

## Lecture 4

# CS 621

## Mobile Computing

### Mobile Cellular Systems

Zubin Bhuyan,  
Department of CSE, Tezpur University  
<http://www.tezu.ernet.in/~zubin>

Several slides and images in this presentation have been taken from Prof. Nityananda Sarma's class notes/ppt.  
Several images have been taken from the book Mobile Communication by Jochen Schiller.

# Cellular Implementations (Gs)

- **1G**: Analog cellular systems (450-900 MHz)
  - Frequency shift keying for signaling
  - FDMA for spectrum sharing
  - NMT- Nordic Mobile Telephone (Europe), AMPS – Advanced Mobile Phone System (US)
- **2G**: Digital cellular systems (900, 1800 MHz), < 14.4 kbps
  - TDMA/CDMA for spectrum sharing
  - Circuit switching
  - GSM-Global System for Mobile communications (Europe), IS-136 – Interim Standard 136 (US), PDC – Pacific Digital Cellular (Japan), CDMAOne – US, Korea, Asia.
- **2.5G**: Packet switching extensions , 14.4 – 144 kbps
  - Digital: GSM to GPRS (General Packet Radio Service), EDGE (or EGPRS)
  - Analog: AMPS to CDPD (Cellular Digital Packet Data)
- **3G**: High speed (384 kbps to 2 Mbps), data and Internet services
  - IMT-2000 (International Mobile Telecommunications)
  - CDMA2000 1X EV-DO, EV-DV, 3X, W-CDMA etc.

# Cellular Implementations(Gs)

- **4G:**
- In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards
  - peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars)
  - 1 gigabit per second (Gbit/s) for low mobility communication.
- A 4G system does not support traditional circuit-switched telephony service, but all-Internet Protocol(IP) based communication
- OFDM (Orthogonal frequency-division multiple access) and MC-CDMA (Multi Carrier CDMA)
- The peak bit rate is further improved by smart antenna arrays for multiple-input multiple-output (MIMO) communications.

# 1G Cellular Systems

- Many Different Standards:
  - AMPS (US)
  - NMT (Northern Europe)
  - TACS (Europe)
  - NTT (Japan)
  - many others...
- Spectrum
  - around 800 and 900 MHz

# Frequency Division Duplex (FDD)



**Two separate frequency bands** are used for forward and reverse links.

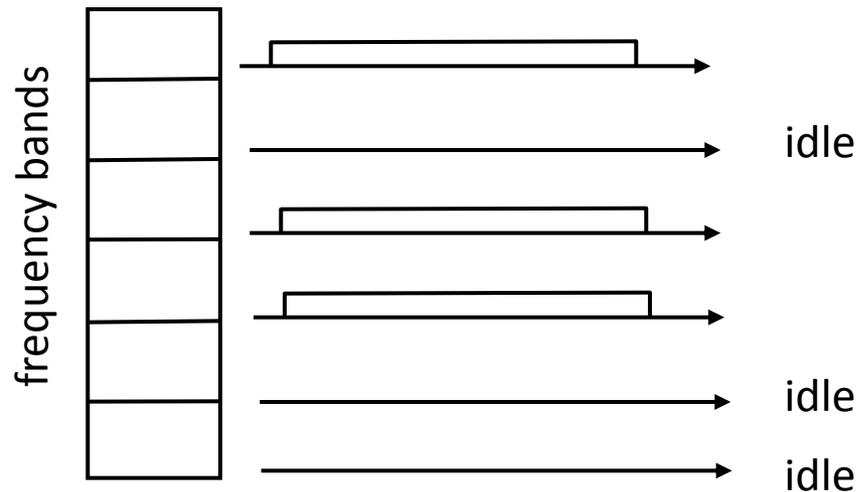
Typically, 25 MHz in each direction.

AMPS: 824-849 MHz (forward or downlink)  
869-894 MHz (reverse or uplink)

AMPS : Advanced Mobile Phone System, Bell Labs, 1983 (US)

# Frequency Division Multiple Access (FDMA)

- The spectrum of each link (forward or reverse) is further divided into frequency bands.
- Each station assigned fixed frequency band.



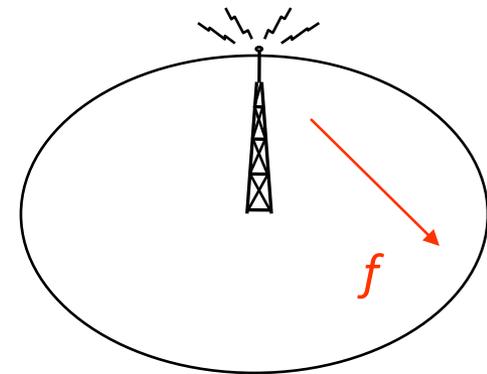
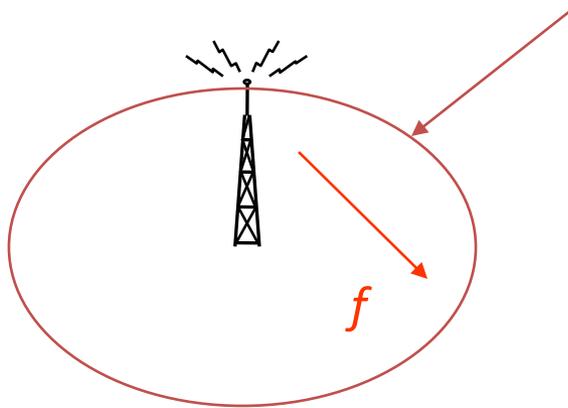
- FDMA gives users an individual allocation of one or several frequency bands, or channels. It is particularly commonplace in satellite communication.
- FDMA allows multiple users simultaneous access to a transmission system, FDD refers to how the radio channel is shared between the uplink and downlink

# Number of User Channels in AMPS

- Bandwidth allocated to each user in each link (forward or reverse) is 30 KHz.
- No. of user channels  
= Total bandwidth / user bandwidth  
= 25 MHz / 30 kHz  
= 833
- Is it enough?

# Frequency Reuse

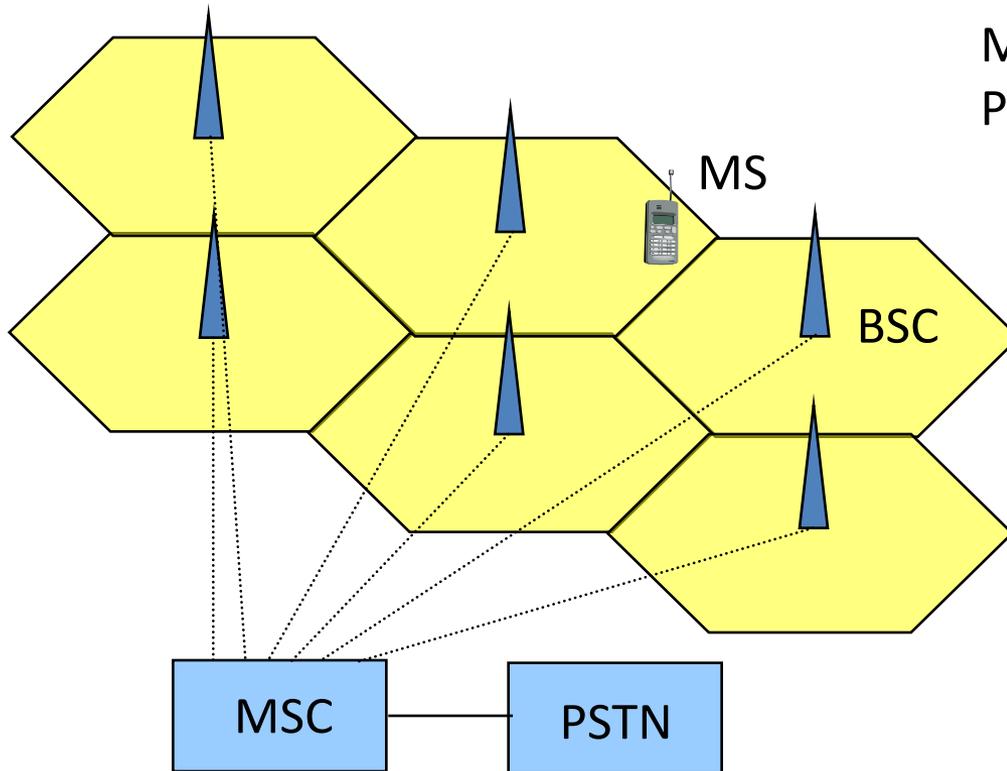
Radio coverage,  
called a cell.



The same frequency can be reused in different cells, if they are far away from each other

# Cellular Architecture

MS – Mobile Station  
BSC – Base Station Controller  
MSC – Mobile Switching Center  
PSTN – Public Switched Telephone Network



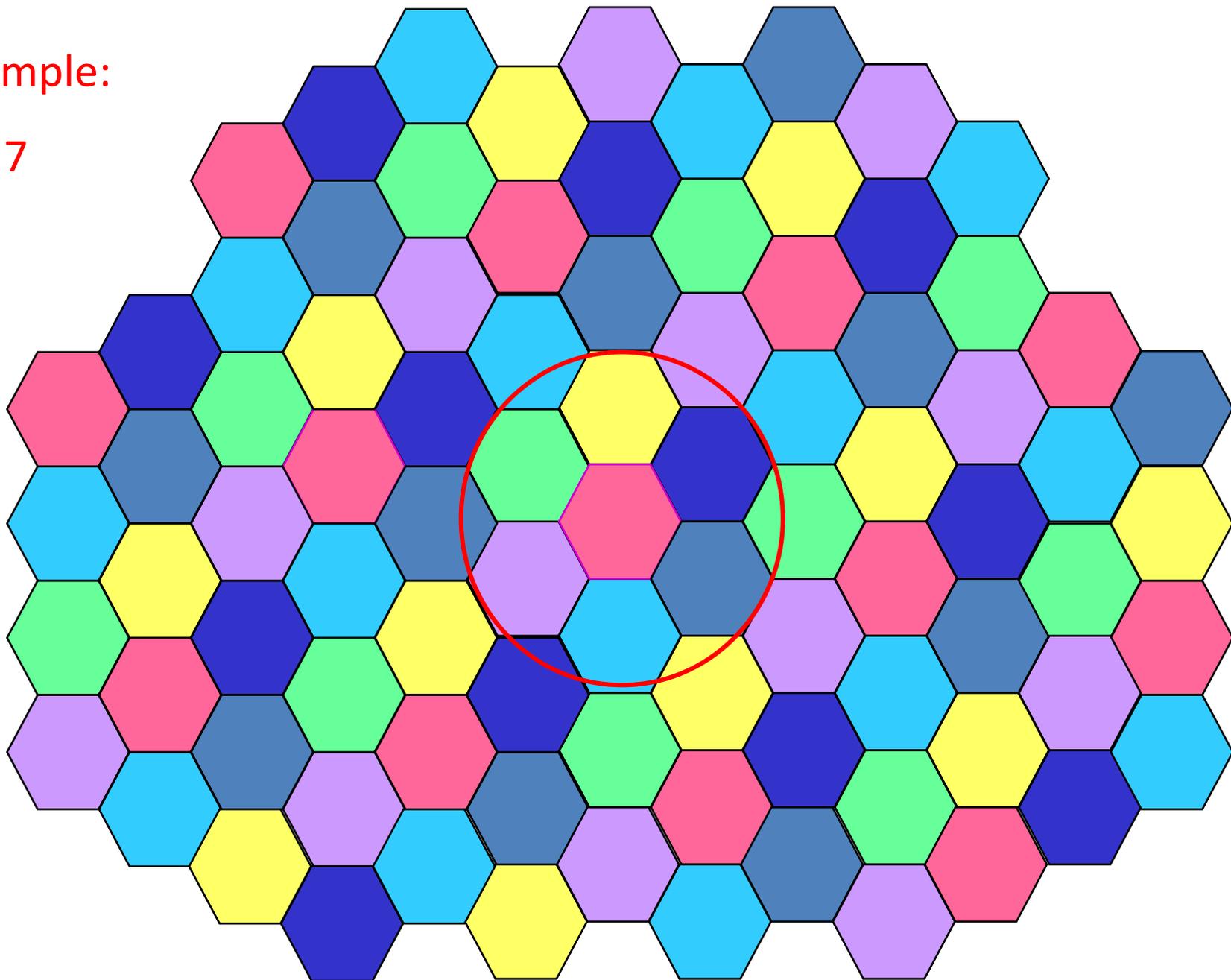
segmentation  
of the area into  
cells

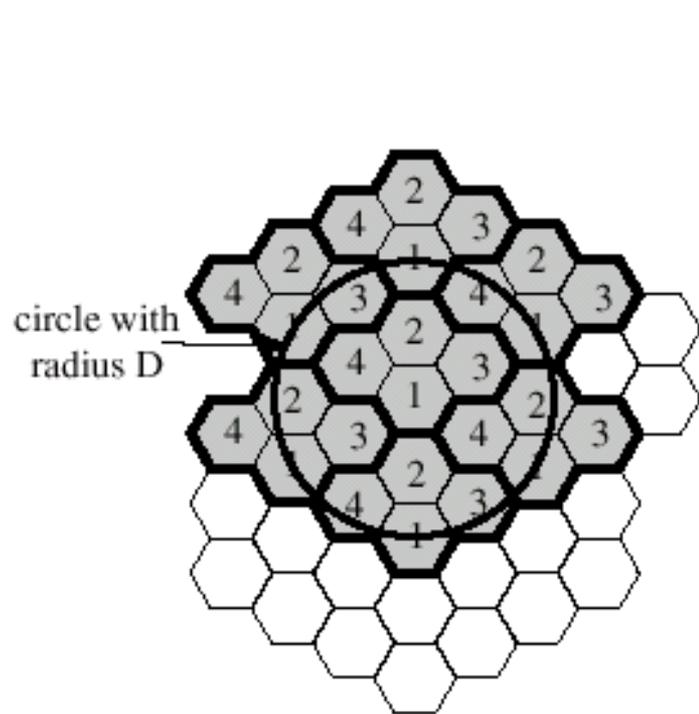
# Channel Reuse

- The total number of channels are divided into  $K$  groups.
  - $K$  is called **reuse factor** or **cluster size**.
- Each cell is assigned one of the groups.
- The same group can be reused by two different cells provided that they are **sufficiently far apart**.

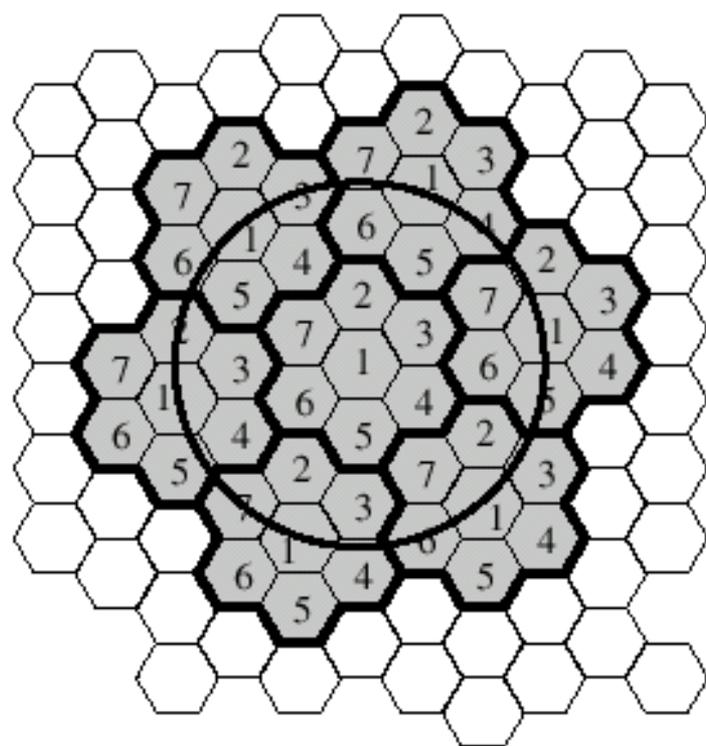
Example:

$K = 7$





(a) Frequency reuse pattern for  $N = 4$



(b) Frequency reuse pattern for  $N = 7$

**THANKS!**