LNMIIT
The LNM Institute of Information Technology

The LNM Institute of Information Technology, Jaipur

Electronics and Communication Engineering Department

Introduction to Green Communication and Networking(ECE3091)

Exam Type: Mid Term **Academic Year:** 2022-23 **Semester:** ODD

Degree: B. Tech ***Programme:*** ECE ***Year:*** 3rd

Time : 90 minutes **Date:**29/09/2022 **Full Marks:** 50

	CO1	CO2	CO3	CO4	CO5
Questions	1,5c,d,e	2,3	5a,b	-	-
Marks	10+5	10+10+10	5	-	-
CO Weightage	30	60	10	-	-

Instruction: *Answer must be brief and to the point. All parts of the question must be answered at one place.*

Q 1. a) Why should we strive for Green Communication and Networking? Explain in terms of GHG and ICT
b) Differentiate between Inverted Efficiency metric and Linear consumption metric with diagram/plot.
c) Define Green Networking as per "Environmental Point of View" and "Engineering Point of View". Give suitable examples for each case.

[2+(2+2)+4=10]

Q2.a) Following parameters are given for a transport and access network. Determine TEER for the same

Given $P_{Total} = 0.4P_{max} + 0.4P_{50} + 0.2P_{sleep}$

Transport: $Throughput = 40\ Gbps,\ P_{max} = 1000\ W,\ P_{50} = 950\ W,\ P_{sleep} = 900\ W$

Access: $Forwarding\ capacity = 160\ Gbps,\ P_{max} = 4320\ W,\ P_{50} = 3000\ W,\ P_{sleep} = 1500\ W$

b) Give examples of two Facility Level and two equipment level metrics.
c) The power consumption of different access networks and Customer Premise Equipment(CPE) using the access method is given in the following table. Determine the total annual energy consumption in Megawatt-Hour and carbon Footprint.Assume 80% power is due to Fossil Fuel and 0.385 kg of CO2 emissions per kWh.

	VDSL2-Vectoring	HFC	FTTH – PtP	FTTH – GPON
Active network elements in the access network	538 street cabinets + 6 central offices	794 fibre nodes + 12 CMTS	36 PoPs	36 PoPs
Power consumption access network [kW]	142	114	64	19
Power consumption CPE [kW]	253	456	341	341

[(2+2)+ 2+4=10]

Q3.a) The energy consumption of a BTS is given by $E_{BTS} = P_{rh}T_{rh} + P_{oh}T_{oh}$. Given, $T_{rh} \overset{def}{=} \frac{\frac{M}{n}}{C_{BTS}}$, $T_{oh} \overset{def}{=} \frac{\frac{m}{n}}{S_{BTS}}$ where M = Number of application bit and n= number of BTS. The inter-site distance of two RANs are D_1 and D_2, cell average spectral efficiency η_1 and η_2. The load activity factor for RAN are
α_1 and α_2 with $\alpha_1 = 1$. The bandwidths of the system are same ($B_1 = B_2$). For the least inter-site distance $ECG_{RAN} = TPG_{RAN} = 1$.

Using this relations prove that

$$\frac{D_2}{D_1} = \sqrt{\frac{\alpha_2 P_{rh,2} + P_{oh,2}}{P_{rh,1} + P_{oh,1}}} = \sqrt{\frac{\alpha_2 \eta_2}{\eta_1}}$$

b) Using the result obtained in part (a) prove that $ECG_R.TPG_R = \frac{ECR_1}{ECR_2}$. Given $TPG_R = \frac{M_2}{M_1} = \frac{\frac{S_2}{A_2}}{\frac{S_1}{A_1}}$

c) Show that the SE-EE trade-off relation for point-to-point transmission in Additive White Gaussian Noise (AWGN) channels, using Shannon's capacity formula is given by

$$\eta_{EE} = \frac{\eta_{SE}}{(2^{SE} - 1)N_0}$$

[4+3+3=10]

Q4. a) A downlink in a noise limited cellular system requires an SNR of 30 dB. The bandwidth is 200 kHz, and operates at a center frequency of 900 MHz. The mobile receiver has a noise figure of 10 (linear). The base station transmits with an antenna that has a gain of 0dB, while the receiver antenna has unity gain . The path loss L_p is according to the Friis Transmission formula. The 4G mobile receiver has sensitivity -120 dBm. Calculate the Transmit power P_t. Given d=3 km.

b) The power consumption of Base Station is given by following set of equations

$$P_{BS,Macro} = N_{sector} \cdot N_{PApSec} \cdot \left(\frac{P_{TX}}{\mu_{PA}} + P_{SP}\right) \cdot (1 + C_C) \cdot (1 + C_{PSBB}) \quad (1)$$

$$P_{BS,Micro} = P_{Static,\ Micro} + P_{Dynamic,\ Micro} \quad (2)$$

$$P_{Static,Micro} = \left(\frac{P_{TX}}{\mu_{PA}} C_{TX,Static} + P_{SP,\ Static}\right) \cdot (1 + C_{PS}) \quad (3)$$

$$P_{Dynamic,Micro} = \left(\frac{P_{TX}}{\mu_{PA}} (1 - C_{TX,Static}) \cdot C_{TX,NL} + P_{SP,\ NL}\right) N_L \cdot (1 + C_{PS}) \quad (4)$$

Table -1 power consumption parameters

Item	Unit	Macro cell	Micro Cell
Number of sector n_s	-	3	1
Number of PA/Sector N_{PApSec}	-	2	1
Number of total subcarriers	-	-	300
Number of Active Links	-		25
Cell radius	m	1500	100
Transmit Power P_{TX}	W	24	2
Signal Processing Power Macro BTS P_{SP}	W	58	-
Static power Consumption $P_{Static,Micro}$	W	30	-
Dynamic power Consumption/link $P_{Dynamic,Micro}$	W	-	-
Static Signal Processing Power, $P_{SP,\ Static}$	W	-	15
Dynamic Signal Processing Power/link , $P_{SP,\ NL}$	W	-	0.55
Cooling Coefficient C_C	-	0.2	-
Power Supply and Battery Back Up coefficent C_{PSBB}	-	0.1	-
Power Supply loss coefficent C_{PS}	-	-	0.1
Static Transmit Power coefficient $C_{TX,Static}$	-	-	0.8
Dynamic Transmit Power coefficient $C_{TX,NL}$	-	-	0.04
PA efficiency μ_{PA}		38%	20%

The site has 1 Macro cell with hexagonal geometry and Micro- cells are at the corners of the hexagon. Calculate the ECG of Macro and Micro system to Macro only system.

[4+6=10]

Q5. a) In a communication link with SONET hierarchy, identify areas to save energy.
b) Give a schematic for SONET speed mapping from OC-192 to T1 line.
c) In terms of energy efficiency, which value of PUE is better: 1.06 or 1.97 or 0.7?
d) Name three European projects on Green ICT?
e) What is the accepted value of SAR for mobile in India? What is the threshold for body core temperature rise due to EMF exposure below 300GHz to be called harmful as per latest 2018 guideline of ICNIRP?

[2+3+1+2+2=10]