

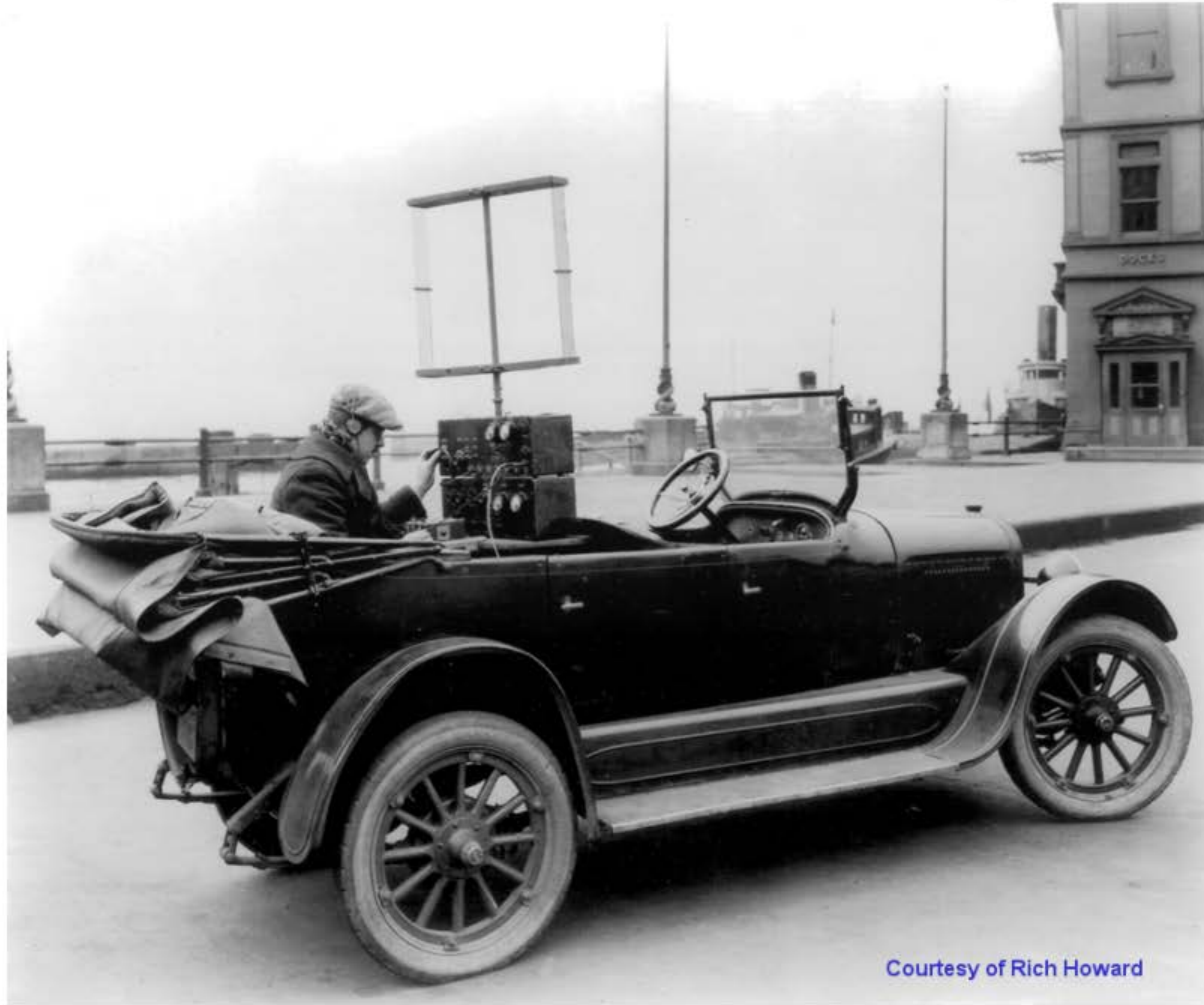


# INTRODUCTION TO WIRELESS COMMUNICATION SYSTEMS

# Labs

- In the Lab 4, you'll have the opportunity to get your Lab 3 checked by the GTAs while I'll evaluate your project understanding (2-3 minute viva) in parallel.
- Completed Lab document (Lab 1, 2 & 3) and Project report submission deadline is **20 December** through Moodle.

# First Mobile Radio Telephone 1924



Courtesy of Rich Howard

# Evolution of Mobile Radio Communications

## ■ Major Mobile Radio Systems

- ❑ 1934 - Police Radio uses conventional AM mobile communication system.
- ❑ 1935 - Edwin Armstrong demonstrate FM
- ❑ 1946 - First public mobile telephone service - push-to-talk
- ❑ 1960 - Improved Mobile Telephone Service, IMTS - full duplex
- ❑ 1960 - Bell Lab introduce the concept of Cellular mobile system
- ❑ 1968 - AT&T propose the concept of Cellular mobile system to FCC.
- ❑ 1976 - Bell Mobile Phone service, poor service due to call blocking
- ❑ 1983 - Advanced Mobile Phone System (AMPS), FDMA, FM
- ❑ 1991 - Global System for Mobile (GSM), TDMA, GMSK
- ❑ 1991 - U.S. Digital Cellular (USDC) IS-54, TDMA, DQPSK
- ❑ 1993 - IS-95, CDMA, QPSK, BPSK

# Evolution of Mobile Radio Communications

## ■ Major Mobile Radio Systems

- ❑ 1997 — Release of IEEE 802.11 WLAN protocol
- ❑ 1999 — Bluetooth specification introduced
- ❑ 1999 — First of the "third generation" cellular systems are standardized: Universal Mobile Telecommunication System (UMTS) and cdma2000
- ❑ 2005 — First mobile WiMAX system (IEEE 802.16e)
- ❑ 2009 — Release of IEEE 802.11n WLAN protocol, supporting up to 150 Mbit/s data rates in both the 2.4 GHz and 5 GHz ISM bands.
- ❑ 2010 — LTE (4G) mobile and then LTE-A in 2013
- ❑ ??? — 5G and beyond

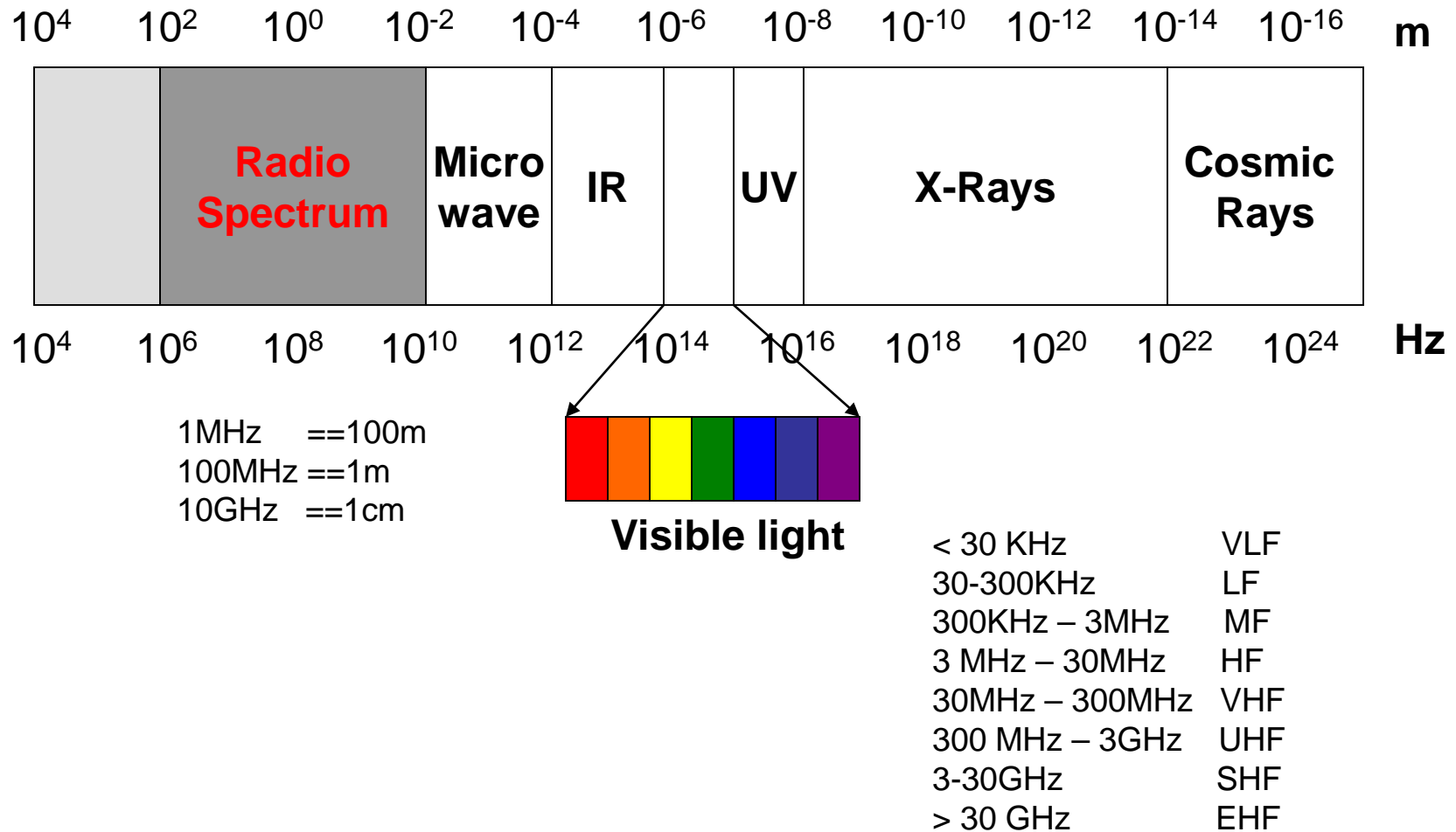
# Example of Mobile Radio Systems

- Examples
  - Cordless phone
  - Remote controller
  - Hand-held walkie-talkies
  - Pagers
  - Cellular telephone
  - Wireless LAN
- Mobile - any radio terminal that could be moved during operation
- Portable - hand-held and used at walking speed
- Subscriber - mobile or portable user

# Wireless Communication

- Transmitting voice and data using electromagnetic waves in open space
- Electromagnetic waves
  - Travel at speed of light ( $c = 3 \times 10^8$  m/s)
  - Has a frequency ( $f$ ) and wavelength ( $\lambda$ )
    - $c = f \times \lambda$
  - Higher frequency means higher energy photons
  - The higher the energy photon the more penetrating is the radiation

# Electromagnetic Spectrum





# Wavelength of Some Technologies

- **GSM Phones:**
  - frequency  $\approx$  900 MHz
  - wavelength  $\approx$  33cm
- **PCS Phones**
  - frequency  $\approx$  1.8 GHz
  - wavelength  $\approx$  17.5 cm
- **Bluetooth:**
  - frequency  $\approx$  2.4GHz
  - wavelength  $\approx$  12.5cm

# Frequency Carriers/Channels

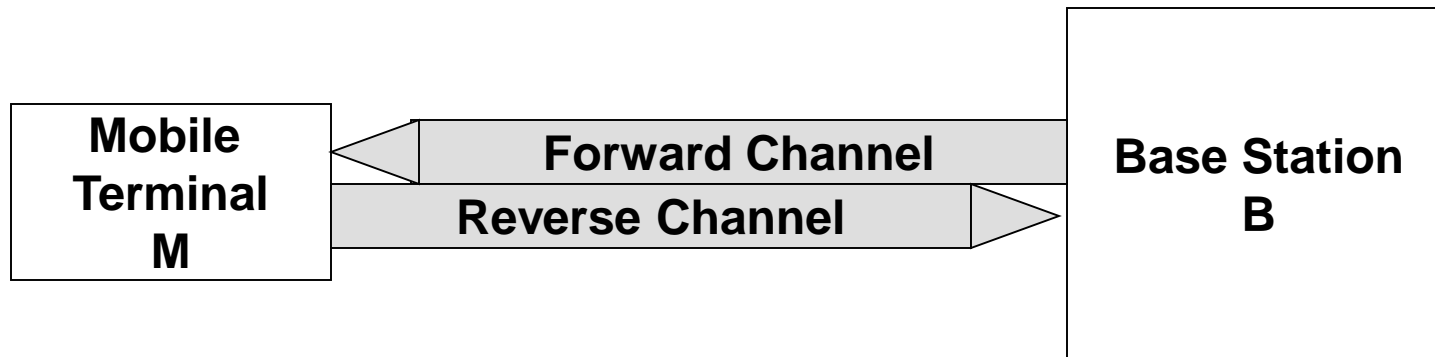
- ❑ The information from sender to receiver is carrier over a well defined frequency band.
  - This is called a channel
- ❑ Each channel has a fixed frequency bandwidth (in kHz) and Capacity (bit-rate)
- ❑ Different frequency bands (channels) can be used to transmit information in parallel and independently.

# Simplex/Duplex Communication

- Normally, on a channel, a station can transmit only in one way.
  - This is called simplex transmission
- To enable two-way communication (called half/full-duplex communication)
  - We can use Frequency Division Multiplexing
  - We can use Time Division Multiplexing

# Duplex Communication - FDD

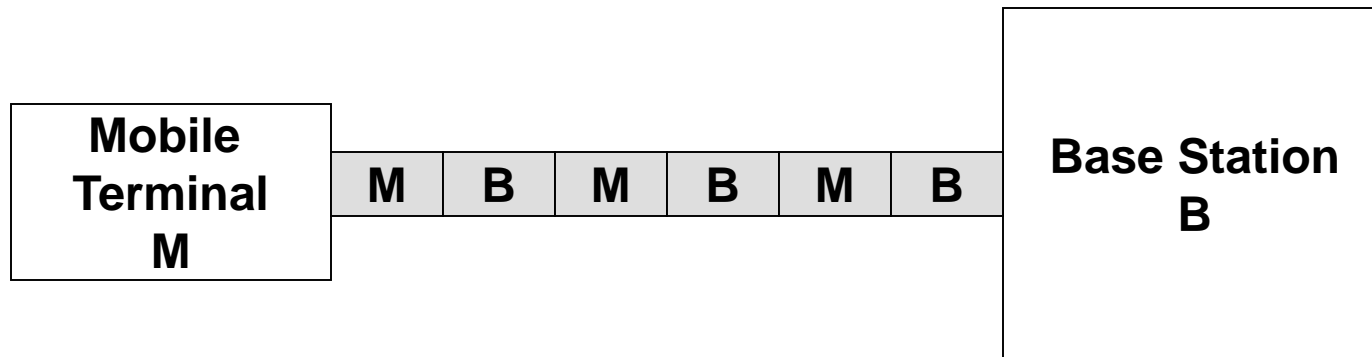
- FDD: Frequency Division Duplex



**Forward Channel and Reverse Channel use different frequency bands**

# Duplex Communication - TDD

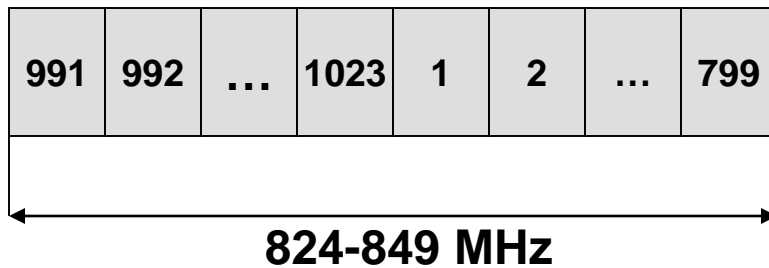
- TDD: Time Division Duplex



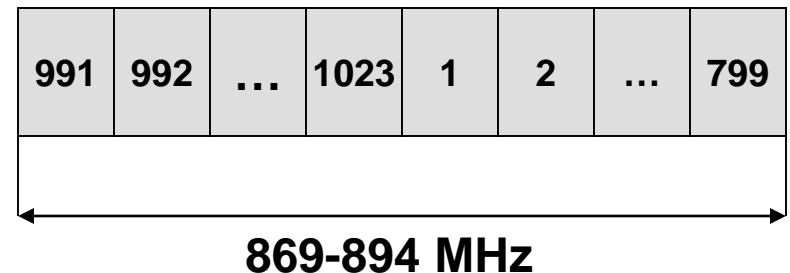
**A single frequency channel is used. The channel is divided into time slots. Mobile station and base station transmits on the time slots alternately.**

# Example - Frequency Spectrum Allocation in U.S. Cellular Radio Service

**Reverse Channel**



**Forward Channel**



Channel Number		Center Frequency (MHz)
Reverse Channel	$1 \leq N \leq 799$	$0.030N + 825.0$
	$991 \leq N \leq 1023$	$0.030(N-1023) + 825.0$
Forward Channel	$1 \leq N \leq 799$	$0.030N + 870.0$
	$991 \leq N \leq 1023$	$0.030(N-1023) + 870.0$
(Channels 800-990 are unused)		

# What is Mobility

- Initially Internet and Telephone Networks is designed assuming the user terminals are static
  - No change of location during a call/connection
  - A user terminals accesses the network always from a fixed location
- Mobility and portability
  - Portability means changing point of attachment to the network offline
  - Mobility means changing point of attachment to the network online

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# Degrees of Mobility

## ■ Walking Users

- Low speed
- Small roaming area

## ■ Vehicles

- High speeds
  - Large roaming area
  - Uses sophisticated terminal equipment (cell phones)
-

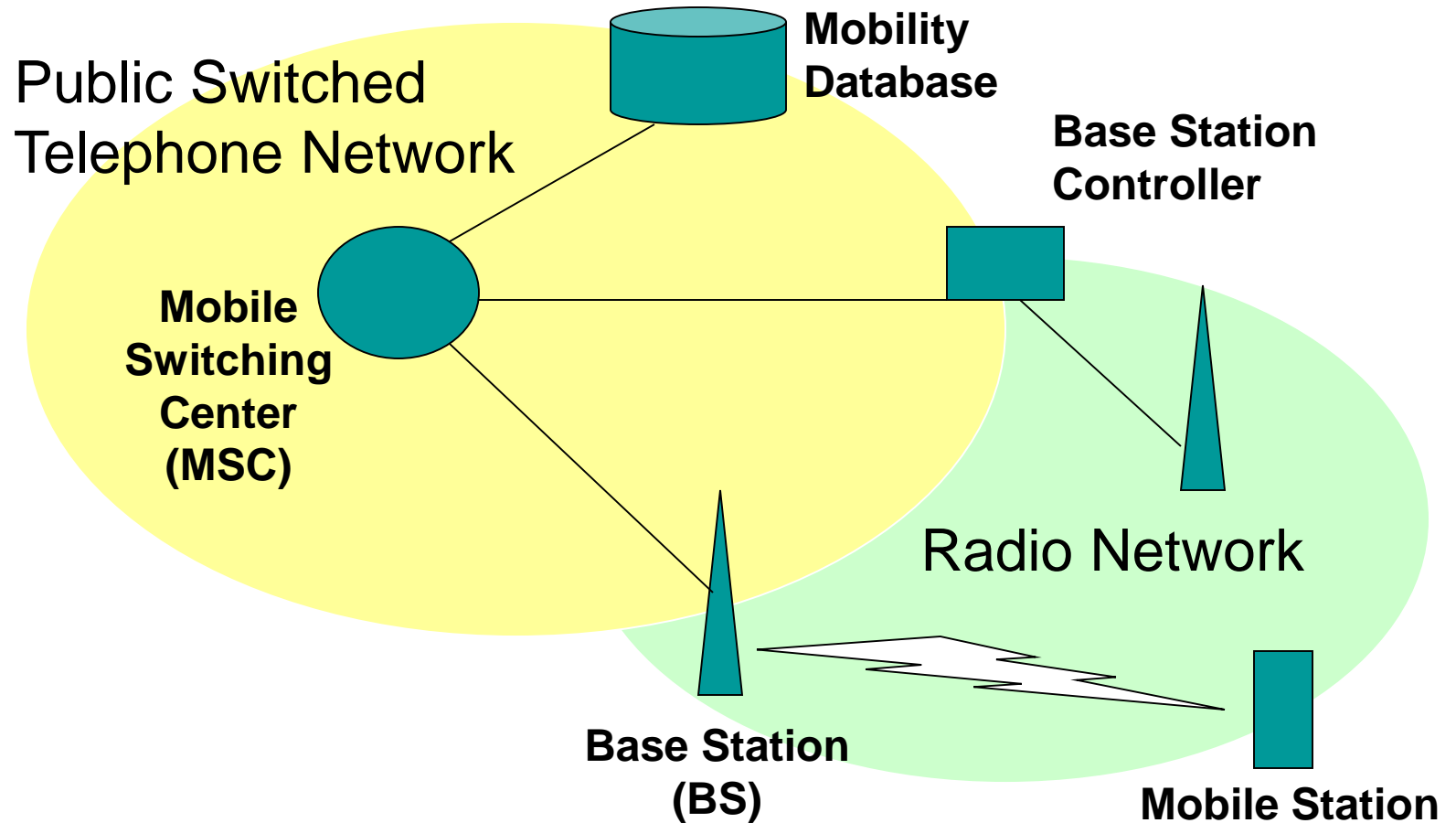


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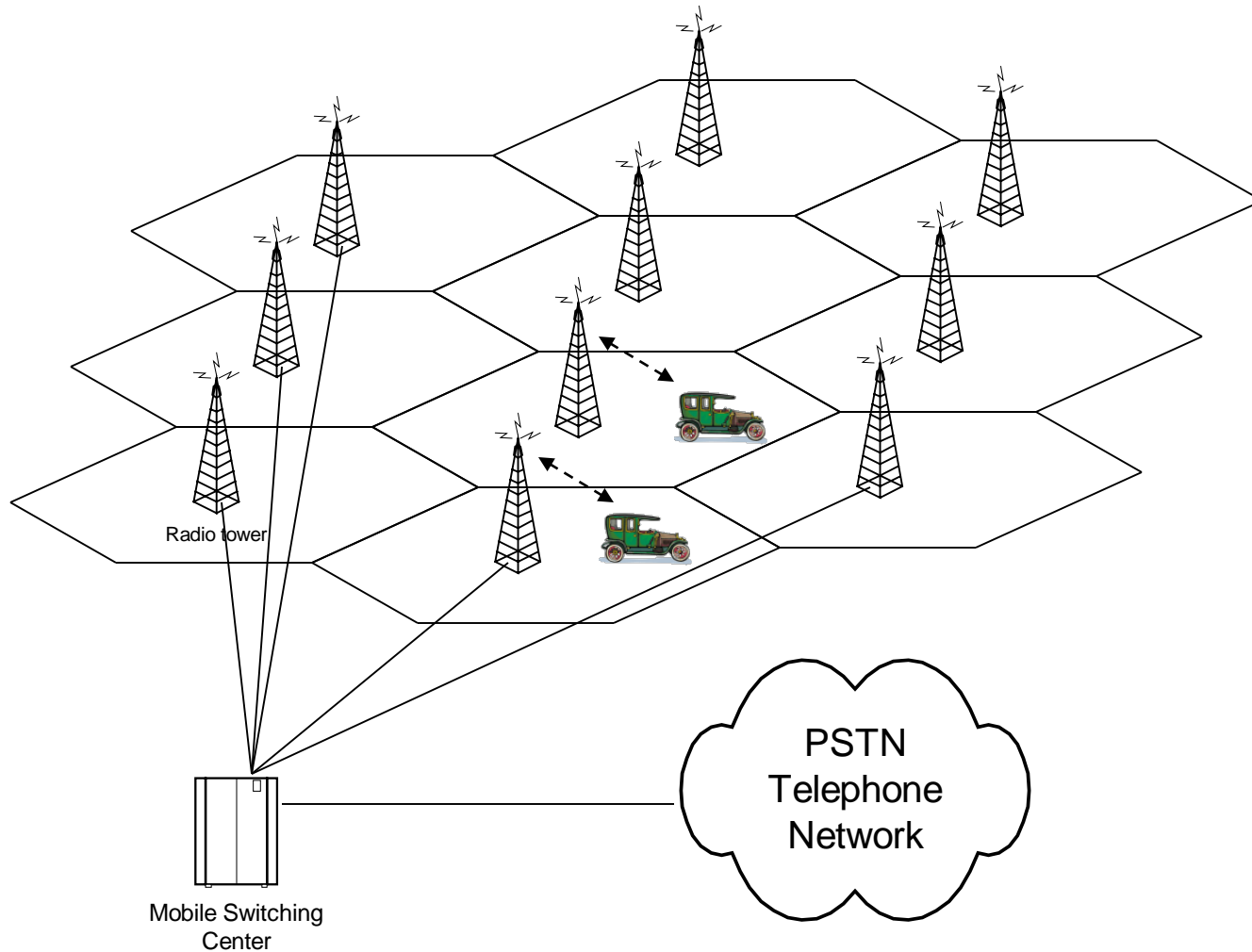
# The Need for Wireless/Mobile Networking

- Demand for Ubiquitous Computing
    - Anywhere, anytime computing and communication
      - You don't have to go to the lab to check your email
    - Pushing the computers more into background
      - Focus on the task and life, not on the computer
      - Use devices **seamlessly** to help you and to make your life more easier.
    - Devices should be location aware
      - Adapt to the current location, discover services
-

# Very Basic Cellular Architecture



# Cellular Telephony - Architecture



# Wireless System Definitions

- ❑ Mobile Station

- ❑ A station in the cellular radio service intended for use while in motion at unspecified locations. They can be either hand-held personal units (portables) or installed on vehicles (mobiles)

- ❑ Base station

- ❑ A fixed station in a mobile radio system used for radio communication with the mobile stations. Base stations are located at the center or edge of a coverage region. They consists of radio channels and transmitter and receiver antennas mounted on top of a tower.

# Wireless System Definitions

- ❑ Mobile Switching Center

- ❑ Switching center which coordinates the routing of calls in a large service area. In a cellular radio system, the MSC connections the cellular base stations and the mobiles to the PSTN (telephone network). It is also called Mobile Telephone Switching Office (MTSO)

- ❑ Subscriber

- ❑ A user who pays subscription charges for using a mobile communication system

- ❑ Transceiver

- ❑ A device capable of simultaneously transmitting and receiving radio signals

# Wireless System Definitions

- ❑ Control Channel

- ❑ Radio channel used for transmission of call setup, call request, call initiation and other beacon and control purposes.

- ❑ Forward Channel

- ❑ Radio channel used for transmission of information from the base station to the mobile

- ❑ Reverse Channel

- ❑ Radio channel used for transmission of information from mobile to base station

# Wireless System Definitions

- ❑ Handoff

- ❑ The process of transferring a mobile station from one channel or base station to another.

- ❑ Roamer

- ❑ A mobile station which operates in a service area (market) other than that from which service has been subscribed.

- ❑ Page

- ❑ A brief message which is broadcast over the entire service area, usually in simulcast fashion by many base stations at the same time.

# Cellular Telephony

- Characterized by
  - ❑ High mobility provision
  - ❑ Wide-range
  - ❑ Two-way voice communication
  - ❑ Handoff and roaming support
  - ❑ Integrated with sophisticated public switched telephone network (PSTN)



# Evolution...

■ 1G

■ 2G

■ 3G

■ 4G

■ 5G