Chapter 1: Introduction

Mobile Computing

Course Outline

- Introduction
  - Course Overview
  - Development History of Mobile Computing
- Wireless Transmission and Networking Technology
  - Limitations in Mobile Networks and Devices
  - Wireless Transmission Technology
  - Networking Technology
  - Mobile TCP/IP

Course Outline

- Mobile Networks and Computing
  - Wireless Networks and Protocols
  - Cellular Networks
  - Wi-Fi
  - Wireless Personal Networks and Bluetooth
  - Mobile Ad hoc Networks
  - Sensors and WSNs

Course Outline

- Applications and Hot Topics
  - Mobile Device Platform and Development Tools
  - Localization Applications
  - Routing protocol design and implementation
  - Vehicular and Mobility Systems

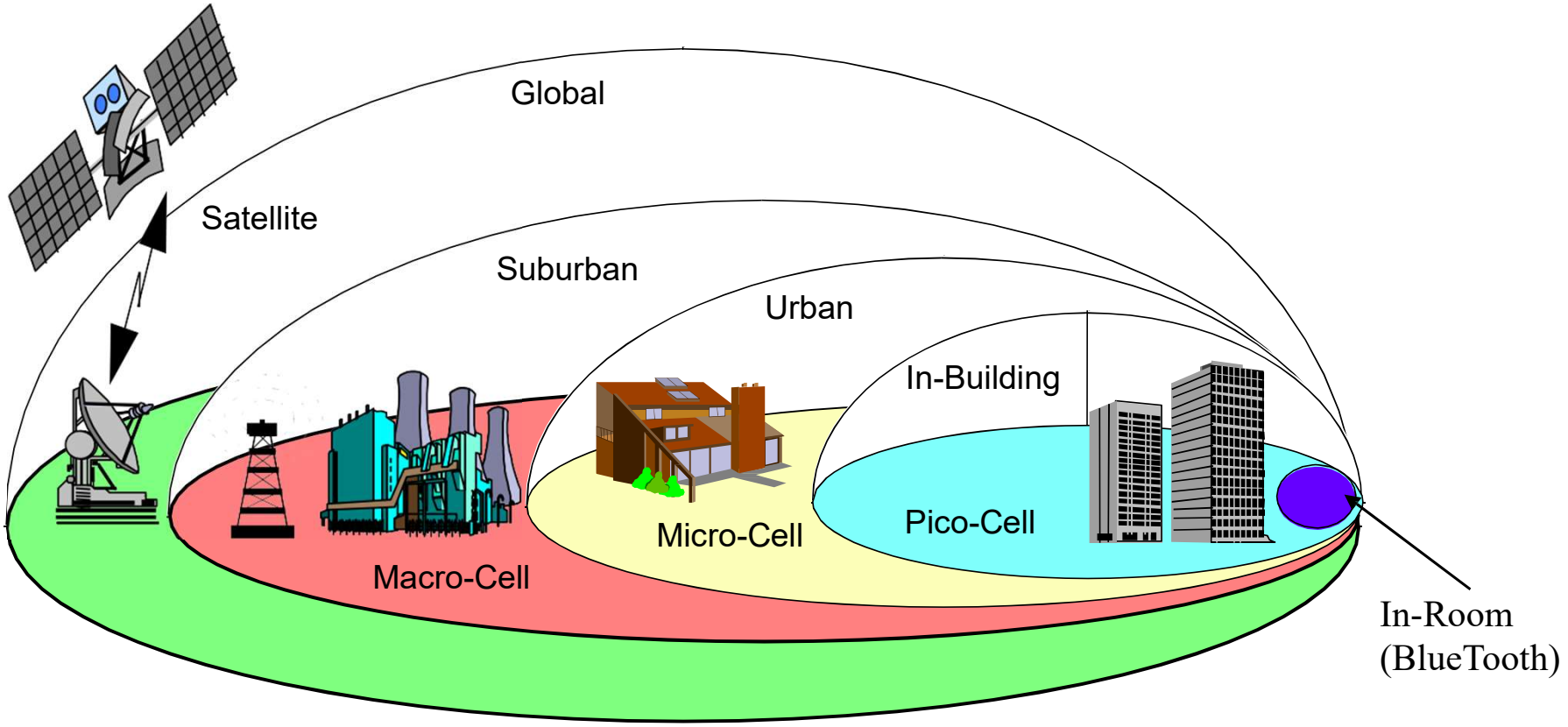
Assessment Methods

Type of Assessment Methods	Weighting
Assignments or Projects	About 50%
Discussion, Quiz, In-class Exercise	About 10%
Final Examination	40%

Reference Book

- Schiller, Jochen, Mobile Communications, 2nd Edition, Pearson Education, 2003.
- Mallick, Martyn, Mobile and Wireless Design Essentials, Wiley Publishing, 2003.
- Kwok, Yu-Kwong Ricky and Lau, Vincent K. N., Wireless Internet and Mobile Computing: Interoperability and Performance, Wiley, 2013.
- Agrawal, Dharma P. and Zeng, Qing-An, Introduction to Wireless and Mobile Systems, 4th Edition, Thomson Learning, 2014.

Wireless Infrastructure

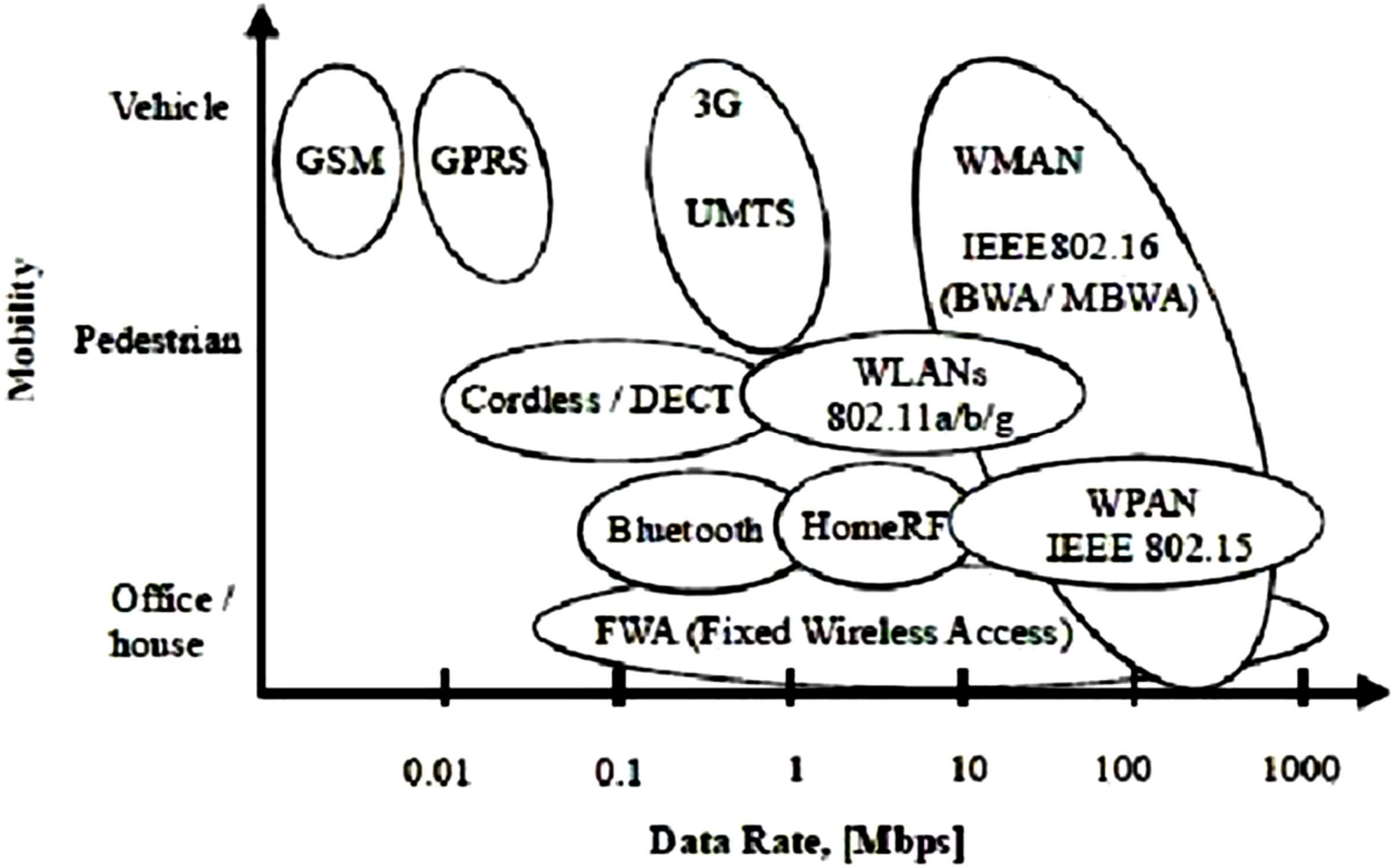


Levels of Mobility

Mobility of physical devices can be viewed at three different levels:

- Macro-mobility: This is mobility through a global network. While moving in such a network, it should be possible to communicate without breaking the existing access. mobile IP, which is the protocol that takes care of macro-mobility.
- Micro-mobility: This is mobility of a device in one single administrative domain of the global network. For cellular networks, this is the lowest level of mobility.
- Ad hoc mobility: This is mobility within a mobile ad hoc network (MANET), caused by device mobility constantly changing the network topology.

Overview of Wireless Communications



Different Protocols

Technology		Frequency	Data Rate	Range	Power Usage	Topology
802.11	Wi-Fi	sub-GHz (802.11ah)	up to 346.667 Mbps	up to a km	Medium	Star
	Wi-Fi 6	2.4 and 5Ghz (802.11ax)	up to 9.607 Gbps	up to 35m (single router)	High	Star
802.15.1	Bluetooth(802.15.1)	2.4GHz	1,2,3 Mbps	up to 90 m	Low	Piconet and Mesh
802.15.4		868 MHz (EU) /915 MHz (NA)	250 kbps			
	Zigbee	2.4GHz	250 kbps	up to 90 m	Low	Mesh, Star, Cluster
	WirelessHART	2.4GHz	250 kbps	up to 90m	Moderate	Mesh
	6LoWPAN	2.4GHz	250 kbps	up to 100m	Moderate	Star
	ISA100.11a	2.4GHz	250 kbps	up to 500m	Moderate	Mesh, Star, Cluster
	Thread	2.4GHz	250 kbps	up to 30m	Low	Mesh
Cellular	GPRS	380 to 1900 MHz	128.4 kbps	several kms	High	Star
	EDGE	380 to1900 MHz	355.5 kbps	several kms	High	Star
	3G-HSDPA	700MHz to 3GHz	14.4 Mbps	several kms	High	Star
	3G-HDPA+	700MHz to 3GHz	337 Mbps	several kms	High	Star
	LTE-Cat1	600MHz to 6GHz	10 Mbps	several kms	Moderate	Star
	LTE-CatM1	600MHz to 6GHz	1 Mbps	several kms	Low	Star
	NB-IoT	600MHz to 6GHz	250 kbps	several kms	Low	Star
	5G	600MHz to 6GHz	20 Gbps	several kms		Star
		24-86Ghz	20 Gbps	several kms		Star

Different Protocols

Z-wave		868.42MHz (EU) / 908.42MHz (NA)	40 kbps	up to 30m	Low	Mesh
LoRaWAN		868.42MHz (EU) / 908.42MHz (NA)	up to 50 kbps	several kms	Low	Star
SigFox		868MHz (EU) /902MHz (NA)	600 bps	up to 800m	Low	Star
ISO 18000	NFC	13.56MHz	106 to 424 kbit/s	10cm	Low	P2P
	RFID	125 kHz to 134 kHz; 6.7 MHz; 27MHz;	106 to 424 kbit/s	up to 10 cm	Low	
		433MHz	848 kbps	1-100m		
		865 to 868 MHz (EU); 902 to 928 MHz (NA)		1-12m		
		2.45 GHz		1-2m		
		5.8 GHz		up to 200m		
		24.125 GHz		up to 200m		

Definition of Mobility

- User Mobility:
  - Users can access the same network services at different places
  - User can be mobile and the services will follow him/her
  - Examples: Call forwarding and Computer Desktop supporting roaming
- Device Portability:
  - Communication device can move and mechanisms in the network and inside the device have to make sure that communication is still possible.
  - Example: Mobile phone system
- In most of the cases, both user mobility and device portability are available.

Mobility Characteristics

- Location changes: Location management
- Heterogeneity in services: bandwidth restrictions and variability
- Dynamic replication of data: data and services follow users
- Querying data-location-based responses: Security and authentication
- System configuration is no longer static

Mobility Characteristics

- Not easy to monitor the proper usage.
- Credential verification: As other users share username and passwords, it poses as a major threat to security.
- The problem of identity theft is very difficult to contain or eradicate.
- Issues with unauthorized access to data and information by hackers, is also an enormous problem.

Definition of Mobile Computing

- Mobile computing allows continuous access to remote resources, to small computing devices such as laptops, pads and other handheld devices like smartphones and smart watches.
- People and their machines should be able to access information and communicate with each other easily and securely, in any medium or combination of media – any time, anywhere, in a timely, cost-effective way.

Definition of Mobile Computing

- Mobile Computing is a technology that allows transmission of multimedia data via any wireless device without having to be connected to a fixed physical link.
- Main Components:
  - Mobile communication
  - Mobile hardware
  - Mobile software

Mobile Communication

- The mobile communication is the technology to ensure that seamless and reliable communication goes on.
- Components:
  - protocols (including data format),
  - services,
  - bandwidth, and
  - portals necessary to facilitate and support the services.

Mobile Hardware

- Mobile devices or device components that receive or access the service of mobility.
- Range from portable laptops, smartphones, tablet, pads, etc.
- These devices will have a receptor medium that is capable of sensing and receiving signals.

Mobile Software

- The program that deals with the requirements of mobile applications.
- Portability is the main factor, the software are able to operate from anywhere.
- It incorporates all aspects of wireless communications.

Major Advantages

- Mobility: enable users to work from anywhere;
- Save Time: no need to travel from different locations or to the office and back
- Enhanced Productivity: Users can work efficiently and effectively from whichever location they find suitable

Major Advantages

- Ease of Installation: The setup and installation of wireless communication network's equipment and infrastructure is very easy
- Disaster Recovery: In case of accidents due to fire, floods or other disasters, the loss of communication infrastructure in wireless communication system can be minimal.

Challenges in Mobile Computing

- Three major challenges:
  - Wireless Channel
  - Mobility
  - Device Limitation

Challenges in Mobile Computing

Specifically,

- Variant Connectivity: Low bandwidth and reliability
- Frequent disconnections: predictable or sudden
- Asymmetric Communication: Broadcast medium
- Monetarily expensive: Charges per connection or per message/packet
- Connectivity is weak, intermittent and expensive

Challenges in Mobile Computing

Basic issues of concern in physical mobility

- Weak connectivity
- Wireless connectivity
- Ubiquitous computing

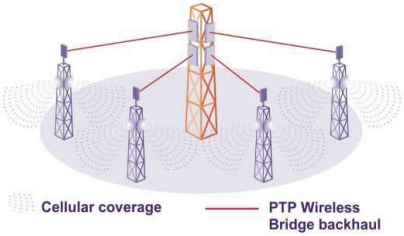
Mobile systems Technical issues for mobility

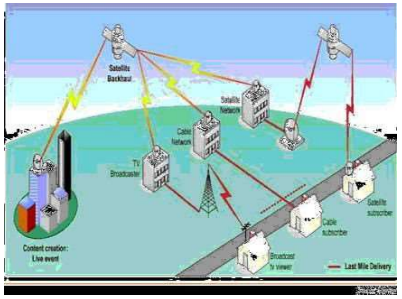
- Security
- Security infrastructure
- Reliability
- Naming and locating

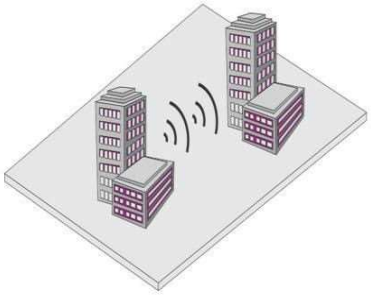
Challenges in Mobile Computing

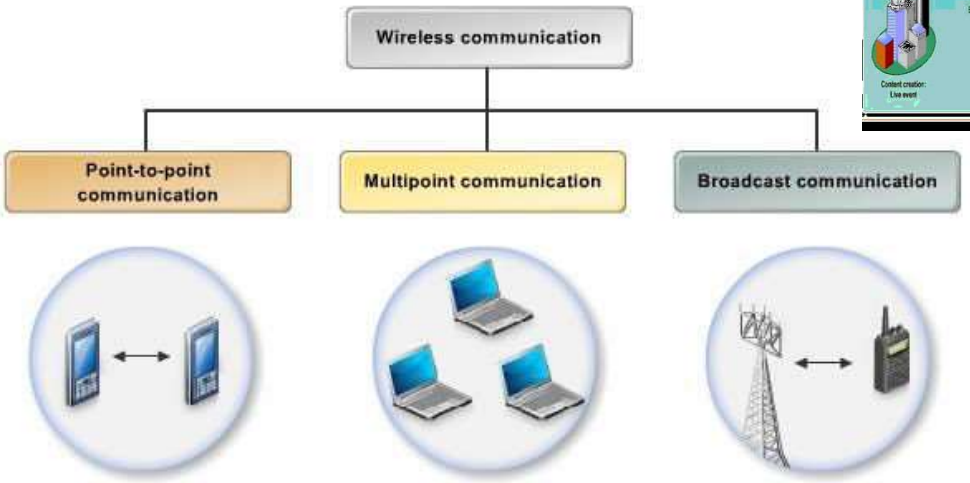
- **Power consumption**: rely entirely on battery power
- **Transmission interferences**: Weather, terrain, and the range from the nearest signal point can all interfere with signal reception.
- **Human interface with device**: Screens and keyboards tend to be small, which may make them hard to use.

Types of Wireless Communications



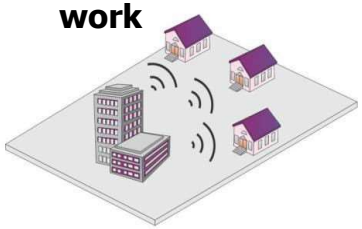






Cellular

Wireless computer network work



Radio service

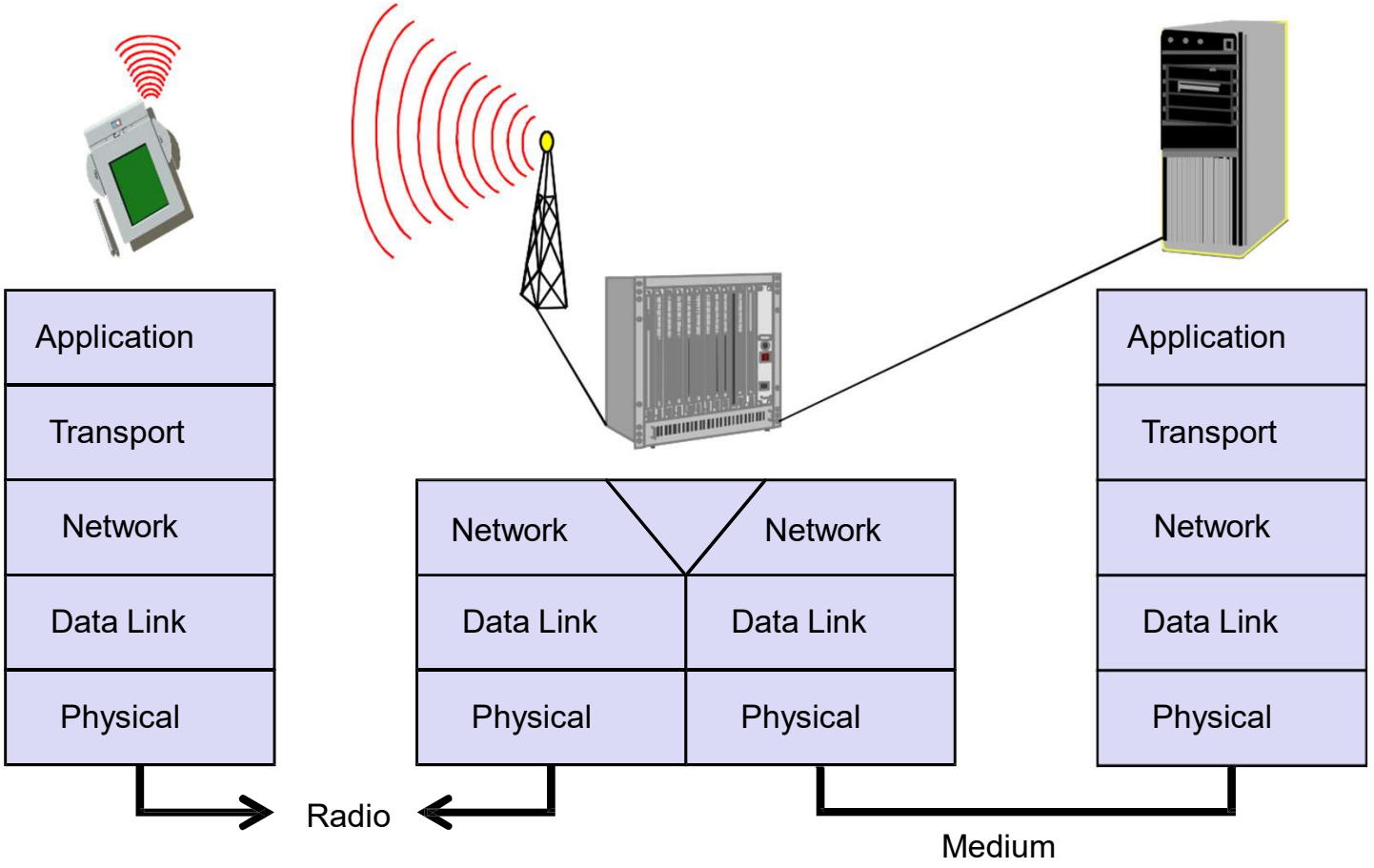
Compared to Wired Network

- Higher loss-rates due to interference
- 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., 9.6kbit/s with GSM

Compared to Wired Network

- 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
  - Secure access mechanisms important
- Always shared medium

Typical Example: Layered Architecture



Challenges of Mobility on Protocol Stack

- Application: new applications and adaptations
- Transport: congestion and flow control
- Network: addressing and routing
- Link: media access and handoff
- Physical: transmission errors and interference

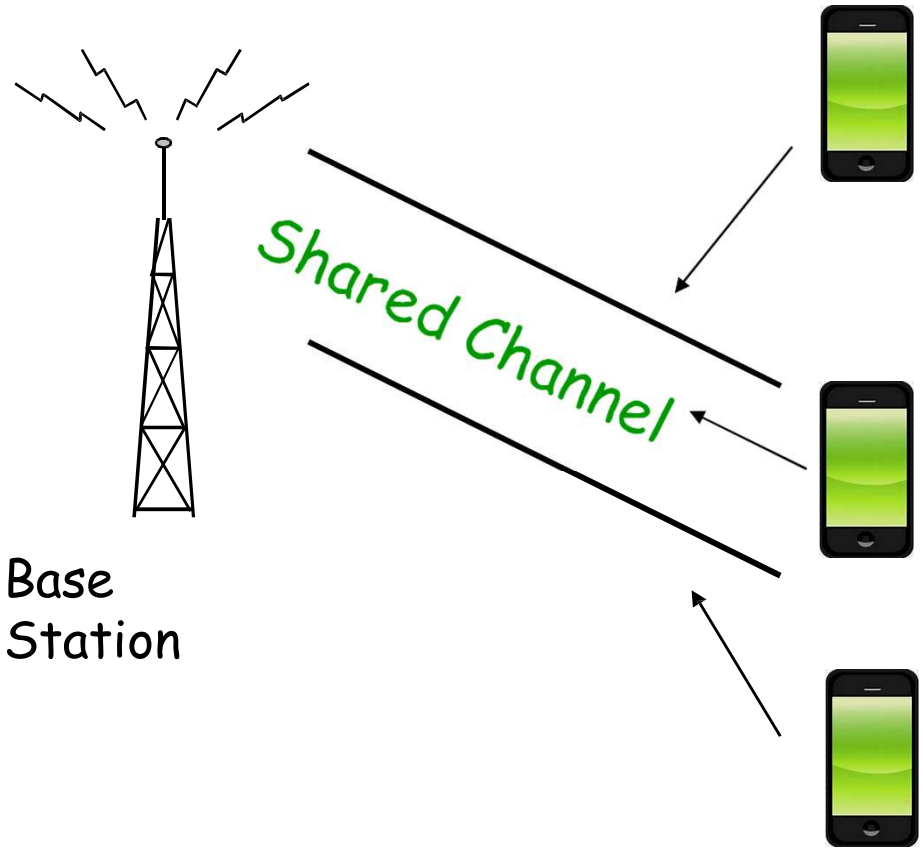
Challenge: High Bit Error Rate

- Optical fiber: 10^{-11} or 10^{-12}
- Mobile channel:
  - Good quality: 10^{-6}
  - Actual condition: 10^{-2} or worse

Implication: High Bit Error Rate

- For wired systems, it is assumed that the channel is error free
- Many protocols are designed with this assumption
- These protocols do not work well in a wireless environment
  - e.g. TCP (*why? Packet loss is only due to congestion not due to error in channel*)

Challenge: Multiple Users to share a channel



Wireless users access the network by means of a shared channel

Access capacity is inherently limited.

Implication: Multiple Users to share a channel

- For wired systems, we can simply install new cables to increase capacity.
- For wireless systems, the channel can only be shared by the users.
  - Capacity does not increase.

Challenge: Interference

- Multiuser Interference
  - Radio signals of different users interfere with each other
- Self-Interference
  - Multipath effect
  - Phase-shifted images of the signal at the receiver interact and may cancel the entire signal, (i.e. destructive interference).

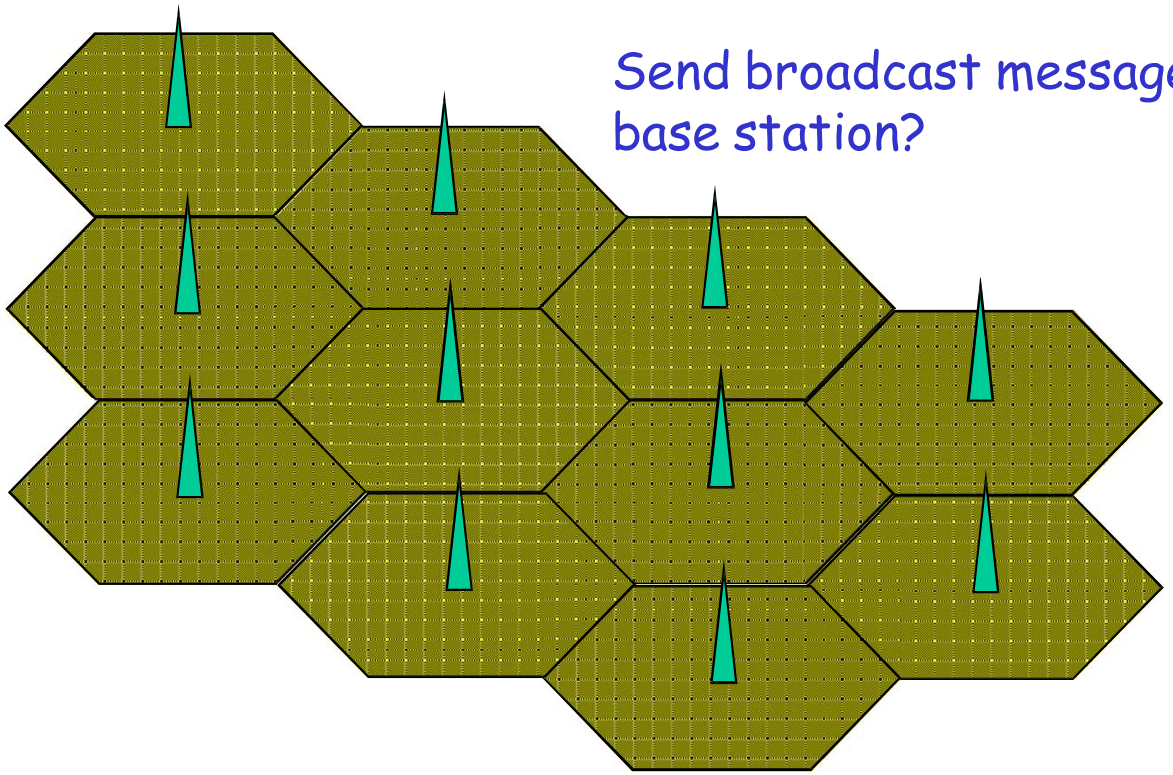
Interference Management

- How to manage multiuser interference?
  - i.e. how to share the channel?
  - Channelization (multiplexing)
    - FDMA, TDMA, CDMA, etc.
  - Random Access Control
    - Aloha, CSMA, etc.
- How to manage self-interference?
  - Physical layer issue
    - Equalization, coding, diversity, etc.

Challenge: User Mobility

- Location Management Problem
  - How does the network know where the intended recipient of a message is currently located?

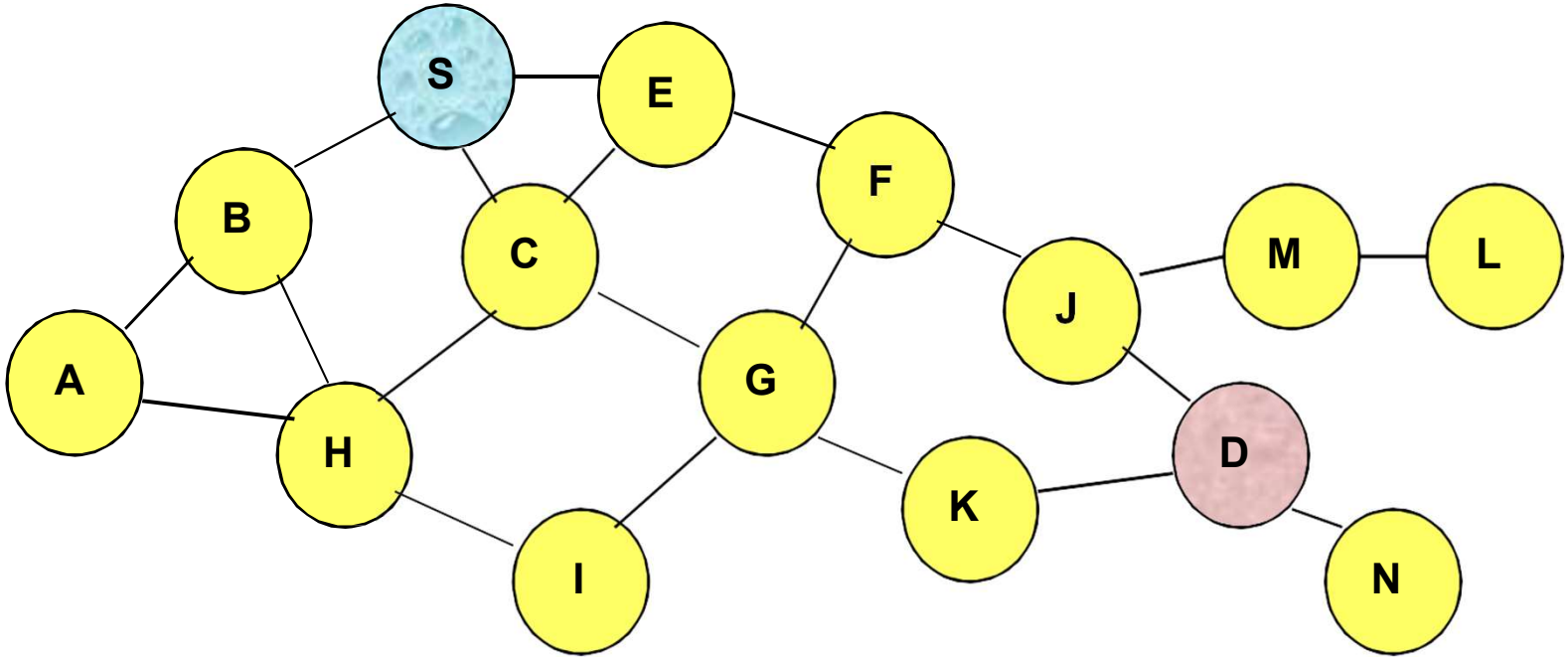
Mobility: Cellular Scenario



Where is 13823063305?

Send broadcast messages from every base station?

Challenge: Routing Problem for Ad Hoc Network



How to find a suitable path from source S to destination D?

Mobile Applications

- Vehicles
  - Transmission of news, road condition, etc.
  - Ad-hoc network with near vehicles to prevent accidents
- IoT
  - Keep track of objects or equipment
- Mobile Office
  - Direct access to central customer files
  - Consistent databases for all agents
  - Mobile office, etc.

Mobile Applications

- Web access
  - Outdoor Internet access
  - Intelligent travel guide with up-to-date location dependent information
- Location aware services
  - Find services in the local environment, e.g. printer
- Information services
  - Push: e.g., stock quotes
  - Pull: e.g., nearest cash ATM
- Entertainment
  - Ad-hoc networks for multi user games

Acknowledgement

- The lecture notes are compiled from different sources of online materials and reference books.