USN | | | | | | | | | | |

CMRIT — CMR INSTITUTE OF TECHNOLOGY, BENGALURU. ACCREDITED WITH A+ GRADE BY NAAC

Internal Assessment Test 1 – March 2021

Sub:	Wireless Cellular and LTE 4G Broadband					Sub Code:	17EC81	Branch:	ECE
Date:	20.05.2021	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VIII ECE - A,B,C, D & TCE		OBE

Answer any FIVE FULL Questions	MARKS	CO	RBT
1. List the advantages of OFDM leading to its selection for LTE and explain.	[10]	CO1	L1
2. Explain the following in brief: (i) Angular Spread and Coherence distance (ii) Doppler Spread and coherence time.	[10]	CO1	L2
3. (a) Define Path loss and shadowing with relevant expressions.	[05]	CO1	L3
(b) Consider a user in the downlink of a cellular system, where the desired base station is at a distance of 500 meters and there are numerous nearby interfering base stations transmitting at the same power level. If there are three interfering base stations at a distance of 1km, three at a distance of 2km, and ten at a distance of 4 km. Use empirical path loss formula to find the signal-to-interference ratio (SIR) when α = 3 and α = 5.	[05]	CO1	L3
4. a) Explain the cellular concept and discuss how interference can be reduced in cellular communication. b) Discuss briefly the cell capacity expansion technics.	[05] [05]	CO1	L3
5. Draw the block diagram of end-to-end architecture of EPC supporting current and Legacy radio access networks and discuss the elements of EPC.	[04+06]	CO1	L1
6. Explain the techniques used for mitigating narrowband fading.	[10]	CO1	L2

Signature of CI

Signature of CCI

SOLUTION

1. List the advantages of OFDM leading to its Selection for LTE and Explain.

Sol^n i) Elegant Solution to multipath interference:-

→ Critical challenge to high bit rate transmission in a wireless channel is inter symbol Interference (ISI) caused by multipath

→ at high data rate Symbol time is shorter thus it only takes a small delay to cause ISI. OFDM is multicarrier modulation technique that overcomes this challenge

→ It increases the symbol duration of each stream such that the multipath delay spread is only a small fraction of symbol duration

→ Subcarriers are orthogonal to one another over symbol duration

→ Thereby avoiding non-over lapping Subcarrier channels to estimate ISI

ii) Reduced Computational complexity:

→ OFDM can be easily implemented using (FFT | IFFT) fast fourier transforms. Computational frequency grows only slightly faster than linearly with data rate of bandwidth.

-> The computational Complexity of OFDM = $B \log BT_m$

B -> Band width

T_m -> delay spread

-> Reduced complexity is practically attractive in the down link.

-> It reduces mobile device cost & power consumption

iii) Enables efficient multi-access scheme:

-> OFDM can be used as multi-access scheme by partitio-ning different subcarriers among multiple users

-> This is reffered to as OFDMA and it is exploited in LTE

iv) Exploitation of frequency diversity:

-> OFDM facilitates coding & interleaving across subcarrier in the frequency domain

-> which provide robustness against burst errors / cause by portion of transmission spectrum

-> OFDM allows for bandwidth to be scalable without impacting the hardware design of the base station & the mobile station

v) Suitable for coherent demodulation:

-> It is relatively easy to do pilot-based channel estim-ation in OFDM systems. which renders suitable for coherent demodulation schemes that more power efficient

vi) Facilitates use of MIMO:-

→ It refers to collection of signal processing techniques that use for multiple antennas at both transmitter and receiver & improves system performance.

→ multipath delays donot cause ISI

vii) Graceful degradation of performance under excess delay:

→ OFDM performance system degrade gracefully as the delay spread exceeds designed value.

→ It is well suited for adaptive modulation coding

→ which allows system to make the best of available channel conditions

viii) Robust against narrow band Interference:-

→ OFDM is relatively robust against narrow band interference.

→ Since such interference affects only a friction of the subcarriers

ix) Efficient support of broadcast Service:-

→ It is possible to operates OFDM network as single frequency Network (SFN)

→ It allows broadcast cells to combine over the air significantly enhance the received signal power

→ enabling higher data rate broadcast for given transmission power

3 a) Define path loss and Shadowing with relevant expressions

Path loss:

It is the reduction in power density of an EM wave as it propagates through space from transmitter path-loss models generally path loss is same as transmit-receiver distance

-> Lower frequency are more desirable and more crowded

-> Reflection from earth and other objects. A reflected wave often experiences 180° phase shift

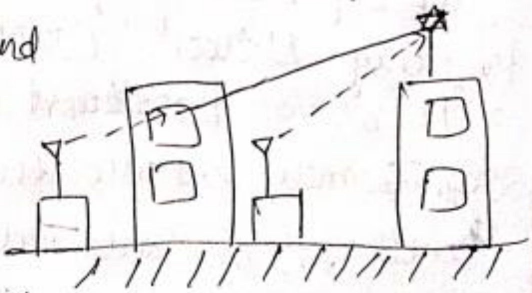
-> path loss is

$$P_r = \frac{P_t G_t G_r h_r^2 h_t^2}{d^4}$$

-> equation is dependent on antenna heights h_t & h_r and carrier frequency

Shadowing:

-> It is the attenuation of received signal strength due to presence of obstacles like trees and buildings located b/w transmitter and Receiver



-> It is also called as large scale fading

-> It can cause large deviations from path loss prediction

→ Shadowing empirical path loss formula

$$P_r = P_t P_0 \times \left(\frac{d_0}{d}\right)^n$$

→ It causes received SINR to vary dramatically over long term scales

3b)

Sol^n Given:

desired base station distance = 500m

3 interference base station at a distance of 1 km

~~for α=3 and d0~~ Received power

for $\alpha = 3$, $P_{rd} = P_t P_0 d_0^3 (0.5)^{-3}$

Interference power

$$P_{rt} = P_t P_0 d_0^3 \left[3(1)^{-3} + 3(2)^{-3} + 10(4)^{-3}\right]$$

Signal to interference ration for $\alpha = 3$

$$SIR = \frac{P_{rd}}{P_{rt}} = \frac{(0.5)^{-3}}{\left[3(1)^{-3} + 3(2)^{-3} + 10(4)^{-3}\right]} = 2.27$$

$$= 3.55\ dB$$

$$SIR(\alpha=5) = \frac{P_{rd}}{P_{rt}} = 10.32 = 10.32\,dB$$

2) Explain the following in brief.

i) Angular spread and Coherence distance

→ RMS angular spread of a channel can be denoted as θ_{rms} stastical distribution of the angle of the arriving energy

→ Channel can also vary over space

→ Large θ_{rms} - channel energy is coming from many directions due to lot of local scattering & small θ_{rms} is channel energy is more focused

→ Angular spread is coherence distance D_C as Angular spread increases coherence distance decreases

$$D_C = \frac{2\lambda}{\theta_{rms}}$$

→ Coherence distance of d - any physical position & separated by d have uncorrelated received signal amplitude and phase

→ Rayleigh fading with uniform angular spread

$$D_C = \frac{9\lambda}{16\pi}$$

→ Coherence distance indicates how far the antennas should be spread apart. for multiple antenna system.

ii) Doppler spread and coherence time:

→ Doppler power spectrum gives statistical power distribution of the channel v/s frequency for a single frequency transmission

→ It cause due to motion b/w Tx & Rx & is the fourier transform of $A_t(\Delta t)$

$$P_t(\Delta f) = \int_{-\infty}^{\infty} A_t(\Delta t) e^{-\Delta f \cdot \Delta t} (d\Delta t)$$

→ Doppler spread

$$f_D = \frac{V f_c}{C}$$

V – maximum spread b/w Tx & Rx,

f_c – carrier frequency

C – speed of light

$$B \ll f_c \quad |t_1 - t_2| \leq T_C \Rightarrow h(t_1) \approx h(t_2)$$

$$|t_1 - t_2| > T_C \Rightarrow h(t_1) \ \& \ h(t_2) \text{ are uncorrelated}$$

→ Relation b/w Coherence time & dopplers spread

$$T_C \simeq \frac{1}{f_D}$$

They are inversely proportional to each other.

5) Draw the block diagram of end-to end architecture of EPC supporting current & legacy radio access Network and discuss the elements of EPC

Soln

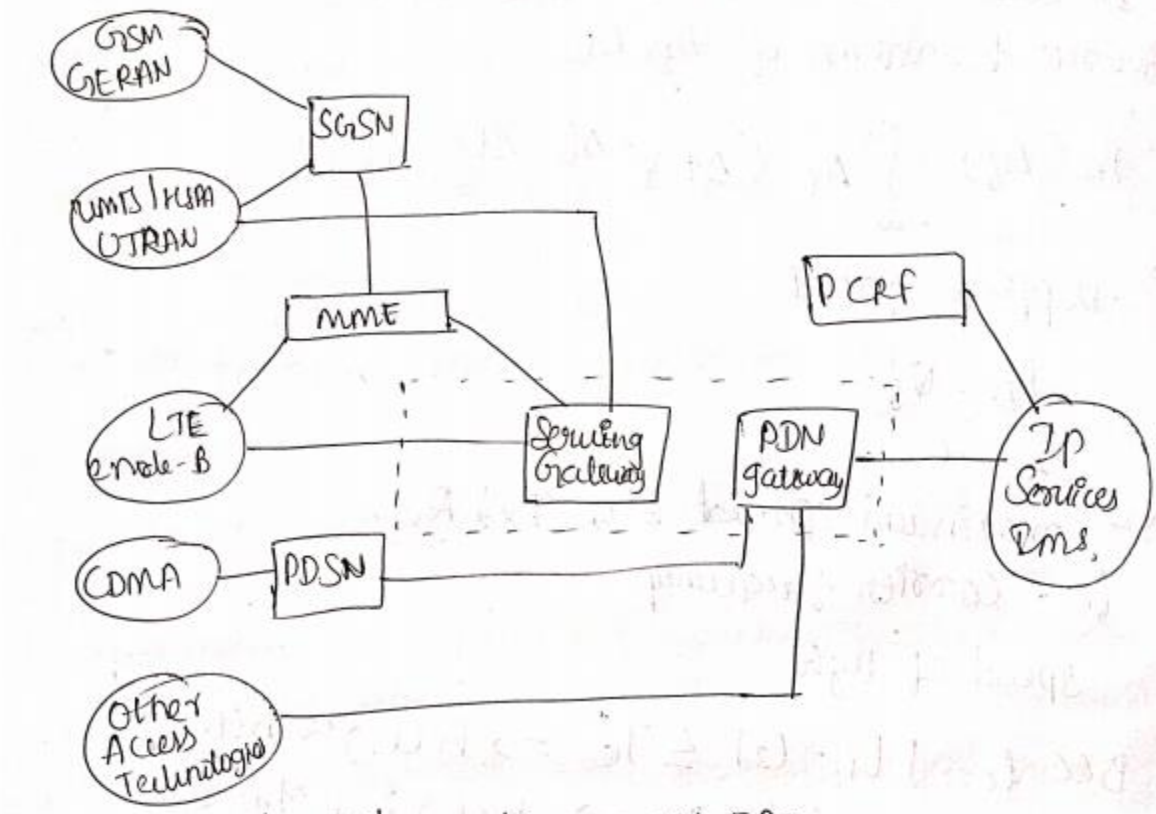


fig. Block diagram of EPC

→ Core N/w design presented in 3GPP release 8 to support LTE is evolved packet core (EPC)

→ function provided by EPC:

i) Access control
ii) Packet routing & transfer
iii) mobility management
iv) Security radio resource management

v) Network managemen

→ EPC includes 4 elements

1. SGW (Serving Gateway)

→ which terminates the interference towards to 3GPP radio acess Network

→ Manages mobility, down link packet buffering, Inter-operator charging.

2. Packet data network gateway (PGW)

→ Controls IP data services, documents routing

→ allocates IP address

→ provides acess for non-3GPP access nws

→ enforces policy, packet filtering

→ Charging Support.

3. MME (Mobility managment entity:

→ Supports user equipment context and identifies authenticates & authorises users.

→ location tracking

→ paging, roaming, handover security

4. Policy and charging rules function (PCRF):

→ manages QoS aspects

→ Supports data flow

→ detection, policy enforcement, flow-Based charging

GERAN - GSM/EDGE - Radio access Network
IMP:- IP Multimedia Services
MME - mobility managment entity
PDN - Packet data Network
PCRF - policy & charging Rules Function
PDSN: Packet data Servicing Node
SGSN: Servicing GPRS Service Node
UTRAN: UMTS Terrestrial Radio acess Network.

---

4) b) Cell capacity expansion techniques are

1) Cell splitting:

Process of subdividing a congested cell into smaller cells

→ Each have its own BS & corresponding reduction in antenna height & Tx power

→ Increased no. of cells increased the no. of clusters increases the no. of channel reused & capacity

→ Each cell is divided into 4 new smaller cells with 1/4th area of the larger cells and use the same channel

→ To preserve the frequency reuse plan. Tx power these cells are reduced by factor of 16 or 12dB

ii) Cellular Sectoring:

→ It is used to increase the cellular system capacity through reducing the co-channel interference

→ It is fixed sectoring with 3 or 6 sectors & identical sector size

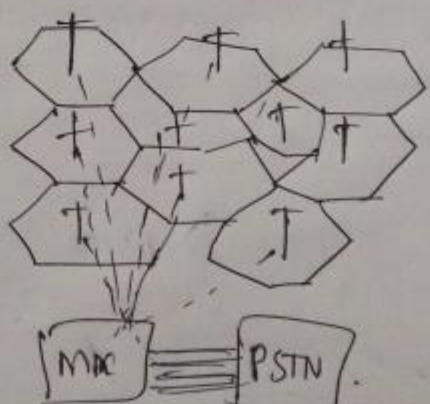
→ It is efficient to mitigate the interference in case of uniform traffic in a cell

4a) Cellular concept

→ AT & T proposed a core idea of cellular system in 1971

→ In cellular systems, the service area is sub divided into smaller geographic areas called cells.

→ Each cell served by their own lower power Base station (BS)



→ Neighbouring cells do not use same set of frequencies to prevent interference

→ In order to minimize interference b/w cells, the transmit power level of each BS is regulated to be just enough to provide the required signal strength