

4th Year IT-IS-SW

Cellular Network –
(Lecture 2-Part2)

Question 1

There are 1000 users subscribed to a cellular network. The call request rate for each user is 2 call requests per week. For each cell, the average call duration is 10 min.

$$A = \lambda T$$

$$\begin{aligned} \text{request} &= 1000 \times 2 \\ \text{avg Time} &= 10 \text{ min} \end{aligned}$$

$$\lambda = \frac{2 * 1000}{7 * 24 * 60} = \frac{2000}{10080}$$

days hours min

$$T = 10$$

$$A = \lambda T = \frac{2000}{10080} * 10 = 1.98 \text{ Erlang}$$

Question 2

During a busy hour, the number of calls per hour for each of the 12 cells of a cellular cluster is 2220, 1900, 4000, 1100, 1000, 1200, 1800, 2100, 2000, 1580, 1800 and 900.

Assuming the average hold time of 60 seconds, what is the total Erlang value of the system?

Total number of calls in the system =

$$(2220 + 1900 + 4000 + 1100 + 1000 + 1200 + 1800 + 2100 + 2000 + 1580 + 1800 + 900) = 21600 \text{ calls}$$

Avg. call holding time $T = 60$ seconds

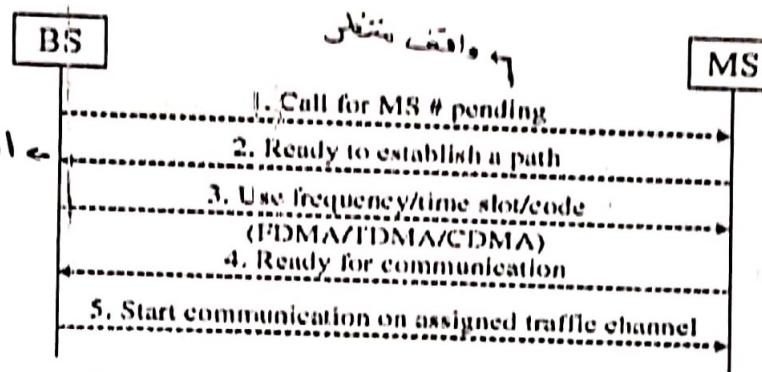
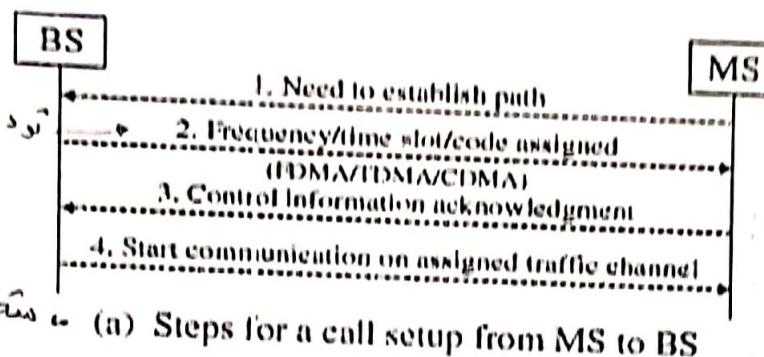
Call arrival rate per hour $\lambda = 21600$

$$\text{Traffic load } A = \lambda * T = \frac{21600}{3600} * 60 = 360 \text{ Erlangs}$$

$$\frac{21600}{60 \times 60} * 60 =$$

mobile switch

Handshake steps for a call setup between MS and BS using control channels



Type of Signal

Control Signal	Traffic Signal
Used to control bearer traffic (Establish Session, Terminate Session, authentication, subscriber info, call parameter negotiations يتم وفظ مع BS الثالثة)	Used for subscriber traffic (voice & data) الاتصالات
May be downlink or uplink	May be downlink or uplink

Downlink Signal	Uplink Signal
Signal Follows (BS → MS)	Signal Follows (MS → BS)
Channels used are either <i>control</i> or <i>data</i>	

الخطيط Cell Planning

- If the cell area is increased, Then
 - ✓ The number of channels per unit area must be reduced ورم عدد ارجون
 - ✓ reduce the number of cell phone subscribers وأناب عقل
- If number of cell phone users is increased, Then
 - ✓ Increase the number of the channels
 - ✓ Reduce the cell size

Note: area

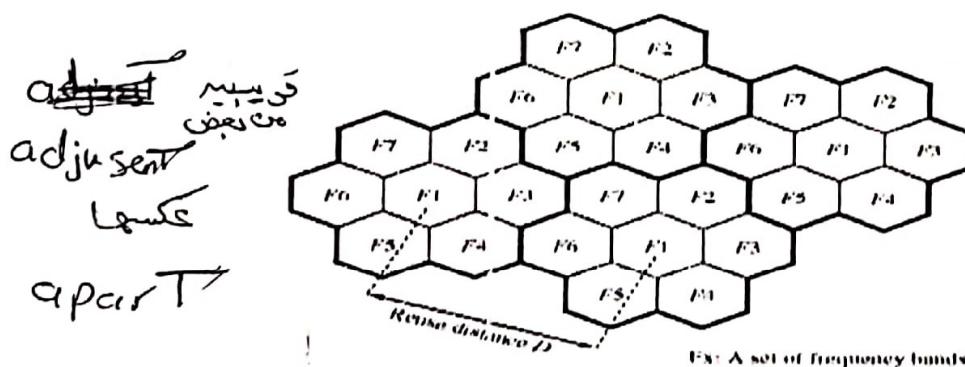


Cell area and the boundary length are important parameters that affect the handoff

Handoff Definition: hard - soft
 A handoff refers to the process of transferring an active call or data session from one cell in a cellular network to another or from one channel in a cell to another.

Frequency Reuse

A frequency band or channel in a cell can be *reused* in another cell if those cells are apart and there would be no interference



المسافة الى تتحلى المركبة

Reuse Distance

المسافة اللى تتحلى المركبة بين اد cell وار cell بتاع انفس Center

The closest distance between the centers of two cells using the same frequency

$$\text{مسافة انتخان} \quad D = \sqrt{3NR} \quad \sqrt{3N} \approx R$$

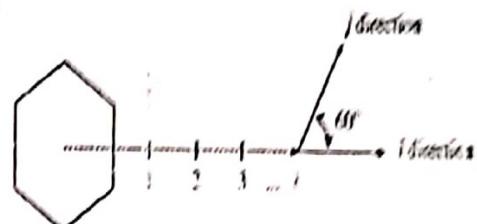
نستخدم
مساحة عصبات فسيب در

- N (number of cells in a cluster)
- R (cell radius)

Cells Cluster

جموع مسافات كل Cells مختلفة (مكانت تكرار

- Cluster size N is usually set to 1, 3, 4, 7, 9, ...
- $N = i^2 + ij + j^2$
 - i is number of cells in along direction
 - j is number of cells in direction 60° to direction of i



(a) 1 cell



(b) 3 cells



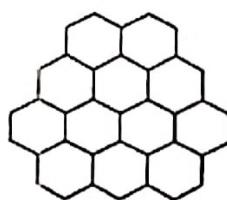
(c) 4 cells



(d) 7 cells



(e) 9 cells



(f) 12 cells



(g) 13 cells



(h) 16 cells

In real world, there are two parameters that determine the coverage of each base station and interference to other calls

- Path Loss

➤ model that describes signal attenuation between Tx and Rx antennas as a function of the propagation distance and other parameters

$$L(dB) = 10n \log_{10}(d) + C$$

- $n \rightarrow$ path loss exponent (2 to 4 in free space and 4 to 6 in indoor environments)
- $d \rightarrow$ distance between Tx and Rx
- $C \rightarrow$ constant for system loss

- Link budget

➤ formal way for calculating the Signal to Noise Ratio (SNR) and determine how much antenna transmitter power is needed?

Example

In a cellular mobile system, if the cell radius is 2 Km, what is the reuse distance for each of the following configurations:

- i. Three-cell reuse pattern in cluster
- ii. Seven-cell reuse pattern in cluster $> N$

$$D = \sqrt{3N} R$$

I. $D = \sqrt{3N} R = \sqrt{9} * 2k = 6 km$

II. $D = \sqrt{3N} R = \sqrt{21} * 2k = 9.1 km$

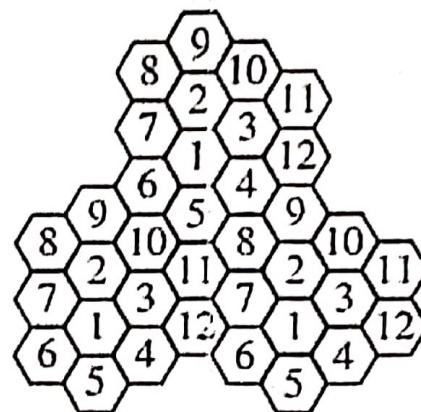
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Example

- In the figure below, find the reuse distance if the radius of each cell is 2 km $D = \sqrt{3N} * R$
- If each channel is multiplexed among 8 users, how many calls can be simultaneously processed by each cell if only 10 channels per cell are reserved for control, assuming a total bandwidth of 30MHz is available and each simplex channel consists of 25 kHz?

يعني كل رقم امن بـ 2
ما half duplex

Solution



يعطي على كل رقم دايم ف انتكر كام رج

يعطي ده عدد اد cluster

دايم ف كل cluster

يعطى على كل cell

يعطي لدار cluster ده 12

يعطي كل 12 ده cell

و دا يعنى صاحب cell

مست اد cluster

Overview of Wireless Network

- PAN (Personal Area Network)
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)

All wireless Access Network are based on the IEEE 802 with different versions

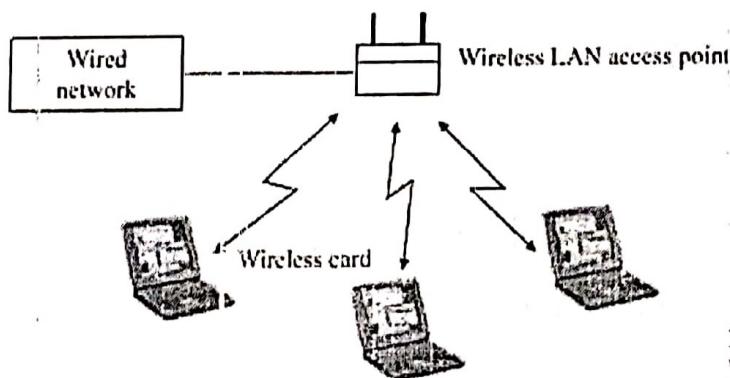
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Wireless Local Area Networks (WLANs - WiFi)

- Based on the IEEE 802.11 standard but with different version

	802.11 a	802.11 b	802.11 g	802.11 n
Frequency Range	5-6 GHz	2.4-5 GHz	2.4-5 GHz	2.4-5 GHz
Speed	Up to 54Mbps	Up to 11Mbps	Up to 54Mbps	Up to 200Mbps

- 802.11 b use DSSS (direct sequence spread spectrum in physical layer)
- Easy installation, cost efficient
- Wireless stations are either wireless access points (AP), clients
 - APs usually support 115 to 250 clients

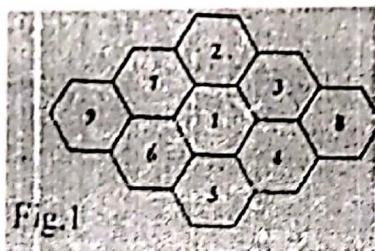


- AP admin choose frequency for AP
- Interference and collision possible (if channel can be same as that chosen by neighboring AP)

HW

Question

A user multiplexed-based system, shown in figure 1, has total bandwidth of 30MHz and contains 20 control channels per cell with equal channel spacing of 30KHz. The area of each cell is equal to 8Km^2 and total area 3600km 2



1. Total number of clusters			
a) 20	b) 9	c) 50	d) 10
2. The cell radius km			
a) 1.6	b) 33.8	c) 12	d) 8
3. The reuse distance km			
a) 62.3	b) 8.3	c) 175.6	d) 36
4. Total number of traffic channels/cell			
a) 820	b) 91	c) 1000	d) 100
5. If each channel multiplexed among 5 users, then total number of cells by each cell is			
a) 455	b) 164	c) 2000	d) 500