

EE4316 Mobile Data Networks

Question Bank from Past Papers

1. What is the key difference between first- and second-generation cellular systems?

Ans:

The major difference between the two generations is that the first generation systems are purely analog, whereas second generation systems are digital.

2. Considering that the required SIR is 15dB and the path-loss gradient $\alpha = 3$, determine the frequency reuse factor N needed for the implementation of the system.

Ans:

$$P_d = kP_t d^3 \text{ and } 15\text{dB} = 10 \log(\text{Power}) \rightarrow \text{Power} = 31.6$$

$$\frac{S}{I} = \frac{1}{6} \left(\frac{D}{R} \right)^3 = \frac{1}{6} (\sqrt{3N})^3 > 31.6 \rightarrow N > 11$$

Since $N = i^2 + ij + j^2$, the nearest $N = 12$, with $i = j = 2$

The list of the value N : {1, 3, 4, 7, 9, 12, 13, 16, 19, 21, ... }

3. What is the difference between hard handoff and seamless handoff?

Ans:

Hard handoff occurs when the MS completely breaks connection with the old BS before connecting to the new BS. In seamless handoff, the new channel is established before the old BS is disconnected.

4. What are the advantages and disadvantages of Centralized Power Control?

Ans:

Advantages:

- ✓ The service area has more cells, and hence larger network capacity.
- ✓ Required transmitted power is lower because the terminal is closer to the BS.
- ✓ This increase the battery lifetime and reduces the size of a terminal.

Disadvantages:

- ✗ As more cells are needed, the cost and time of deploying the network increases.
- ✗ The number of handoff increases, which increases the complexity of the design and deployment of the network as well as the signaling load in the fixed part.

5. Consider a cluster of three cells. The offered traffic to each individual cell are, 40 Erlangs, 70 Erlangs, and 80 Erlangs, respectively. With fixed non-uniform channel allocation and designated blocking probability of 0.01, what is the total number of channel needed in this cluster?

Ans:

Using the Erlang-B table, the required number of the channel in each individual cell are 53 (40 Erlangs), 85 (70 Erlangs) , 96 (80 Erlangs), respectively. Since non-uniform fixed channel allocation is used. The total number of channels in the cluster is $53+85+96=234$.

6. We have an installed cellular system with 100 sites, a frequency reuse factor of $N=7$ and 500 overall two-way channels:

- (a) Give the total number of channels available to the operator if the channel density (number of channels / unit area) of each cell is equal.

Ans:

For uniform channel density, the number of channels per cell is $500 \div 7 = 71$, the remaining channels are not used. Total number of channels available to the provider is $71 \times 100 = 7100$.

- (b) To expand the network capacity, we decide to create an underlay-overlay system where the new system uses a frequency reuse factor $k = 3$. Let D_0 and R_0 be the co-channel distance and radius of micro cell respectively. Given that $D_1 = 3R_0$, by expressing R_1 in terms of R_0 , determine the number of channels assigned to inner and outer cells to keep a uniform channel density over the entire coverage area.

Ans:

$$\frac{D_0}{R_0} = \sqrt{3 \times 7} = 4.6 = \frac{D_1}{R_1}$$

$$\text{Using } D_1 = 3R_0 \rightarrow \frac{3R_0}{R_1} = 4.6 \rightarrow R_0 = 1.53 \cdot R_1$$

$$\text{Area} = k \cdot R^2 \rightarrow \frac{A_0}{A_1} = \frac{kR_0^2}{kR_1^2} = (1.53)^2 \rightarrow A_1 = 0.425 \cdot A_0$$

$$\text{Let } X \text{ be the number of the channel, } 3 \times (0.425 \cdot X) + 7 \times (0.575 \cdot X) = 497 \rightarrow X \cong 94$$

$$\text{For the micro cells: } 0.425 \cdot X = 40 \text{ channels}$$

$$\text{For the macro cells: } 0.575 \cdot X = 54 \text{ channels}$$

7. In a cellular network, the total number of channels per cell is 10. The new cell arrival rate is 2.5 calls/minute, the handoff request rate is 1.5 calls/minute and the mean channel holding time is 2 minutes.

(a) Use the Erlang-B formula to calculate the blocking probability of a handoff request.

Ans:

mean channel holding time=2 minutes mean service rate=0.5 calls/minutes

$$A = \frac{2.5 + 1.5}{0.5} = 8$$

$$E_{10}(8) = \frac{8^{10}/10!}{\sum_{i=0}^{10} 8^i/i!} = 0.1217$$

(b) Now, one channel is reserved exclusively for handoff request, calculate the new blocking probability of a new cell and a handoff request.

Ans:

$$S = 10 \quad S_R = 1 \quad S_c = 9$$

$$p_0 = \left[\sum_{j=0}^9 \frac{(\lambda_o + \lambda_H)^j}{j! \mu^j} + \frac{(\lambda_o + \lambda_H)^9 \lambda_H}{10! \mu^{10}} \right] = 4.45 \times 10^{-4}$$

$$B_o = p_4 + p_5 = 0.2140 \quad B_H = p_5 = 0.0494$$

8. Describe the frequency planning procedure in UMTS networks.

Ans:

All cells in a UMTS ratio network use the same frequency, no frequency planning is required.

9. What handover technique is used in UMTS networks?

Ans:

Soft handoff

10. When GSM is upgraded to UMTS, the Base Station subsystem (BSS) is completely re-designed and becomes UMTS Terrestrial Radio Access Network (UTRAN). Name the two element in UTRAN.

Ans:

Base Station (Node B), Radio Network Controller (RNC)

11. A cellular network has the following data which can be used to evaluate the impact of location updates on the radio response:

Density of MS in the cell = 10000 MS/km²

Cell Radius = 500 m

Average moving velocity of an MS = 10 km/hour

Number of cells per LA = 10

(a) Calculate the rate of location update in a cell.

Ans:

$$L = 6R \left[\frac{1}{3} + \frac{1}{2\sqrt{3N} - 3} \right] = 6 \times 0.5 \left[\frac{1}{3} + \frac{1}{2\sqrt{30} - 3} \right] = 1.377 \text{ km}$$

$$\lambda_{LU} = \frac{v\rho L}{\pi} = \frac{10 \times 10000 \times 1.377}{\pi} = 43831 \text{ LUs/hour}$$

(b) Out of 120 location updates, the distribution and duration of each type is given by the following table:

Type	Number	Duration
Intra-VLR LU	20	600 ms
Inter-VLR LU with TMSI	40	3000 ms
Inter-VLR LU with IMSI	60	5000 ms

Determine the number of channels required to achieve 1% of blocking of location updates.

Ans:

$$\text{Mean duration of } LU = \frac{20 \times 0.6 + 40 \times 3 + 60 \times 5}{120} = 3.6 \text{ s}$$

$$\text{Traffic Intensity } I = \lambda_{LU} \times \frac{LU}{60 \times 60} = 43.831 \text{ Erlang}$$

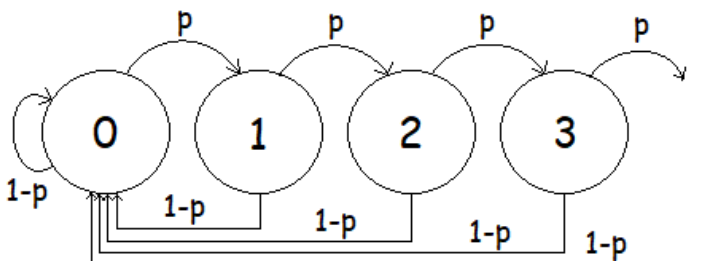
From the Erlang B table, to achieve 1% blocking, the number of channels are 57.

12. Assume that operation of BEB in the MAC protocol 802.11 is modified to allow as many attempts as needed. In back off state φ , $\varphi = 0, 1, 2, 3, \dots$ the contention window size ω_i for a

node is given by $\omega_i = \begin{cases} 2^\varphi \omega & 0 \leq i < r \\ 2^i \omega & i \geq r \end{cases}$ where ω is the initial window state.

A node starts a new packet only after it has successfully transmitted a packet. Assume that the probability that a packet transmission experiences a collision be p . Draw the Markov chain which models the modified BEB operation at a node.

Ans:



13. In each of the following case, name the inter-frame spacing parameters by which a node needs to ensure the channel is idle before transmission.
- (a) A node wants to send a data frame.
 - (b) A node wants to send a RTS frame.
 - (c) A node wants to send a CTS frame.

Ans:

- (a) DIFS
- (b) DIFS
- (c) SIFS

14. Below is a list of logical channels defined in GSM, indicate the direction of each channel.

Logical channel	Direction
Broadcast control channel	Base Station to mobile (downlink)
Paging channel	Base Station to mobile (downlink)
Fast associated control channel	Two way

15. What flexibility is provided in the channel allocation of GPRS?

Ans:

Multiple users can share one physical channel and multiple channels can be assigned to single user.

16. What are the new elements added to the GSM infrastructure to support GPRS, and what are their functions?

Ans:

Packet Control Unit (PCU)

Handles the data packetizing process for BSS.

Serving GPRS Support Node (SGSN)

Responsible for mobility management, session management, tunneling and routing, compression, authentication, encryption, and the generation of charging data records.

Gateway GPRS Support Node (GGSN)

Acts as a logical interface to the public data networks. It maintains routing information related to a MS, so that it can route packets to the SGSN servicing the MS.