   - Passive scanning simply means listening into the medium to find other networks, i.e., receiving the beacon of another network issued by the synchronization function within an access point.
   - Active scanning comprises sending a probe on each channel and waiting for a response. Beacon and probe responses contain the information necessary to join the new BSS.
3. The station then selects the best access point for roaming based on, e.g., signal strength, and sends an association request to the selected access point AP2.
4. The new access point AP2 answers with an association response. If the response is successful, the station has roamed to the new access point AP2. Otherwise, the station has to continue scanning for new access points.
5. The access point accepting an association request indicates the new station in its BSS to the distribution system (DS). The DS then updates its database, which contains the current location of the wireless stations.

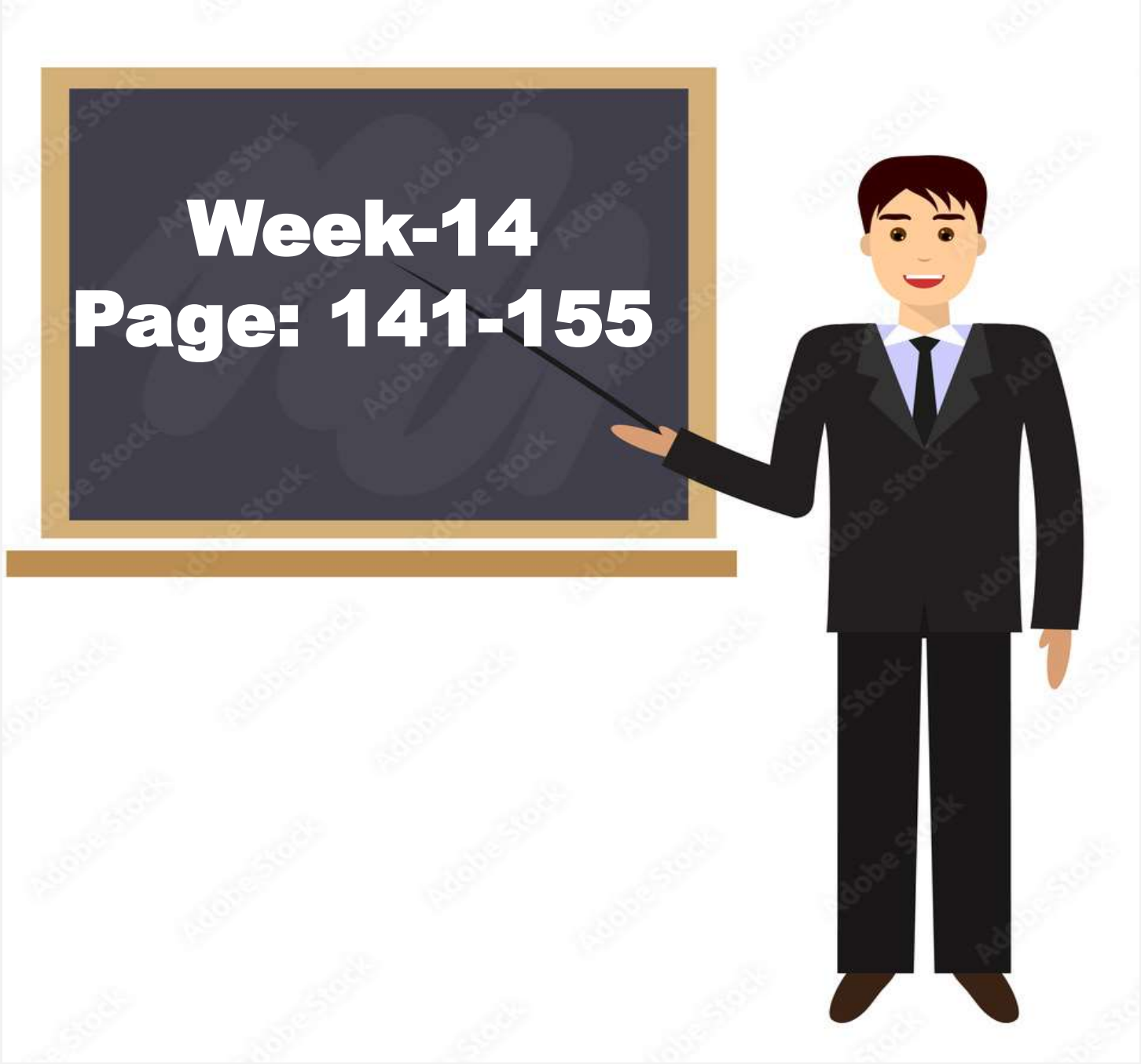
The steps for roaming between access points

- To manage wireless links.
- Beacon. Sent periodically by MAC sublevel to inform about the existence of a wireless network
  - Interval: configurable parameter.
- Probe request. Enable MAC sublevel to search for wireless networks within an area.
  - Informs about transmission rates.
- Probe response. Response to Probe Request.
- Association request. MAC sublevel requests the connection to a wireless network.
- Association response. Connection confirmation.

- Unfortunately, many products implemented proprietary or incompatible versions of protocols that support roaming and inform the old access point about the change in the station's location.
- The **standard IEEE 802.11f** (Inter Access Point Protocol, IAPP) should provide a compatible solution for all vendors.
- This also **includes load-balancing** between access points and key generation for security algorithms based on IEEE 802.1x (IEEE, 2001).

The steps for roaming between access points

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Objectives

- **At the end of this session students will be able to:**
  - Define MAC
  - Examine how to use data link layer
  - Discuss on hidden and exposed terminal in the Layer 2 of OSI model
  - Discuss on Near and Far terminal in the Layer 2 of OSI model
  - Know and explain MA Techniques
  - Define Multiple access with collision avoidance
  - Define Bluetooth and explain the current trends of Bluetooth

Medium access control @ Layer 2 of the OSI Model

- Medium access control comprises all mechanisms that regulate user access to a medium using SDM, TDM, FDM, or CDM.
- MAC is thus similar to traffic regulations in the highway/multiplexing.
- The fact that several vehicles use the same street crossing in TDM, for example, requires rules to avoid collisions; one mechanism to enforce these rules is traffic lights.
- While the previous chapter mainly introduced mechanisms of the physical layer, layer 1, of the ISO/OSI reference model, MAC belongs to layer 2, the **data link control layer (DLC).**

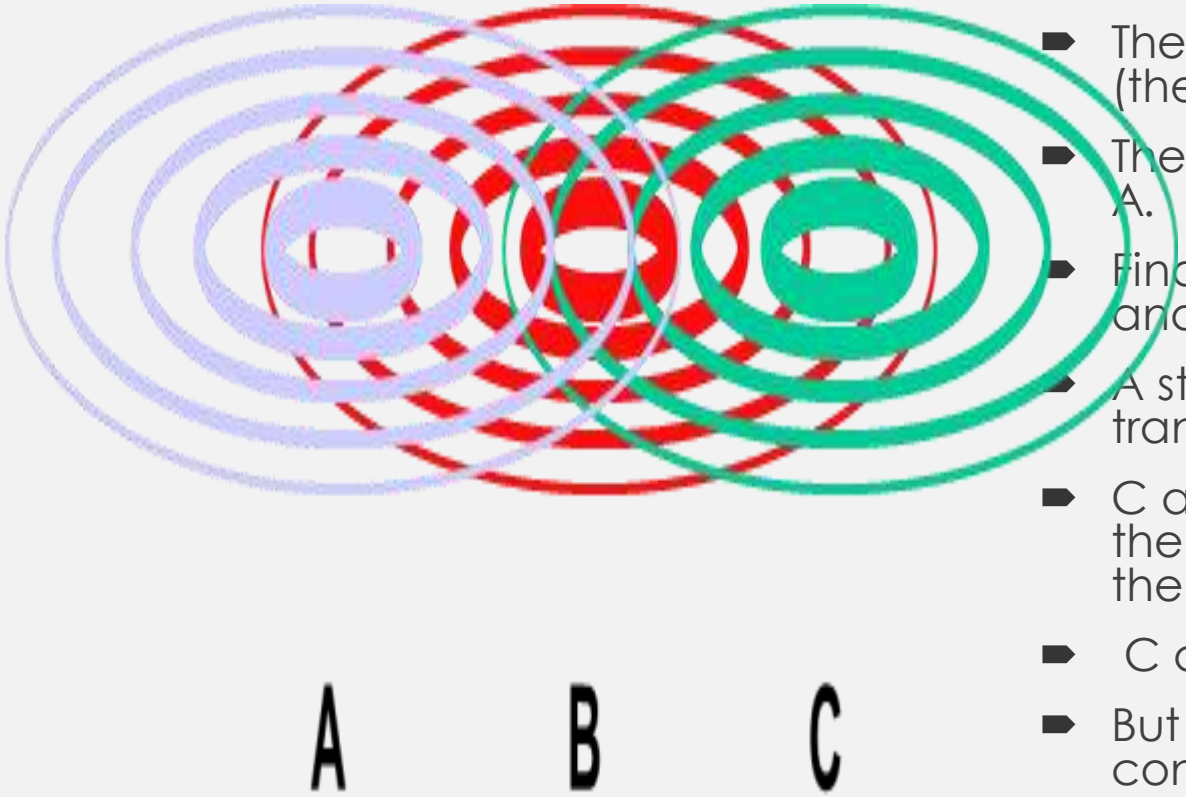
Medium access control @ Layer 2 of the OSI Model

- The main question in connection with MAC in the wireless is whether it is possible to use elaborated MAC schemes from wired networks, for example, CSMA/CD as used in the original specification of IEEE 802.3 networks (aka Ethernet).
- Just consider **carrier sense multiple access** with collision detection,(CSMA/CD) which works as follows.
- A sender senses the medium (a wire or coaxial cable) to see if it is free.
- If the medium is busy, the sender waits until it is free.
- If the medium is free, the sender starts transmitting data and continues to listen into the medium.
- If the sender detects a collision while sending, it stops at once and sends a jamming signal.
- **Why does this scheme fail in wireless networks?**
- CSMA/CD is not really interested in collisions at the sender, but rather in those at the receiver.

Medium access control @ Layer 2 of the OSI Model II

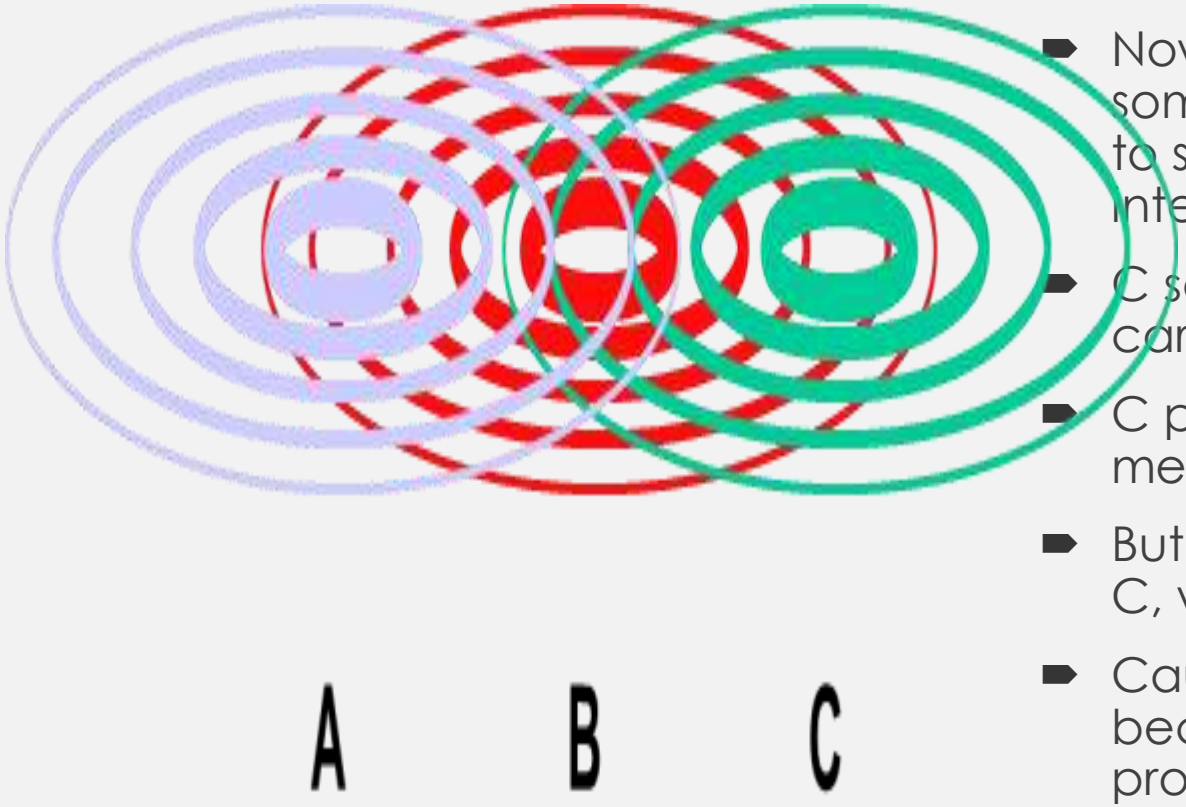
- The situation is different in wireless networks.
- The strength of a signal decreases proportionally to the square of the distance to the sender. Obstacles attenuate the signal even further.
- The sender may now apply carrier sense and detect an idle medium. The sender starts sending – but a collision happens at the receiver due to a second sender->**hidden terminal**.
- Collision detection is very difficult in wireless scenarios as the transmission power in the area of the transmitting antenna is several magnitudes higher than the receiving power.

Hidden and exposed terminals



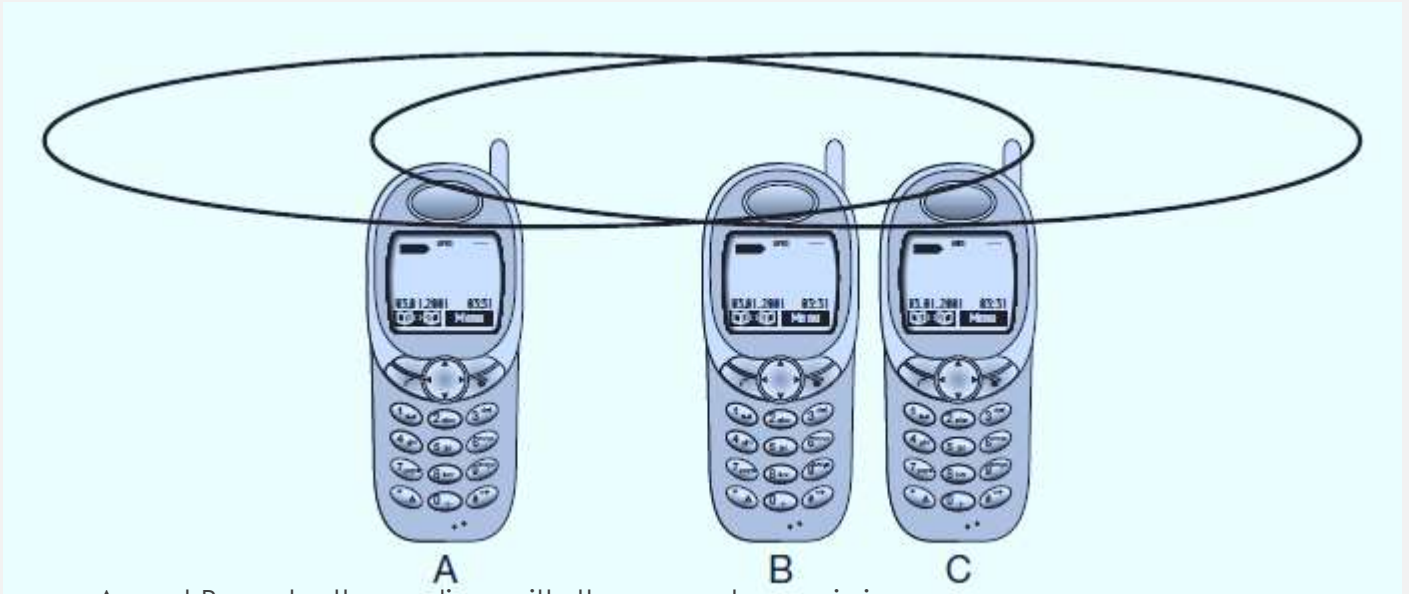
- The transmission range of A reaches B, but not C (the detection range does not reach C either).
- The transmission range of C reaches B, but not A.
- Finally, the transmission range of B reaches A and C, i.e., A cannot detect C and vice versa.
- A starts sending to B, C does not receive this transmission.
- C also wants to send something to B and senses the medium. The medium appears to be free, the carrier sense fails.
- C also starts sending causing a collision at B.
- But A cannot detect this collision at B and continues with its transmission.
- A is hidden for C and vice versa.

Hidden and exposed terminals



- Now consider the situation that B sends something to A and C wants to transmit data to some other mobile phone outside the interference ranges of A and B.
- C senses the carrier and detects that the carrier is busy (B's signal).
- C postpones its transmission until it detects the medium as being idle again.
- But as A is outside the interference range of C, waiting is not necessary.
- Causing a 'collision' at B does not matter because the collision is too weak to propagate to A.
- In this situation, C is **exposed** to B.

Near and far terminals



- A and B are both sending with the same transmission power.
- As the signal strength decreases proportionally to the square of the distance, B's signal drowns out A's signal.
- As a result, C cannot receive A's transmission.
- Now think of C as being an arbiter for sending rights (e.g., C acts as a base station coordinating media access).
- In this case, terminal B would already drown out terminal A on the physical layer.
- C in return would have no chance of applying a fair scheme as it would only hear B.
- The near/far effect is a severe problem of wireless networks using CDM->All signals should arrive at the receiver with more or less the same strength.

MA Techniques

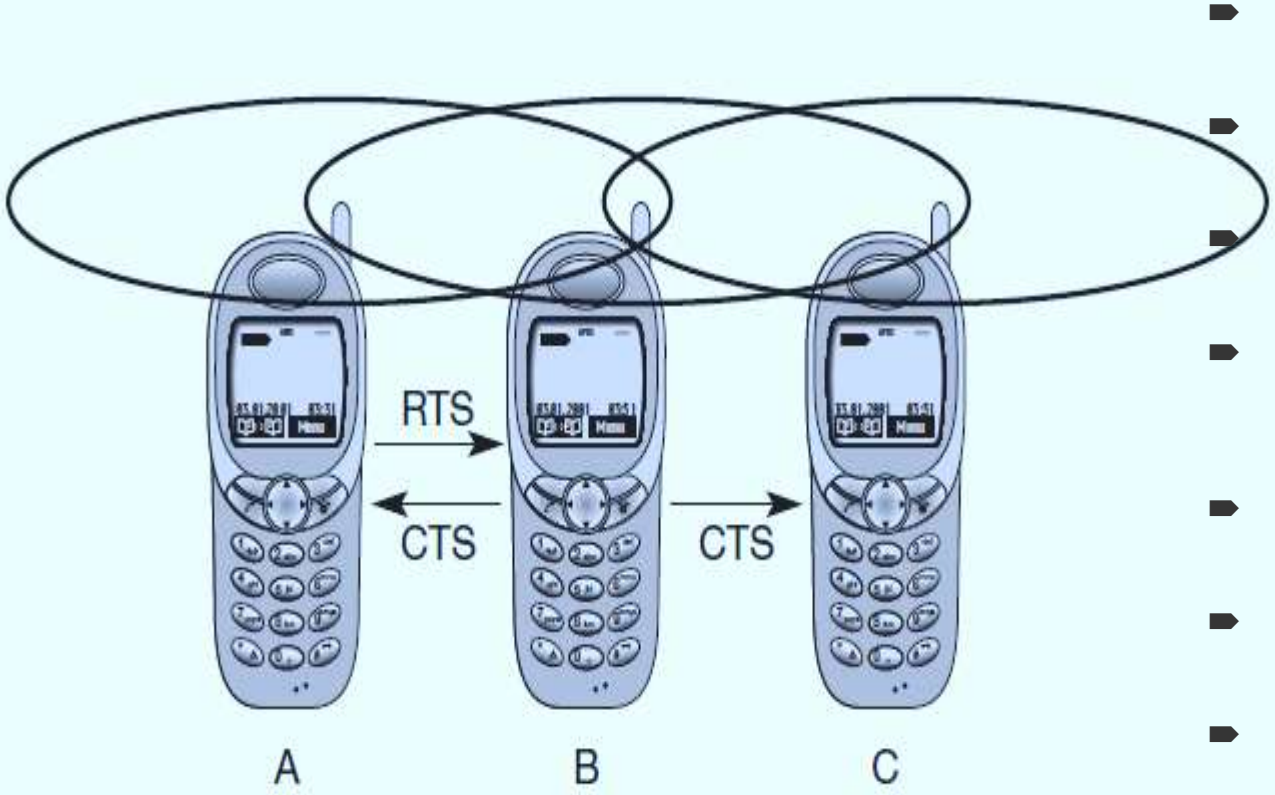
- **Space Division Multiple Access (SDMA)** is used for allocating a separated space to users in wireless networks.
- A typical application involves assigning an optimal base station to a mobile phone user.
- The mobile phone may receive several base stations with different quality.
- A MAC algorithm could now decide which base station is best, taking into account which frequencies (FDM), time slots (TDM) or code (CDM) are still available (depending on the technology).
- Typically, SDMA is never used in isolation but always in combination with one or more other schemes.
- The basis for the SDMA algorithm is formed by cells and sectored antennas which constitute the infrastructure implementing space division multiplexing (SDM)

MA Techniques II

- **Frequency division multiple access (FDMA)** comprises all algorithms allocating frequencies to transmission channels according to the frequency division multiplexing (FDM) scheme.
- Allocation can either be fixed (as for radio stations or the general planning and regulation of frequencies) or dynamic (i.e., demand driven).
- Channels can be assigned to the same frequency at all times, i.e., pure FDMA,
- or change frequencies according to a certain pattern, i.e., FDMA combined with TDMA.
- The latter example is the common practice for many wireless systems to circumvent narrowband interference at certain frequencies, known as frequency hopping.

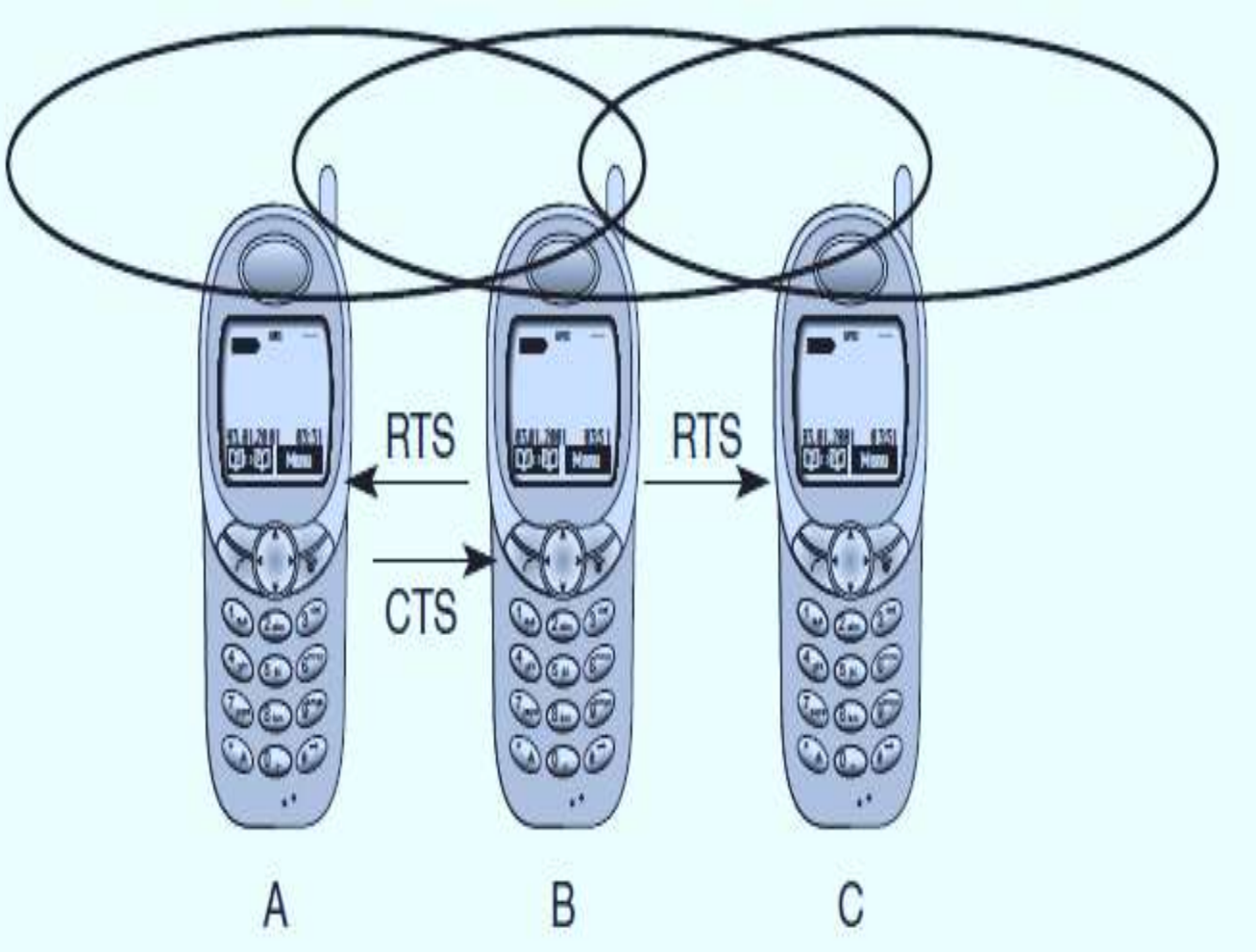
- **Reading assignment on other MAC techniques(ex. CDMA, TDMA,F TDMA, slotted Aloha,…)**

Multiple access with collision avoidance(as a Solution)



- With MACA, A does not start its transmission at once, but sends a request to send (RTS) first.
- B receives the RTS that contains the name of sender and receiver, as well as the length of the future transmission.
- This RTS is not heard by C, but triggers an acknowledgement from B, called clear to send (CTS).
- The CTS again contains the names of sender (A) and receiver (B) of the user data, and the length of the future transmission.
- This CTS is now heard by C and the medium for future use by A is now reserved for the duration of the transmission.
- After receiving a CTS, C is not allowed to send anything for the duration indicated in the CTS toward B.
- A collision cannot occur at B during data transmission, and the hidden terminal problem is solved – provided that the transmission conditions remain the same. (Another station could move into the transmission range of B after the transmission of CTS.)
- Is collision is avoided using MACA?

Multiple access with collision avoidance



- Can MACA also help to solve the ‘exposed terminal’ problem?
- Remember, B wants to send data to A, C to someone else.
- But C is polite enough to sense the medium before transmitting, sensing a busy medium caused by the transmission from B.
- C defers, although C could never cause a collision at A.
- With MACA, B has to transmit an RTS first containing the name of the receiver (A) and the sender (B).
- C does not react to this message as it is not the receiver, but A acknowledges using a CTS which identifies B as the sender and A as the receiver of the following data transmission.
- C does not receive this CTS and concludes that A is outside the detection range.
- C can start its transmission assuming it will not cause a collision at A.
- The problem with exposed terminals is solved without fixed access patterns or a base station. ad-hoc

Ad-hoc network(Bluetooth)

- Compared to the WLAN technologies(802.11x), the Bluetooth technology discussed here aims at so-called ad-hoc Pico nets, which are local area networks with a very limited coverage and without the need for an infrastructure.
- This is a different type of network is needed to connect different small devices in close proximity (about 10 m) without expensive wiring or the need for a wireless infrastructure.
- In 2001, the first products hit the mass market, and many mobile phones, laptops, PDAs, video cameras etc. are equipped with Bluetooth technology today.
- At the same time the Bluetooth development started, a study group within IEEE 802.11 discussed wireless personal area networks (WPAN) under the following
- five criteria:
- **Market potential**: How many applications, devices, vendors, customers are available for a certain technology?
- **Compatibility**: Compatibility with IEEE 802.
- **Distinct identity:** Originally, the study group did not want to establish a second 802.11 standard. However, topics such as, low cost, low power, or small form factor are not addressed in the 802.11 standard.
- Technical feasibility: Prototypes are necessary for further discussion, so the study group would not rely on paper work.
- **Economic feasibility:** Everything developed within this group should be cheaper than other solutions and allow for high-volume production.
- Obviously, Bluetooth fulfills these criteria so the WPAN group cooperated with the Bluetooth consortium. IEEE founded its own group for WPANs, IEEE 802.15.

Ad-hoc network(LAB), How to create ad-hoc network?

Step1:-GO to your lap top and open CMD

Step2:- write this command on CMD window

-netsh wlan set hostednetwork ssid=your_ssid_name key=your_key mode=allow->press enter

Step3:- After cretating ssid write this command to start your network

-netsh wlan start hostednetwork

Step4:-go to your connection window and look available networks.

Step5:- tell what you have seen for your boss

Step6:- select one network to access among those if any

Step7:- Again tell what you face while try to connect to the network again for your boss

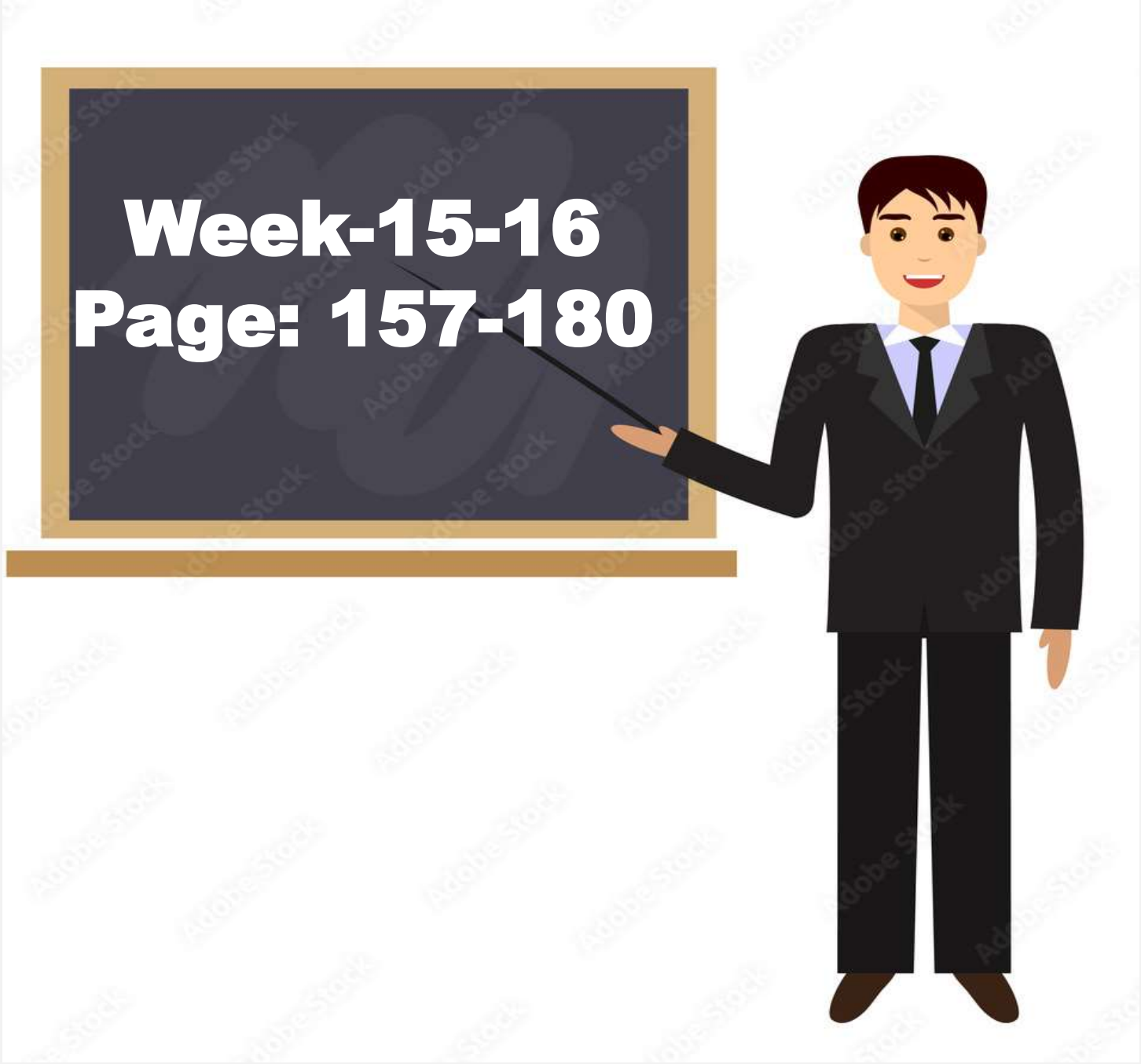
Step8:- get the code from the administrator/owner of the network to which you try to connect and tell your code for your colleges

Step9:- this is all!!!!!

Thank you, Like me on FB!

Next session chapter 4

Questions welcome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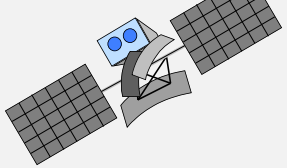
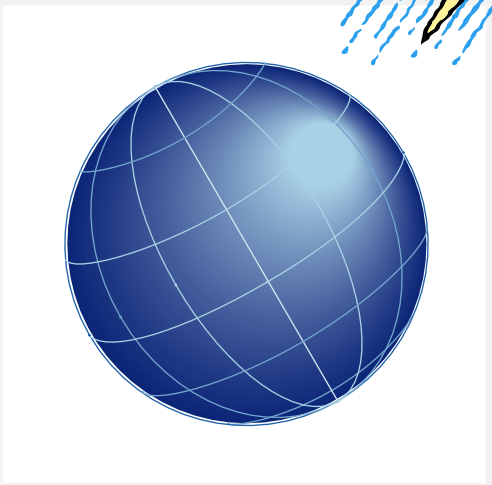




Chapter 4:- MOBILE (CELLULAR) NETWORK and SERVICEs

Objectives

At the end of this session, students will be able to:

- Define cellular networking/communication
- Identify cellular communication components
- Identify Elements which are Connected to The MSC
- Differentiate & understand different databases in the cellular communication system
- Discuss and present the applicability of **Equipment Identity Register (EIR)** in the case of home country
- Discuss on which different Base Stations which are located in the country side(home)
- Identify and their SIM, SIM card, Serial number of the apparatus
- Define handover, handoff, and roaming while moving one point to the other
- Knowing cellular call procedures involved in making different types **of calls**
- Understand the basics of **CDPD** & list applications of **CDPD** in the home country

Know and discuss Satellite Systems

What is Cellular Communication System?

- Cellular communication is designed to provide communications between two moving units, or between one mobile unit and one stationary phone or land unit (PSTN).
- A service provider must be able to locate and track a caller, assign a channel to the call, and transfer the channel from base station to base station as the caller moves out of range (handover/handoff).

To make this tracking possible…..

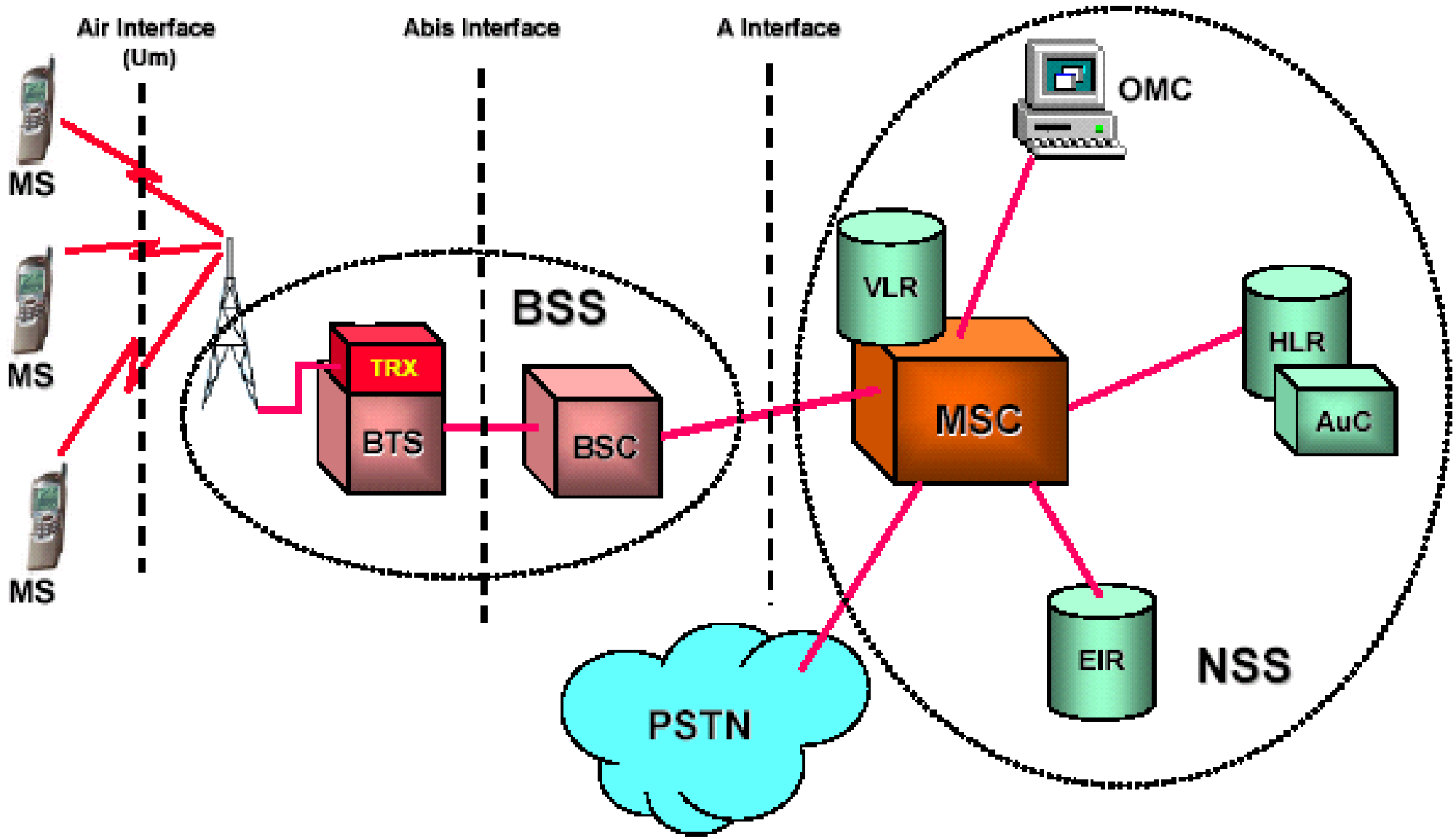
- Each **cellular service area** is divided into small regions called cells.
- Each cell contains an antenna and is controlled by powered network station, called the **base station (BS).**
- Each base station is controlled by a switching office, called a **mobile switching center (MSC)**.
- The MSC coordinates communication between all the base stations and the telephone central office (exchange). It is a computerized center that is responsible for connecting calls, recording call information, and billing.

Main component in cellular communication system

3 main components:

- **Mobile Station (MS) – UE, SIM**
- **Base Station Subsystem (BSS)** – BTS, RBS, BSC
- **Network and Switching Subsystem (NSS) – MSC, VLR, HLR,**

GSM Architecture Overview



Main component in cellular communication system

A. Network & Switching Subsystem (NSS)

- Mobile Switching Center (MSC)
- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Equipment Identify Register (EIR)
- Authentication Centre (AuC)
- Gateway Mobile Switching Center (GMSC)
- SMS Gateway (SMS-G)

NSS:-Mobile Switching Center (MSC)

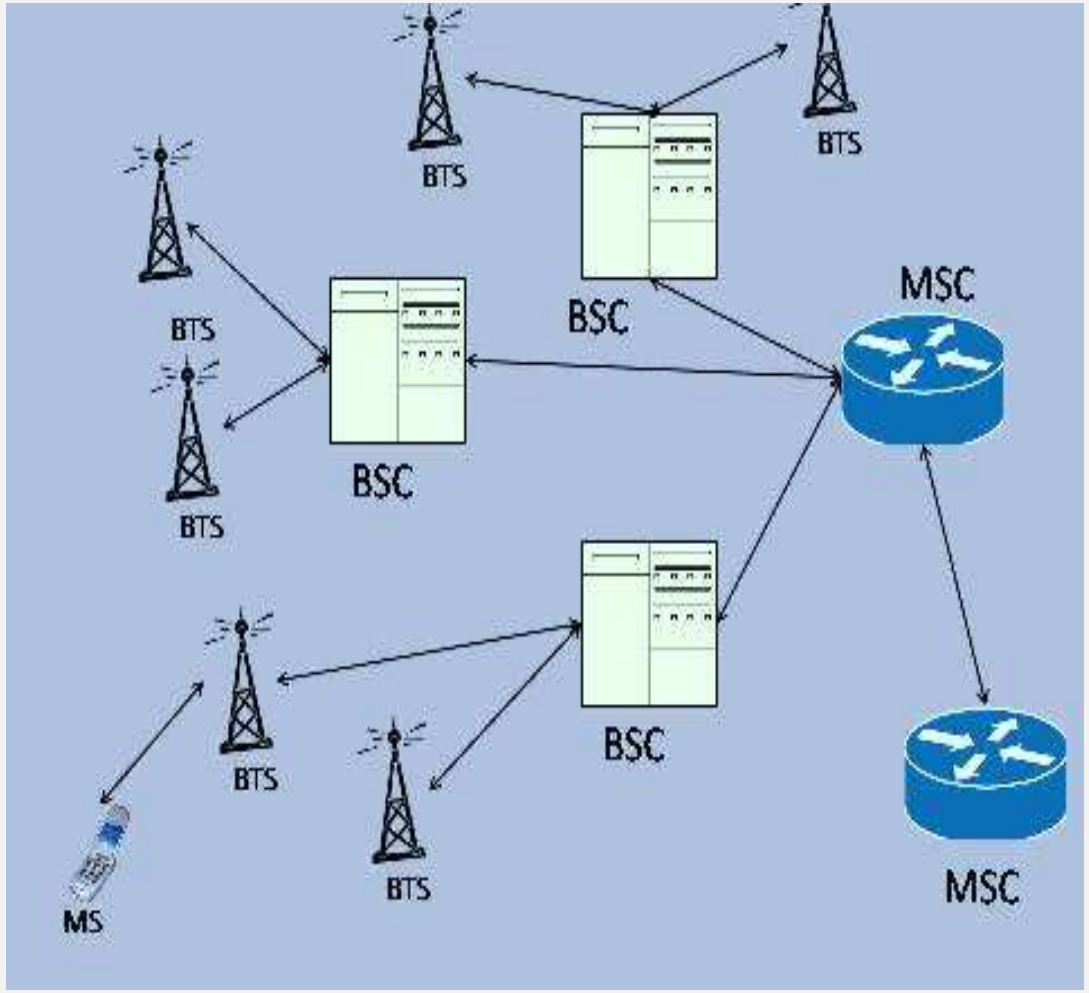
- The MSC is the heart of the GSM network.
- From technical perspective MSC is just an ordinary Integrated Services Digital Network (ISDN) exchange
- One MSC can handles multiple BSCs and also interfaces with other MSC's (Using E-Interface).
- It also handles inter-BSC handoffs as well as coordinates with other MSC's for inter-MSC handoffs.

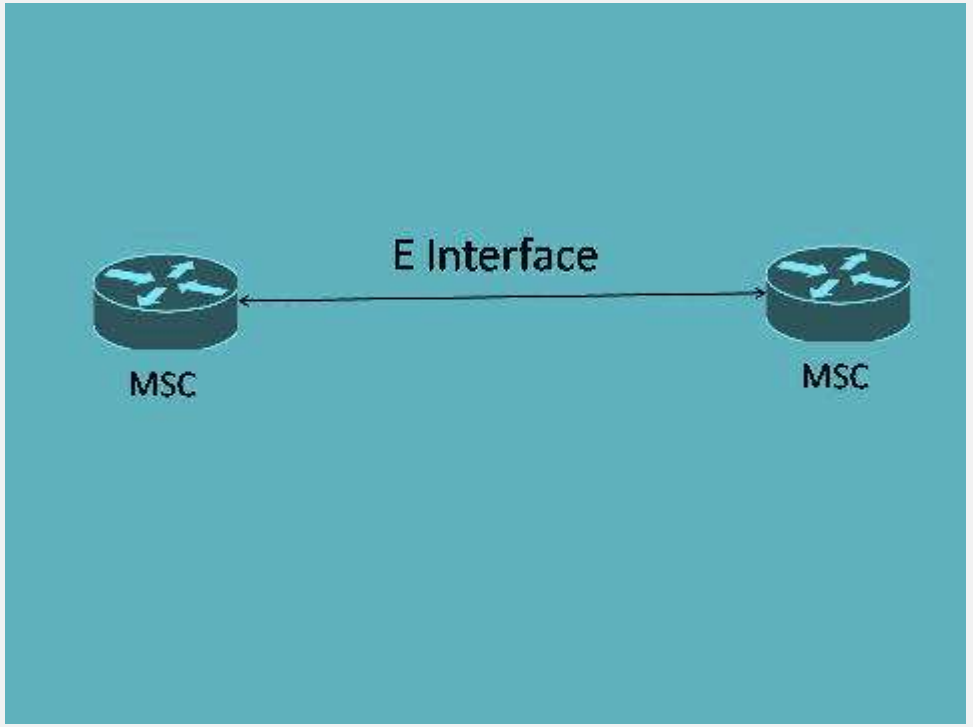
NSS:-Mobile Switching Center (MSC)

Ericsson

The Mobile Switching Centre Server (MSC-S) provides control of high-capacity switching in mobile circuit core networks

NSS:-Mobile Switching Center (MSC)





NSS:-Mobile Switching Center (MSC)

- MSC performs the telephony switching functions of the system.
- Controls calls to and from other telephony and data systems, such as the Public Switched Telephone Network (PSTN) and Public Land Mobile Network (PLMN).
- Difference between a MSC and an exchange in a fixed network, MSC has to take into account the impact of the allocation of radio resources and the mobile nature of the subscribers and has to perform in addition, at least the following procedures:
  - required for location registration
  - procedures required for handover
- MSC can be connected to only one VLR or more VLR. Therefore, all mobile stations that move around under base stations connected to the MSC are always managed by the same VLR.
- MSC would communicate typically with one EIR. While it is possible for an MSC to communicate to multiple EIRs, this is highly unlikely since the EIR provides a centralized and geographic independent function.

NSS:-MSC- The Elements Connected to The MSC

- The MSC connects to the following elements:
  A. The Home Location Register (HLR)
  B. The Visitor Location Register (VLR)
  C. Equipment Identify Register (EIR)
  D. Authentication Centre (AuC)
  E. Gateway Mobile Switching Center (GMSC)
  F. SMS Gateway (SMS-G)

NSS:-MSC- The Elements Connected to The MSC

A. The Home Location Register (HLR)

- HLR is a central database that contains details of each mobile phone subscriber that is authorized to use the GSM core network.
- The HLRs store details of every SIM card issued by the mobile phone operator.
- Each SIM has a unique identifier called an **IMSI** which is the primary key to each HLR record.
- Examples of other data stored in the :
  - GSM services that the subscriber has requested or been given.
  - GPRS settings to allow the subscriber to access packet services.
  - Current location of subscriber (VLR and serving GPRS support node/SGSN).
  - Call divert settings applicable for each associated **MSISDN.**

NSS:-MSC- The Elements Connected to The MSC

A. The Home Location Register (HLR) :Responsibilities

- management of service profiles
- mapping of subscriber identities (MISDN, IMSI)
- supplementary service control and profile updates
- execution of supplementary service logic e.g. incoming calls barred.
- passing subscription records to VLR
- directly receives and processes MAP transactions and messages from elements in the GSM network, for example, the location update messages received as mobile phones roam around.

NSS:-MSC- The Elements Connected to The MSC

B. The Visitor Location Register (VLR)

- When the mobile user visits a PCS network other than the home system, a temporary record for the mobile user is created in the **VLR** of the visited system.
- The VLR temporarily stores subscription information for the visiting subscribers so that the corresponding MSC can provide service.
- In other words, the VLR is the "other" location register used to retrieve information for handling calls to or from a visiting mobile user.
- VLR is a database as same as HLR that contains all subscriber information data for **call handling and mobility management**
- VLR provide dynamic data management (HLR static data management)
- The VLR keeps track of all subscribers roaming in the VLR service area.
- In GSM system the VLR is integrated with the MSC

NSS:-MSC- The Elements Connected to The MSC

B. The Visitor Location Register (VLR):contains

- Selective information function from the HLR
- IMSI (the subscriber's identity number).
- Authentication data.
- MSISDN (the subscriber's phone number).
- GSM services that the subscriber is allowed to access.
- access point (GPRS) subscribed.
- The HLR address of the subscriber.

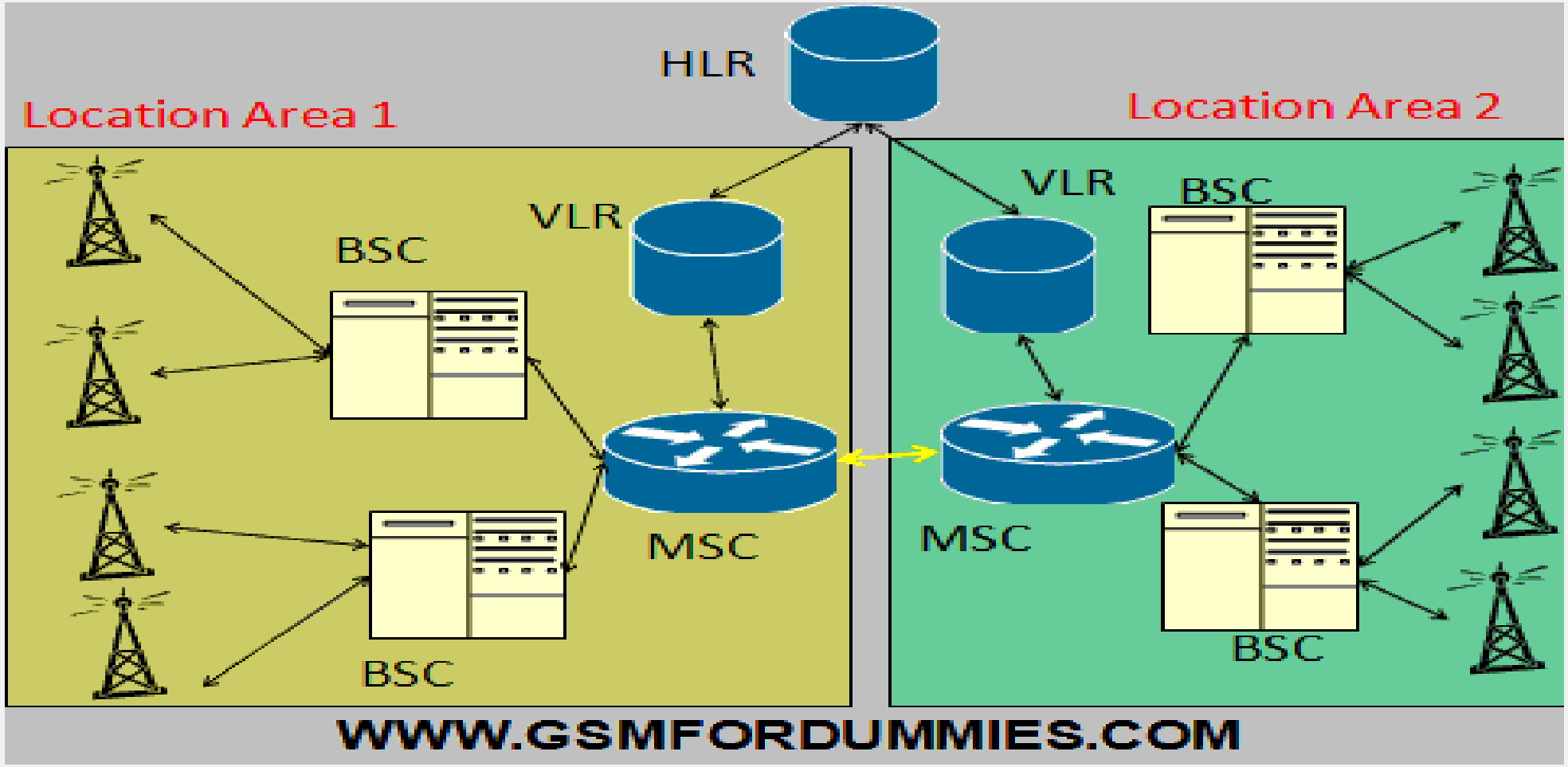
NSS:-MSC- The Elements Connected to The MSC

B. The Visitor Location Register (VLR):Functions

- Executing supplementary service programs (outgoing calls barred)
- Initiating authentication and ciphering
- Initiating paging, **what is paging?**
- Mapping of various identities (MSISDN, IMSI, TMSI, MSRN)
- Passing location information to HLR
- To inform the HLR when subscriber has arrived in the area covered by the VLR.
- To track where the subscriber when idle mode.
- To allow or disallow which services the subscriber may use.
- To allocate roaming numbers during the processing of incoming calls.
- To purge the subscriber record if becomes inactive whilst in the area and deletes the subscriber's data after some period and informs the HLR
- To delete the subscriber record when a subscriber explicitly moves to another, as instructed by the HLR.

NSS:-MSC- The Elements Connected to The MSC

B. The Visitor Location Register (VLR):Functions



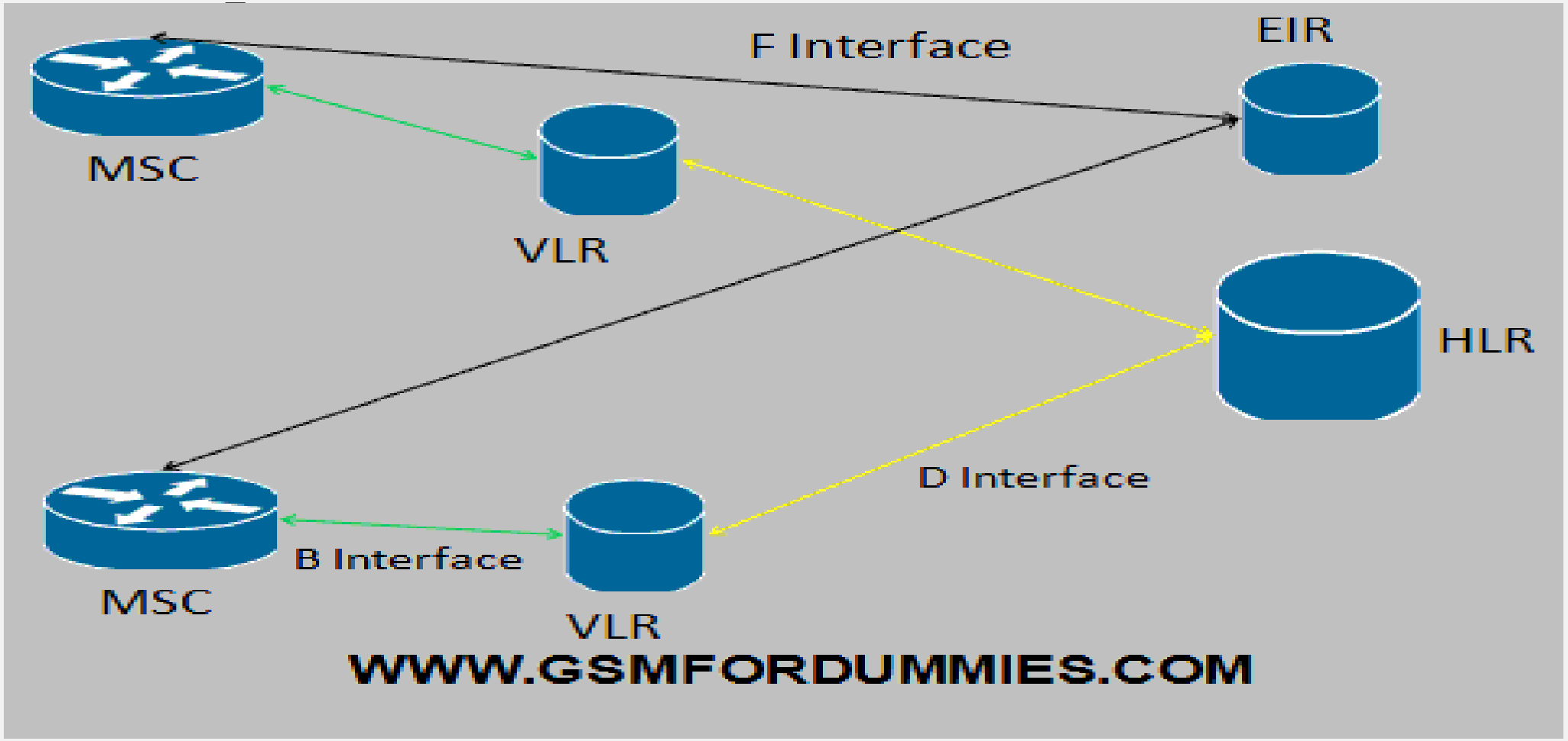
NSS:-MSC- The Elements Connected to The MSC

C. Equipment Identify Register (EIR)

- The EIR is a database that keeps tracks of handsets on the network using the IMEI.
- The EIR was introduced to identify, track and bar such equipment from being used in the network
- There is only one EIR per network.
- Composed of three lists.
  - The White List
  - The Gray List
  - The Black List

NSS:-MSC- The Elements Connected to The MSC

C. Equipment Identify Register (EIR)



NSS:-MSC- The Elements Connected to The MSC

D. Authentication Centre (AuC)

- AUC is always integrated with HLR for the purpose of the authentication.
- The Subscriber Authentication Key (Ki) is allocated to the subscriber, together with the IMSI. The Ki is stored in the AUC and used to provide the triplets, same Ki is also stored in the SIM.
- AUC stores the following information for each subscriber
  - The IMSI number,
  - The individual authentication key Ki
  - A version of A3 and A8 algorithm.

In AUC following steps are used to produce one triplet:

1. A non- predictable random number, RAND, is produced
2. RAND & Ki are used to calculate the Signed Response (SRES) and the Ciphering Key (Kc)
3. RAND, SRES and Kc are delivered together to HLR as one triplet.

HLR delivers these triplets to MSC/VLR on request in such a way that VLR always has at least one triplet.

NSS:-MSC- The Elements Connected to The MSC

E. Gateway Mobile Switching Center (GMSC)

- There is another important type of MSC, called a Gateway Mobile Switching Center (GMSC).
- The GMSC functions as a gateway between two networks.
- If a mobile subscriber wants to place a call to a regular land line,
- then the call would have to **go through a GMSC** in order to switch to the Public Switched Telephone Network (PSTN).

NSS:-MSC- The Elements Connected to The MSC

F. SMS Gateway (SMS-G)

- The **SMS GMSC** (SMS gateway MSC) is a gateway MSC that can also receive short messages.
- The gateway MSC is a mobile network's point of contact with other networks.

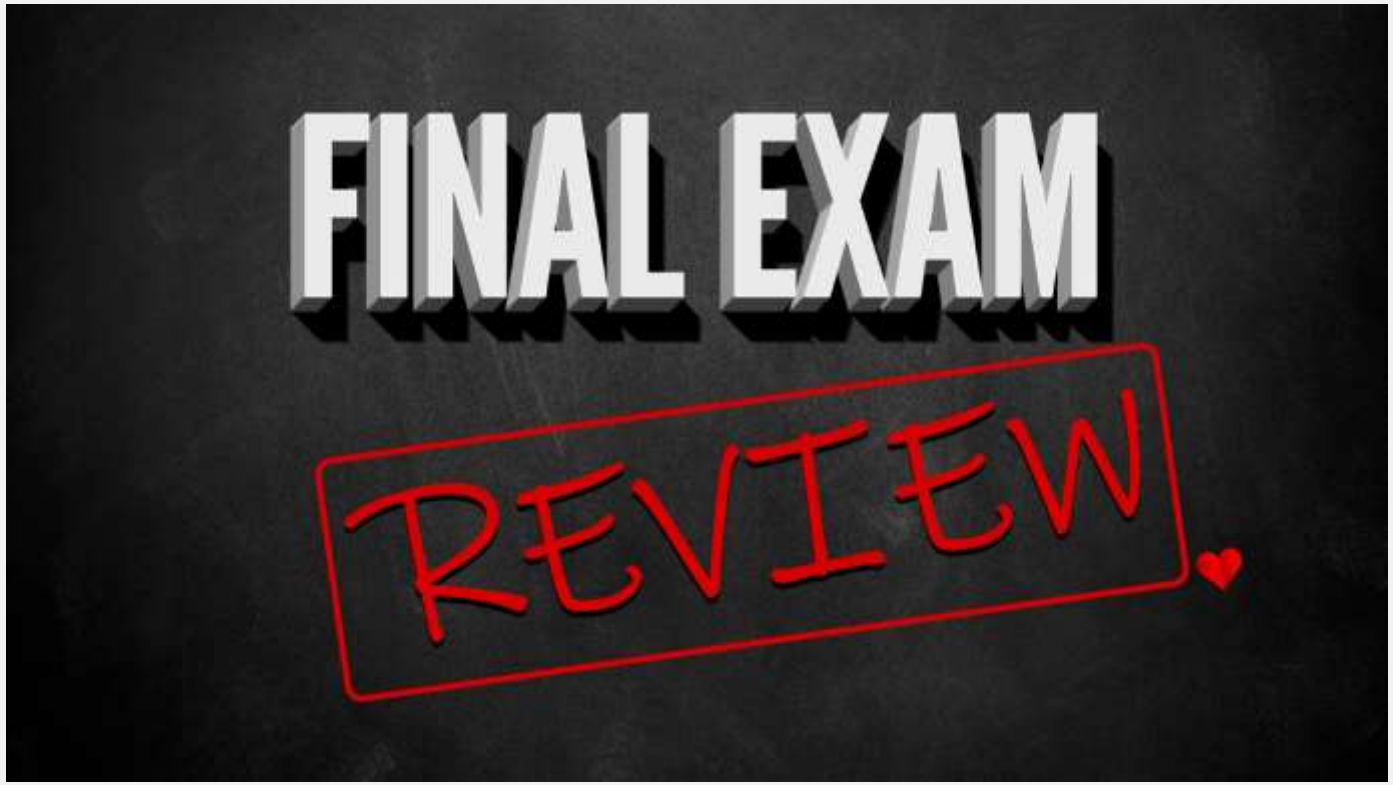
NSS:-MSC- The Elements Connected to The MSC

- The MSC connects to the following elements:
  A. The Home Location Register (HLR)
  B. The Visitor Location Register (VLR)
  C. Equipment Identify Register (EIR)
  D. Authentication Centre (AuC)
  E. Gateway Mobile Switching Center (GMSC)
  F. SMS Gateway (SMS-G)


Week-17

➨Revision and Final Review

Revision and Final Review



Thank YOU !