

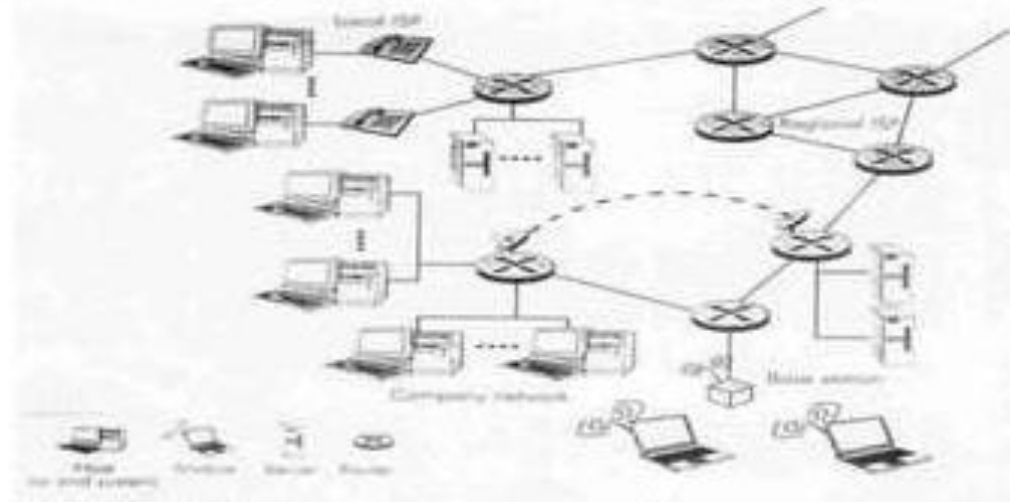


BCS-302 WIRELESS NETWORKS: L1

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- **Wireless Networking:**
 - refers to any kind of networking that does not involve cables.
- Wireless telecommunications networks are generally implemented and administered using a transmission system called **radio waves**.
- This implementation takes place at the physical level (layer) of the network structure



Types of Networks

By Network Formation and Architecture

- Infrastructure-based network.
- Infrastructureless (ad hoc) network.

By Communication Coverage Area.

1. Wireless Wide Area Networks (Wireless WANs)

- Infrastructure-based networks
- Connections can be made over large geographical areas, across cities or even countries
- Use of multiple antenna sites or satellite systems maintained by wireless service providers.
- Examples :Cellular networks (like GSM networks or CDMA networks) and satellite networks

Types of Networks

2. **Wireless Metropolitan Area Networks (Wireless MANs).**

- Referred as fixed wireless , infrastructure-based networks
- Enable users to establish broadband wireless connections among multiple locations ,for example, among multiple office buildings in a city or on a university campus
- Serve as backups for wired networks
- Radio waves and infrared light can be used to transmit data.

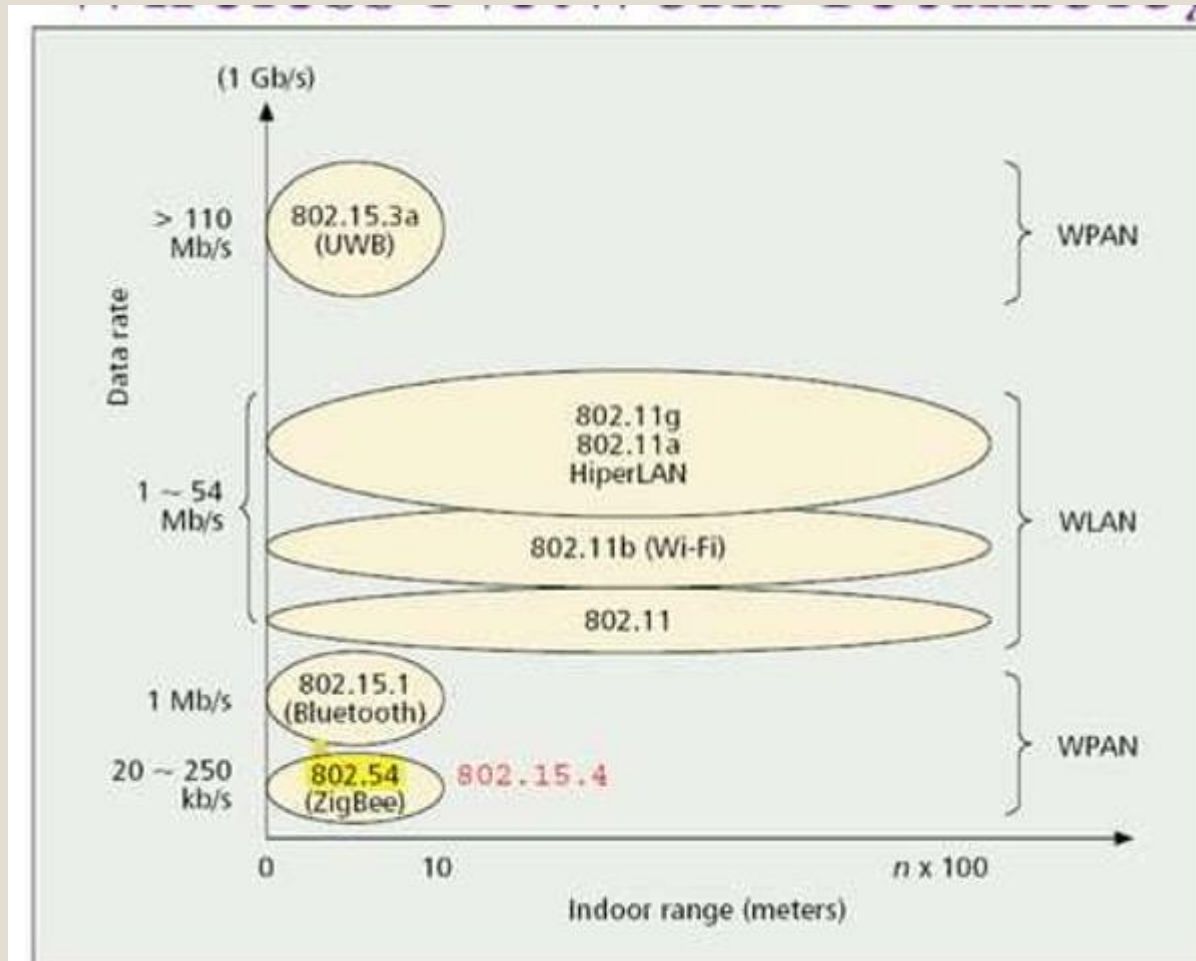
3. **Wireless Local Area Network (Wireless LANs)**

- Enable users to establish wireless connections within a local area with in a 100 m range
- Provide flexible data communication systems that can be used in temporary offices or other spaces that can operate in infrastructure-based or in ad hoc mode
- Include 802.11 (Wi-Fi) and Hiperlan2

4. **Wireless Personal Area Networks (Wireless PANs).**

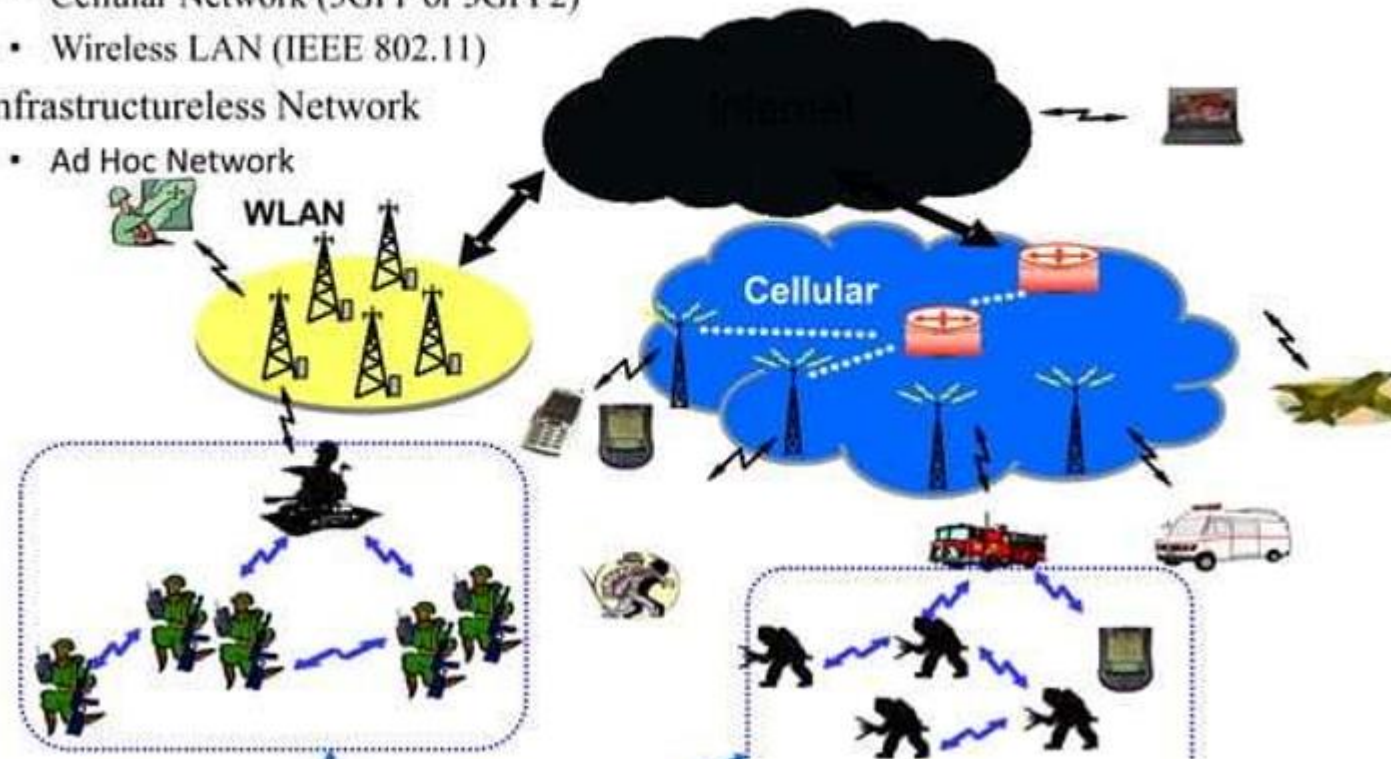
- Enable users to establish ad hoc, wireless communication among personal wireless devices such as PDAs, cellular phones, or laptops that are used within a personal operating space, typically up to a 10 meter range.
- Two key Wireless PAN technologies are
 - **Bluetooth** : is a cable-replacement technology that uses radio waves to transmit data to a distance of up to 9–10 m.
 - **Infrared**: connect devices within a 1 m range.

Wireless Network Technology



Wireless Networks

- Wireless Networks
 - Infrastructured Network
 - Cellular Network (3GPP or 3GPP2)
 - Wireless LAN (IEEE 802.11)
 - Infrastructureless Network
 - Ad Hoc Network



What is Ad-hoc?

- A local area network, or some small networks, parts are time-limited, and only usable for the duration of a communication session
- The routers are free to move randomly, organize themselves arbitrarily
- The wireless topology vary rapidly and unpredictably

Fundamentals of Wireless Communication Technology

■ Electromagnetic Spectrum

- $c = \lambda f$, where c is the speed of light, f is the frequency of the wave in Hz , and λ is the wavelength in meters

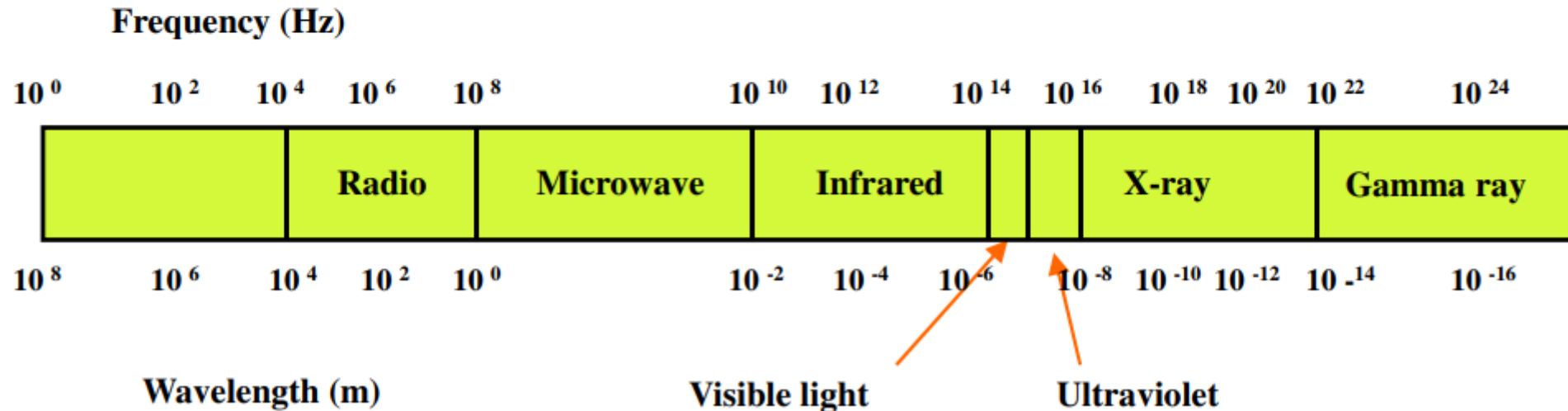


Figure 1.1. The electromagnetic spectrum

Table 1.1. Frequency bands and their common uses

Band Name	Frequency	Wavelength	Applications
Extremely low frequency (ELF)	30 to 300 Hz	10000 to 1000 Km	Powerline frequencies
Voice Frequency (VF)	300 to 3000 Hz	1000 to 100 Km	Telephone communications
Very low frequency (VLF)	3 to 30 KHz	100 to 10 Km	Marine communications
Low frequency (LF)	30 to 300 KHz	10 to 1 Km	Marine communications
Medium frequency (MF)	300 to 3000 KHz	100 to 100 m	AM broadcasting
High frequency (HF)	3 to 30 MHz	100 to 10 m	Long-distance aircraft / ship communications
Very high frequency (VHF)	30 to 300 MHz	10 to 1 m	FM broadcasting
Ultra high frequency (UHF)	300 to 3000 MHz	100 to 10 cm	Cellular telephone
Super high frequency (SHF)	3 to 30 GHz	10 to 1 cm	Satellite communications, microwave links
Extremely high frequency (EHF)	30 to 300 GHz	10 to 1 mm	Wireless local loop
Infrared	300 GHz to 400 THz	1 mm to 400 nm	Consumer electronics
Visible light	400 THz to 900 THz	770 nm to 330 um	Optical communications



Radio Propagation Mechanisms

- Reflection - occurs when signal encounters a surface that is large relative to the wavelength of the signal
- Diffraction - occurs at the edge of an impenetrable body that is large compared to wavelength of radio wave
- Scattering – occurs when incoming signal hits an object whose size is in the order of the wavelength of the signal or less

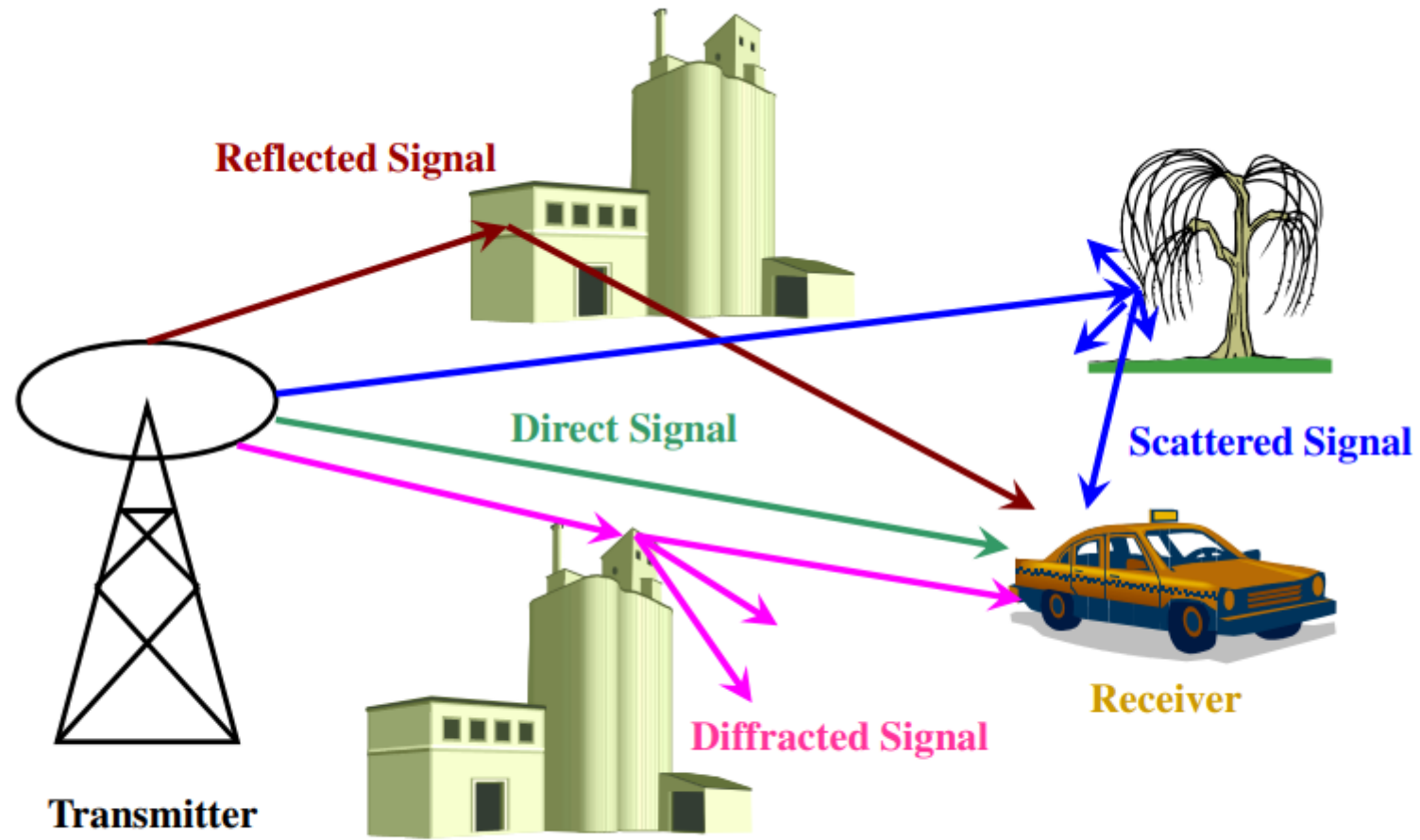


Figure 1.2. Propagation mechanisms

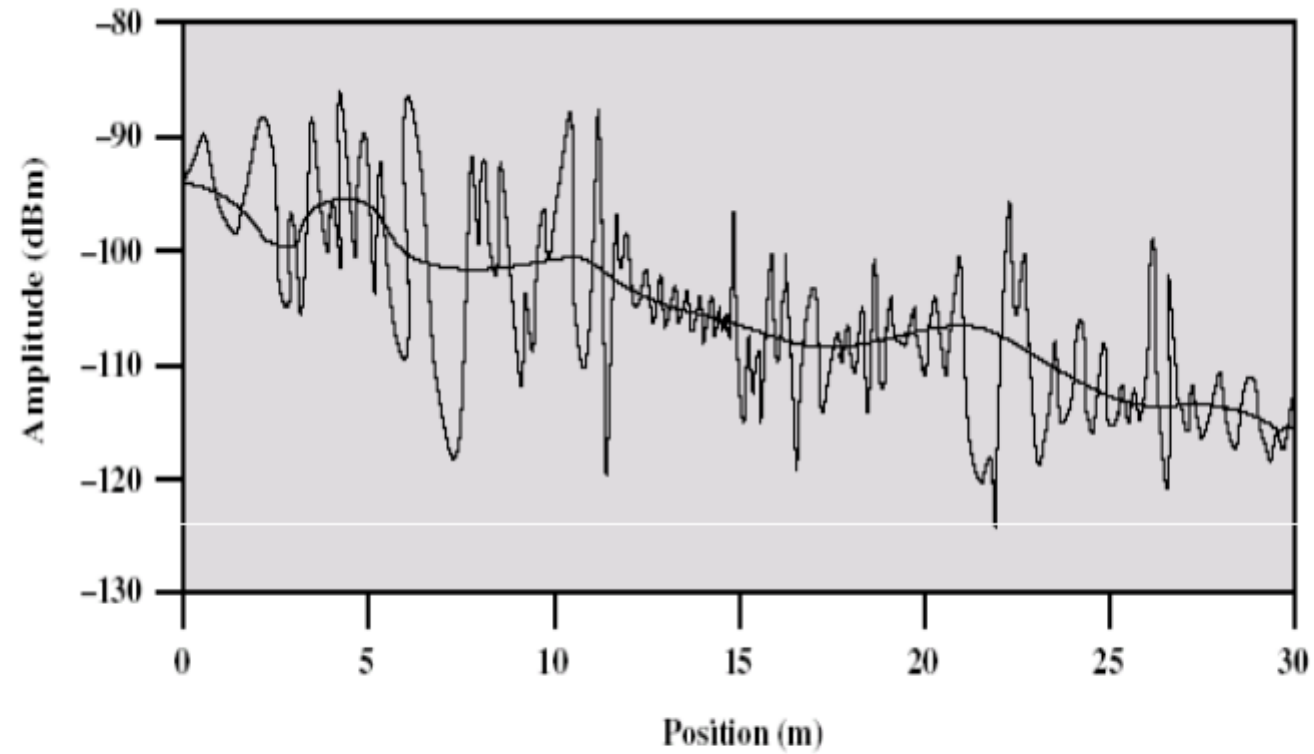
Characteristics of Wireless Channel

- ☐ Path loss
- ☐ Fading
- ☐ Interference
- ☐ Doppler shift



Fading

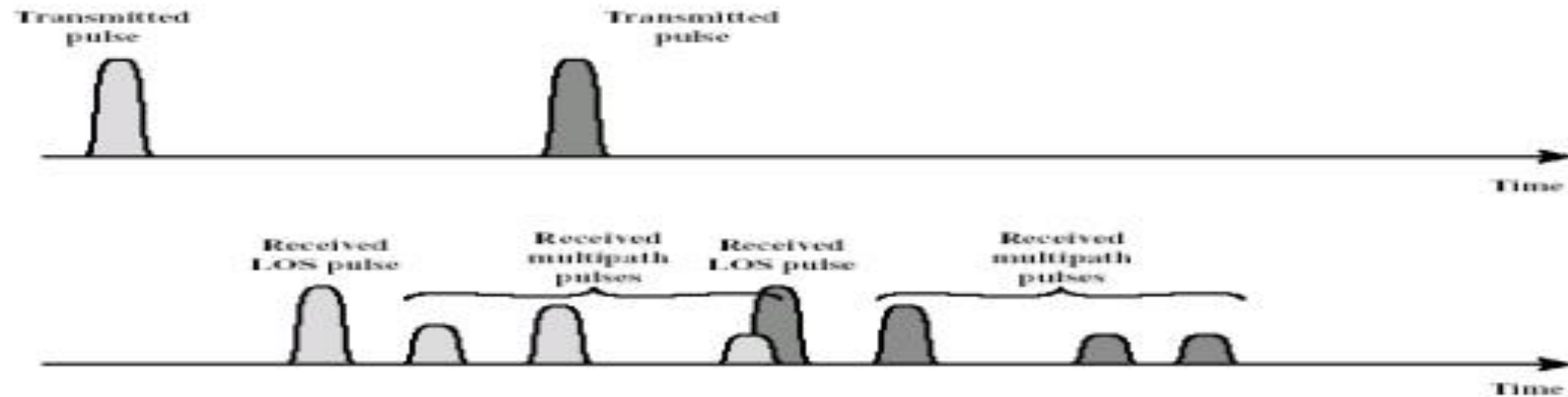
- Fading refers to fluctuations in signal strength when received at receiver
- Fast fading (short-term fading)
 - Observe the distance of about half a wavelength
 - Such as multipath propagation
- Slow fading (long-term fading)
 - Distance large enough to produce gross variations
 - Ex. temporarily shielded by a building , tree, cars, ...



Typical Slow and Fast Fading in an Urban Mobile Environment

Interference

- Adjacent channel interference
- Co-channel interference
- Inter-symbol interference
 - Effect of multipath propagation
 - Can be solved by adaptive equalization mechanisms



Two Pulses in Time-Variant Multipath



Doppler Shift

- Change/shift in the frequency of the received signal with the transmitter and receiver are mobile with respect to each other
 - the Doppler shift is: $f_d = \frac{v}{\lambda}$
 - Where v is the relative velocity between the transmitter and receiver, and λ is the wavelength of the signal

Wireless Network Setup

- There are two types of wireless network types.
 - Infrastructure
 - Ad Hoc

Infrastructure

- Referred to as a “hosted” or “managed” wireless network.
- Consists of one or more access points (known as gateways or wireless routers) being connected to an existing network.

Adhoc Wireless Network

- Also referred to as an “unmanaged” or “peer to peer” wireless network
- it consists of each device connecting directly to each other.
- Allow someone sitting outside in the garden with a laptop to communicate with his desktop computer in the house and access the Internet.

The MANET Problem

- **Mobile**
Random and perhaps constantly changing
- **Ad-hoc**
Not engineered
- **Networks**
Elastic data applications which use networks to communicate

Terminology and Paradigms

"Ad hoc"

- often improvised or impromptu; „*an ad hoc committee meeting*“
Wordnet
- formed or used for specific or immediate problems or needs;
„*ad hoc solutions*“
- fashioned from whatever is immediately available: improvised;
„*large ad hoc parades and demonstrations*“
Encyclopædia Britannica

"Spontaneous"

- arising from a momentary impulse
- controlled and directed internally; „*self-acting*“
- produced without being planted or without human labor;
„*indigenous*“
- developing without apparent external influence, force, cause, or treatment

Basics

(Mobile) Ad Hoc Communication Networks - MANET

- Historical successor of packet radio networks
- Self-organizing, mobile and wireless nodes
- Absence of infrastructure, multi-hop routing necessary
- Systems are both, terminals (end-systems) and routers (nodes)
- Constraints (dynamics, energy, bandwidth, link asymmetry)



Wireless Adhoc Network

- A **wireless ad-hoc network** is a decentralized type of wireless network.
- The network is ad hoc because it **does not rely on a pre-existing infrastructure**, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity.
- In addition to the classic routing, ad hoc networks can use flooding for forwarding the data.

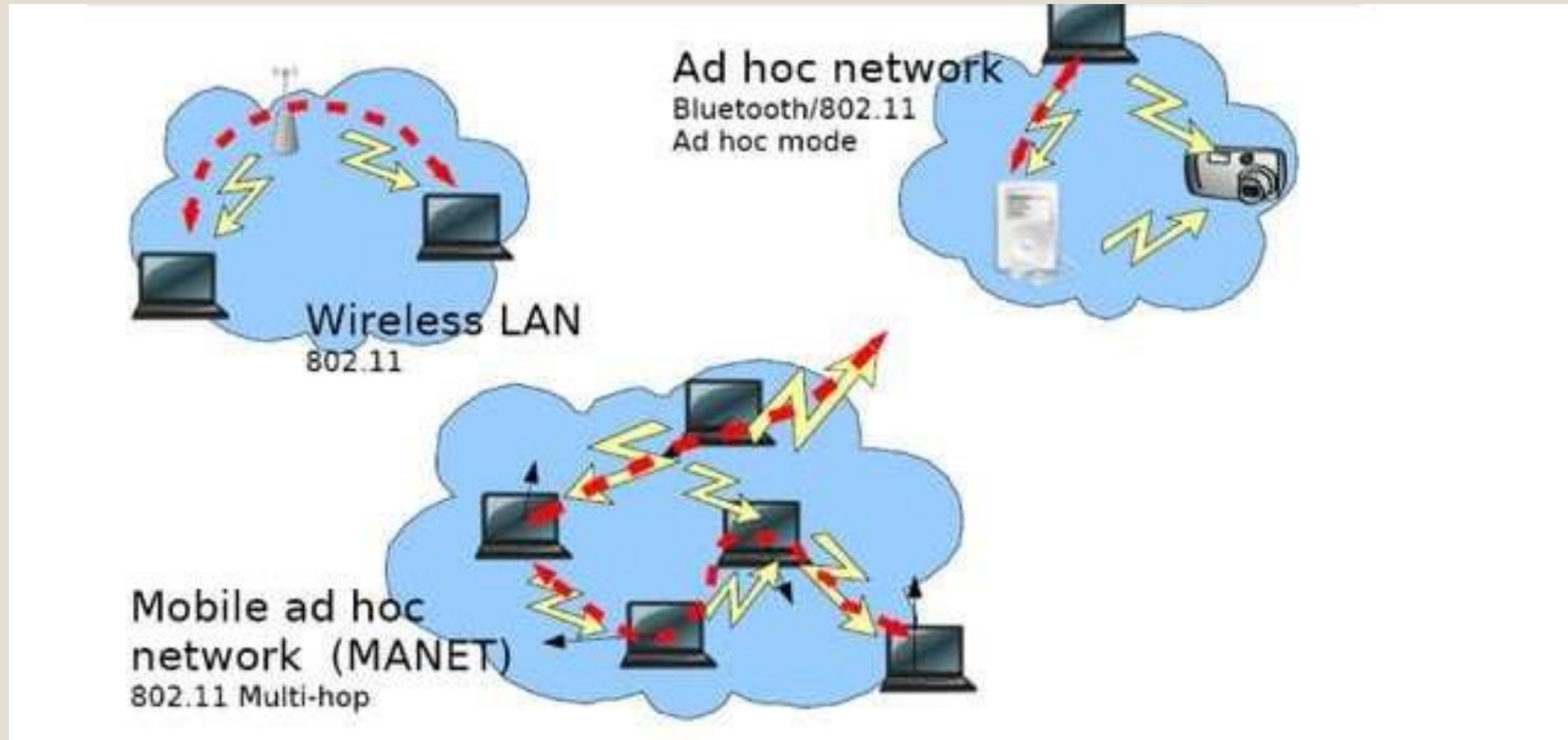
Mobile Adhoc Network

- Self-configuring network of mobile routers (and associated hosts) connected by wireless links
- This union forms a random topology
- Routers move randomly free
- Topology changes rapidly and unpredictably
- Standalone fashion or connected to the larger Internet
- While MANETs are self contained, they can also be tied to an IP-based global or local network – Hybrid MANETs
- Suitable for emergency situations like natural or human-induced disasters, military conflicts, emergency medical situations, etc.

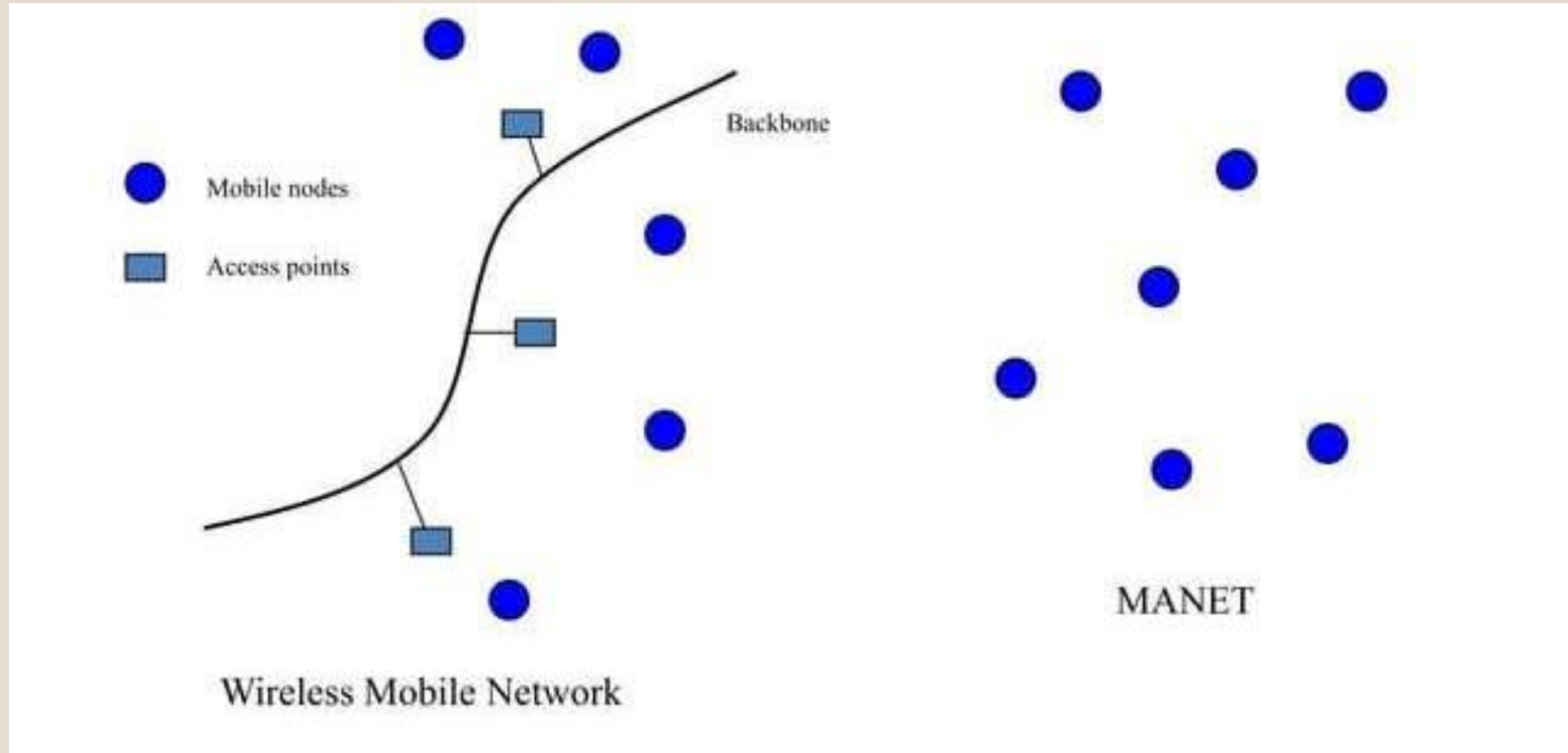
Fundamental Concepts

- Ad hoc networks are autonomous networks operating either in isolation or as “stub networks” connecting to a fixed network
- Do not necessarily rely on existing infrastructure
 - No “access point”
- Each node serves as a router and forwards packets for other nodes in the network
- Topology of the network continuously changes

Differences to other Wireless Network



MANET



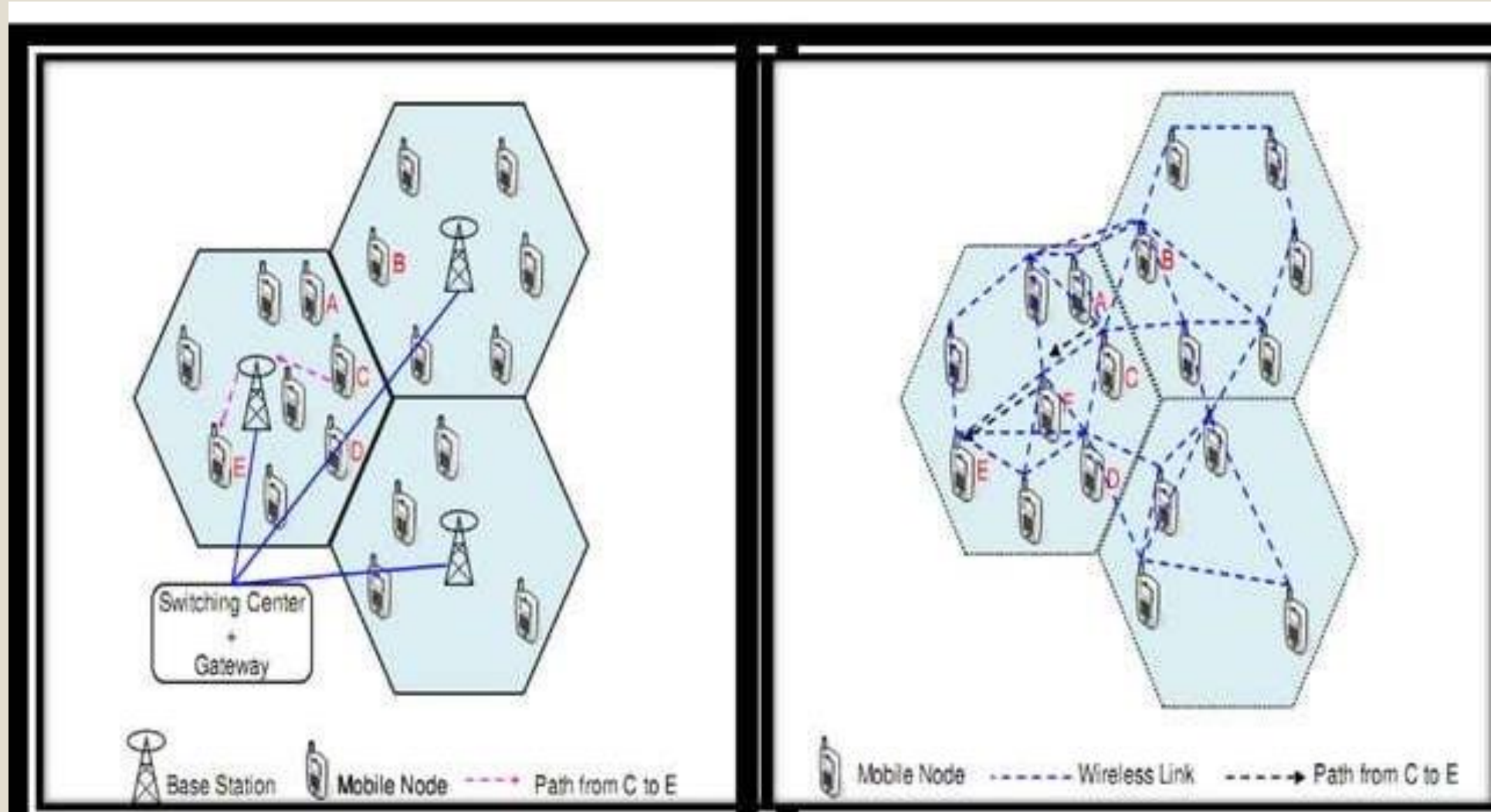
Cellular Vs Adhoc Wireless Network

Cellular Networks	Ad Hoc Wireless Networks
Fixed infrastructure-based	Infrastructure-less
Single-hop wireless links	Multi-hop wireless links
Guaranteed bandwidth (designed for voice traffic)	Shared radio channel (more suitable for best-effort data traffic)
Centralized routing	Distributed routing
Circuit-switched (evolving toward packet switching)	Packet-switched (evolving toward emulation of circuit switching)
Seamless connectivity (low call drops during handoffs)	Frequency path break due to mobility
High cost and time of deployment	Quick and cost-effective deployment
Reuse of frequency spectrum through geographical channel reuse	Dynamic frequency reuse based on carrier sense mechanism

Cellular Vs Adhoc Wireless Network

Easier to achieve time synchronization	Time synchronization is difficult and consumes bandwidth
Easier to employ bandwidth reservation	Bandwidth reservation requires complex medium access control protocols
Application domains include mainly civilian and commercial sector	Application domains include battlefields, emergency search and rescue operation, and collaborative computing
High cost of network maintenance (backup power source, staffing, etc.)	Self-organization and maintenance properties are built into the network
Mobile hosts are of relatively low complexity	Mobile hosts require more intelligence (should have a transceiver as well as routing/switching capacity)
Major goals of routing and call admission are to maximize the call acceptance ratio and minimize the call drop ratio	Main aim of routing is to find paths with minimum overhead and also quick reconfiguration of broken paths
Widely deployed and currently in the third generation	Several issues are to be addressed for successful commercial deployment even

Cellular Vs Adhoc Wireless Network



MANET Applications

Applications	Descriptions/Services
Tactical Networks	<ul style="list-style-type: none">•Military communication, operations•Coordination of military object moving at high speeds such as fleets of airplanes or ships•Automated battlefields
Sensor networks	<ul style="list-style-type: none">•Collection of embedded sensor devices used to collect real time data to automate everyday functions. Data highly correlated in time and space, e.g., remote sensors for weather, earth activities; sensors for manufacturing equipments.•Can have between 1000 -100,000 nodes, each node collecting sample data, then forwarding data to centralized host for processing using low homogeneous rates.
Emergency services	<ul style="list-style-type: none">•Search, rescue, crowd control, and commando operations as well as disaster recovery•for e.g. Early retrieval and transmission of patient data (record, status, diagnosis) from /to the hospital•Replacement of a fixed infrastructure in case of earthquakes,

MANET Applications

Applications	Descriptions/Services
Commercial environments	<ul style="list-style-type: none">•E-commerce, e.g., electronic payments from anywhere (i.e., in taxi).•Business:<ul style="list-style-type: none">dynamic access to customer files stored in a central location on the flyprovide consistent databases for all agentsMobile office•Vehicular services:<ul style="list-style-type: none">transmission of news ,road conditions ,weather, musiclocal ad hoc network with nearby vehicles for road/accident guidance
Home and enterprise networking	<ul style="list-style-type: none">•Home/office wireless networking(WLAN), e.g., shared whiteboard application, use PDA to print anywhere, trade shows•Personal area network (PAN)
Educational applications	<ul style="list-style-type: none">•Set up virtual classrooms or conference rooms•Set up ad hoc communication during conferences, meetings, or lectures

MANET Applications

Applications	Descriptions/Services
Entertainment	Multiuser games Robotic pets outdoor internet access
Location- aware Services	Follow- on services, e.g., automatic call forwarding, transmission of the actual workspace to the current location Information services push, e.g., advertise location-specific services, like gas stations pull, e.g., location-dependent travel guide; services(printer, fax, phone, server, gas stations) availability information; caches, intermediate results, state information, etc.

MANET Overview

- MANET
 - No infrastructure
 - Self organizing networks
 - Communications via mobile nodes
 - Dynamic topology
 - Heterogeneity bandwidth-constrained variable-capacity links
 - Limited physical security
 - Nodes with limited battery life and storage capabilities

Issues in Adhoc Networks

- Medium access scheme
- Routing
- Multicasting
- Transport layer protocol
- QoS provisioning
- Security
- Energy management
- Addressing and service discovery
- Scalability
- Deployment considerations

MR. MT QSEAS Depth