

Lecture 5

CS 621

Mobile Computing

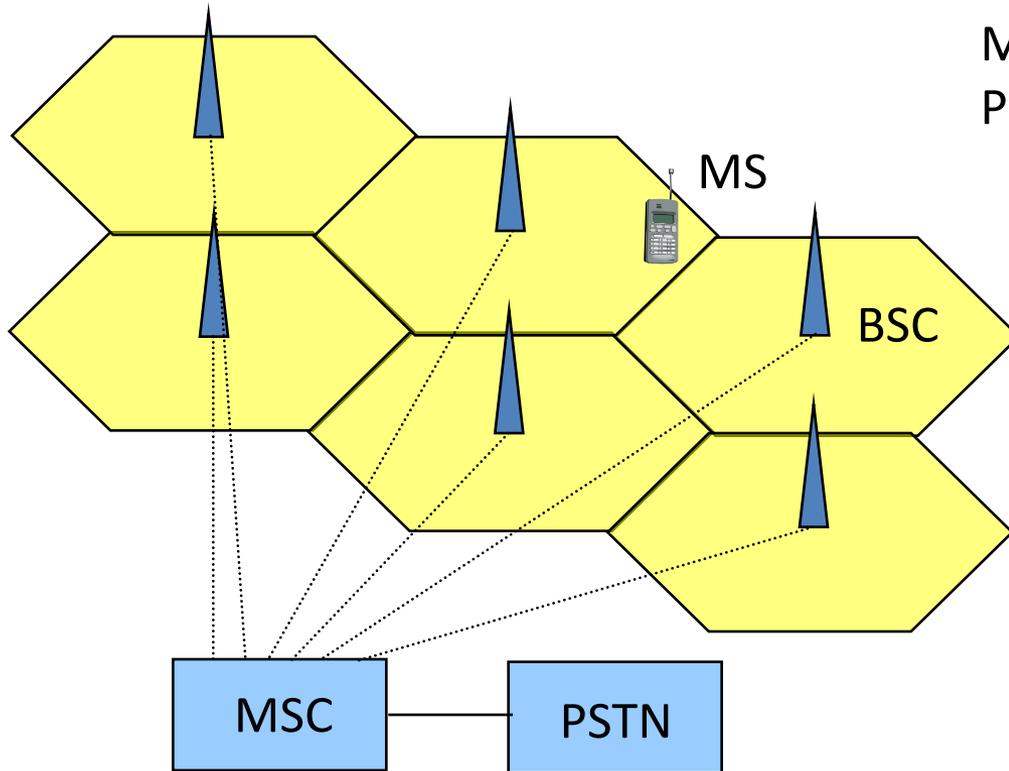
Mobile Cellular Systems

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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.

Recap: Cellular Architecture

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



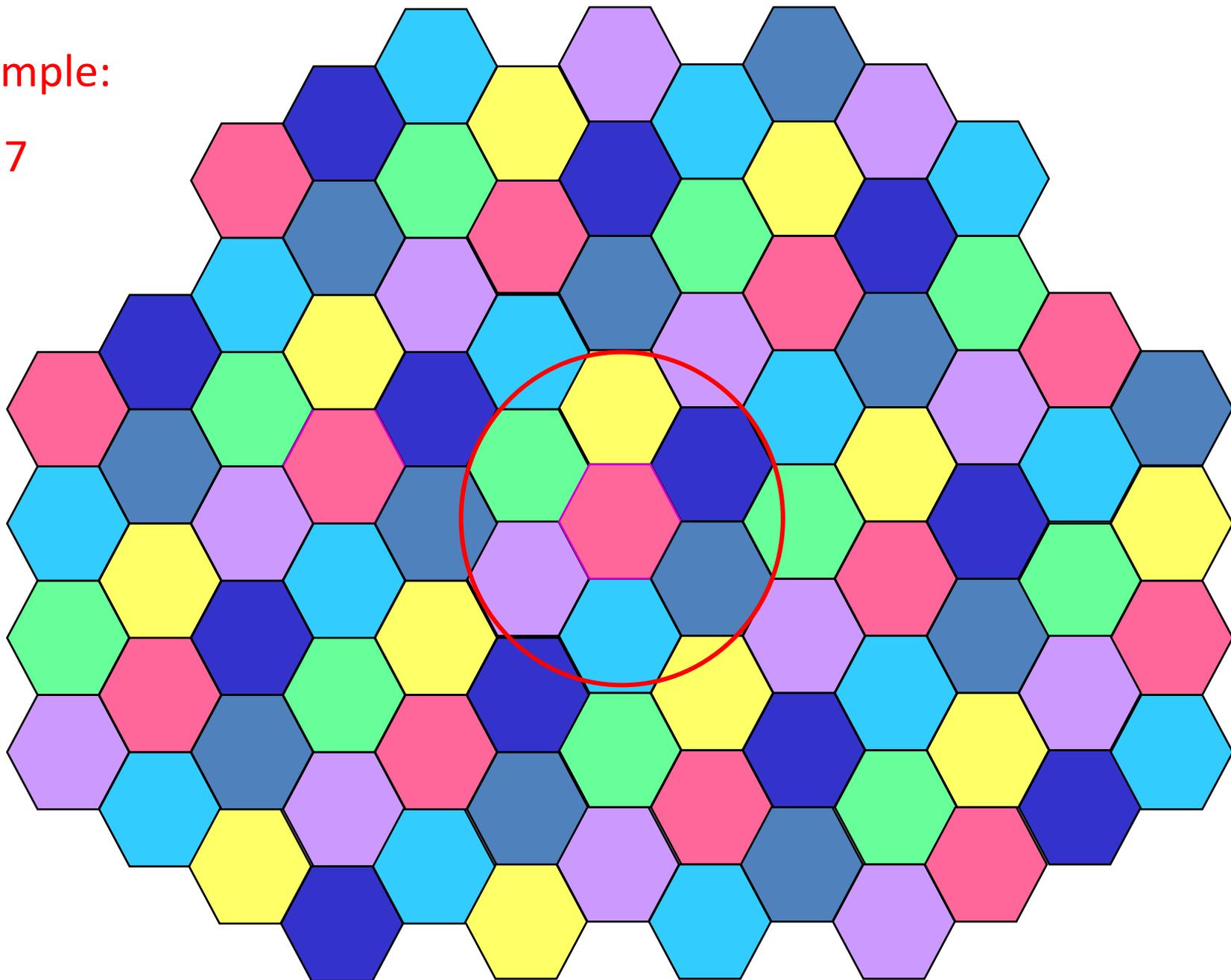
segmentation
of the area into
cells

Recap: Channel Reuse

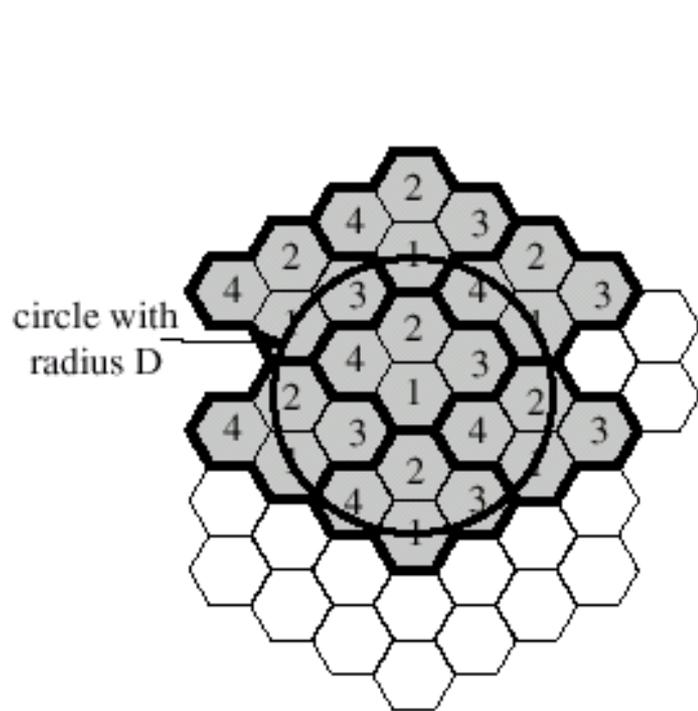
- The total number of channels are divided into K groups.
 - K is called **reuse factor** or **cluster size**.
- Each cell is assigned one of the groups.
- The same group can be reused by two different cells provided that they are **sufficiently far apart**.

Example:

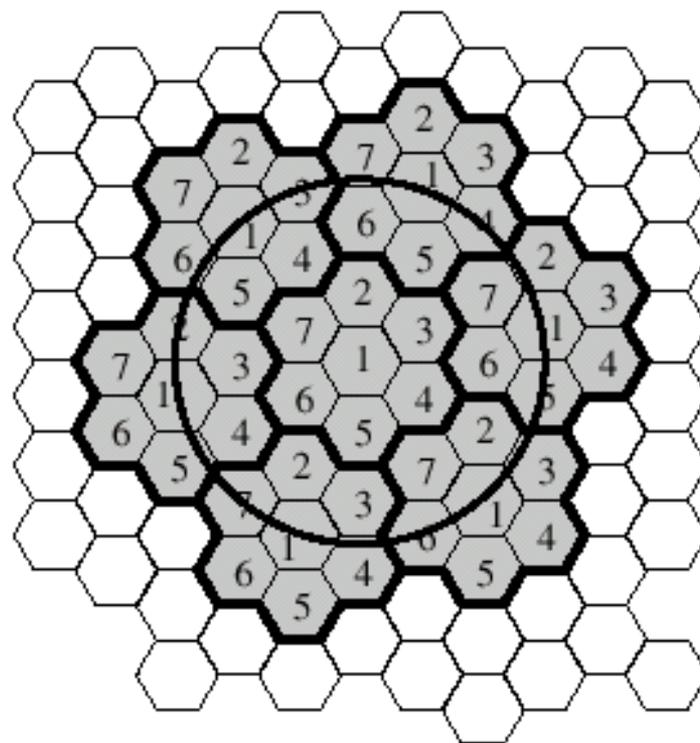
$K = 7$



Recap: Reuse Patterns



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



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

Reuse Distance

- How far apart can two users share the same channel?
 - It depends on whether signal quality is acceptable or not.
 - The larger the distance between the two users, the better the signal quality.
- How to measure signal quality?

Nyquist Bandwidth

- For binary signals (two voltage levels)
 - $C = 2B$
- With multilevel signaling
 - $C = 2B \log_2 M$
 - M = number of discrete signal or voltage levels

Signal Quality

- The signal quality depends on the **ratio between signal power and interference (noise) power**.

$$\frac{S}{I} = \frac{S}{\sum_i I_i}$$

← Interference from the *i*-th interfering BS.

- This is called signal-to- noise (interference) ratio (SNR or SIR).

Signal-to-Noise Ratio

- Ratio of the power in a signal to the power contained in the noise that's present at a particular point in the transmission.
- Typically measured at a receiver.
- Signal-to-noise ratio (SNR, or S/N)

$$(SNR)_{dB} = 10 \log_{10} \frac{\text{signal power}}{\text{noise power}}$$

- A **high SNR** means a **high-quality signal**, low number of required intermediate repeaters
- SNR sets upper bound on achievable data rate

Shannon Capacity Formula

Equation: $C = B \log_2(1 + \text{SNR})$

Represents theoretical maximum that can be achieved.

In practice, only much lower rates are achieved

Impulse noise is not accounted for.

Attenuation distortion or delay distortion not accounted for.

Example of Nyquist and Shannon Formulations

- Spectrum of a channel between 3 MHz and 4 MHz ; $\text{SNR}_{\text{dB}} = 24 \text{ dB}$

$$B = 4 \text{ MHz} - 3 \text{ MHz} = 1 \text{ MHz}$$

$$\text{SNR}_{\text{dB}} = 24 \text{ dB} = 10 \log_{10}(\text{SNR})$$

$$\text{SNR} = 251$$

- Using Shannon's formula: $C = B \log_2(1 + \text{SNR})$

$$C = 10^6 \times \log_2(1 + 251) \approx 10^6 \times 8 = 8 \text{ Mbps}$$

Example of Nyquist and Shannon Formulations

- How many signaling levels are required?

$$C = 2B \log_2 M$$

$$8 \times 10^6 = 2 \times (10^6) \times \log_2 M$$

$$4 = \log_2 M$$

$$M = 16$$

Classifications of Transmission Media

- Transmission Medium

- Physical path between transmitter and receiver

1. Guided Media

- Waves are guided along a solid medium
- E.g., copper twisted pair, copper coaxial cable, optical fiber

2. Unguided Media

- Provides means of transmission but does not guide electromagnetic signals
- Usually referred to as wireless transmission
- E.g., atmosphere, outer space

Propagation Model

- The received signal power depends on the **distance** between the transmitter and the receiver.

$$P_r = P_0 \left(\frac{d}{d_0} \right)^{-\alpha}$$

- P_0 is the power received at a reference distance d_0 .
- α is called the **path loss exponent**.
 - Typically, $3 \leq \alpha \leq 5$.

THANKS!