UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: May 2023

Module Number: EE7217 **Module Name: Telecommunication Networks**

[Three Hours]

[Answer **all questions**, each question carries 12.5 marks]

Q1 a) Briefly explain the following statements in point form.

i) Digital Subscriber Loops provides a better service to customers closer to the exchange.

ii) Users easily get annoyed with international calls made through VOIP services.

iii) STARLINK is more suitable to provide internet services for rural or remote communities.

[3 x 1.5 Marks]

b) i) State how the 2G cellular networks provide better privacy and security when compared with 1G cellular networks.

ii) State four technologies used in 5G New Radio.

iii) Briefly describe in point form how major services such as Facebook and Netflix would utilize the concepts of 5G in advancing their services.

iv) Briefly describe in point form the key differences between 5G and 6G networks.

[4 x 2 Marks]

Q2 Answer the following questions referring to Table Q2.1 and Table Q2.2 whenever necessary.

a) i) Briefly explain in point form why ISDN is a better choice to connect two computer networks in different geographical locations than using a modem over PSTN.

ii) Using appropriate calculations, briefly explain how European standard ISDN PRI channel is a full E1 Link.

iii) Figure Q2 shows the back pane of an ISDN device. State the device type and draw a simple block diagram to show its connection to the ISDN switch at the carrier network.

[3 x 1.5 Marks]

b) i) With the support of calculations and diagrams, briefly explain how the data rate of an E2 channel become 8.448 Mbps.

ii) It has been identified that the spectrum of sounds an Asian elephant can produce is between 10 – 9000 Hz. It is required to continuously monitor sounds produced by 1000 elephants in a safari. Sounds are sampled and encoded using 8-bit pulse code modulation and it is sent over PSTN. Suppose that when transmitting over PSTN, there is an additional 1 data unit overhead for every 3 data units generated via sound encoding. Calculate the required number of DS0 channels for this monitoring project and identify the required digital mux level of North American Standard.

[2 x 3 Marks]

c) With the help of a block diagram, briefly explain the SS7 architecture in point form.

[2 Marks]

Q3 Answer the following questions referring to Table Q3.1 and Table Q3.2 whenever necessary.

a) Briefly explain in point form the following with respect to a telecommunication network. Use equations and/or illustrations whenever necessary.
Note: If an equation is used, terms used in the equation should be explained.

i) The memoryless property of inter arrival time of calls in a telephone exchange.

ii) When call arrivals are Poisson distributed, it is assumed that no more than one call arrives at a given time.

iii) A 3 CCS traffic volume within 5 minutes leads to a traffic intensity of 1 Erlang.

[3 x 1 Marks]

b) Consider an exchange with K channels and no waiting queue. The call arrivals and departures are Markovian with mean call arrival rate being $\boldsymbol{\lambda}$ and the mean call duration being $1/\boldsymbol{\mu}$.
Note: Traffic intensity A can be given by $\boldsymbol{\lambda}/\boldsymbol{\mu}$

i) Derive an expression for the probability of in incoming call being the only call in the system.

ii) Derive an expression for the congestion. Given that the sequential hunting for channels is occupied, derive an expression for the traffic carried by the N^{th} channel.

iii) Prove that $E_K(A) = A_{K-1}(A)/(K + A\,E_{K-1}(A))$, where $E_K(A)$ is the call blocking probability of this system.

iv) Suppose that the mean arrival rate is 0.5 calls per minute and mean call duration is 1 minute. Calculate the probability of call congestion for a system with 4 channels.

[4 x 2 Marks]

v) Suppose that a decision is made to upgrade this system with in addition of a waiting queue. State in point form the changes you expect in the system giving reasons.

[1.5 Marks]

Q4 a) Briefly explain the following in point form in relation to switching in telecommunication networks. Use illustrations when necessary.

i) Blocking network.

ii) Time-slot interchanging.

iii) Hierarchical switching.

[3 x 1.5 Marks]

b) Consider the 3-stage switching network given in Figure Q4 which is used to connect the local subscribers (I_0 to I_7) to external trunk lines (O_0 to O_7). Note that it consists of 2x2 switching elements.

i) Determine the switching capacity of the system.

ii) State the main advantage of using this system over 8x8 Crossbar switch.

iii) Determine if this is a blocking or non-blocking system and briefly explain your answer in point form.

iv) Determine the equipment utilization factor of this system.

[4 x 1.5 Marks]

c) Suppose that you are asked to design the 8-channel exchange (8 input and 8 output folded switch) using ten 4-output two-motion selectors. Draw a block diagram of the switching system and determine the switching capacity.

[2 Marks]

Table Q2.1

Digital Mux Level	# of 64Kbps Channels	North American Standard T (Mbps)	European Standard E (Mbps)	Japanese Standard J (Mbps)
0	1	0.064	0.064	0.064
1	24	1.544		1.544
	30		2.048	
	48	3.152		3.152
2	96	6.312		6.312
	120		8.448	
3	480		34.368	32.064
	672	44.376		
	1344	91.053		
	1440			97.728
4	1920		139.264	
	4032	274.176		
	5760			397.200

Table Q2.2

ISDN			
Access Option	Standard	Channels	Speed
BRI	North American /European	2 B Channels	64 Kbps
		1 D Channel	16 Kbps
PRI	North American	23 B Channels	64 Kbps
		1 D Channel	64 Kbps
PRI	European	30 B Channels	64 Kbps
		1 D Channel	64 Kbps
R -The reference point between non-ISDN equipment and a TA. S -The reference point between user terminals and the NT2. T -The reference point between NT1 and NT2 devices. U -The reference point between NT1 devices and line-termination equipment in the carrier network			

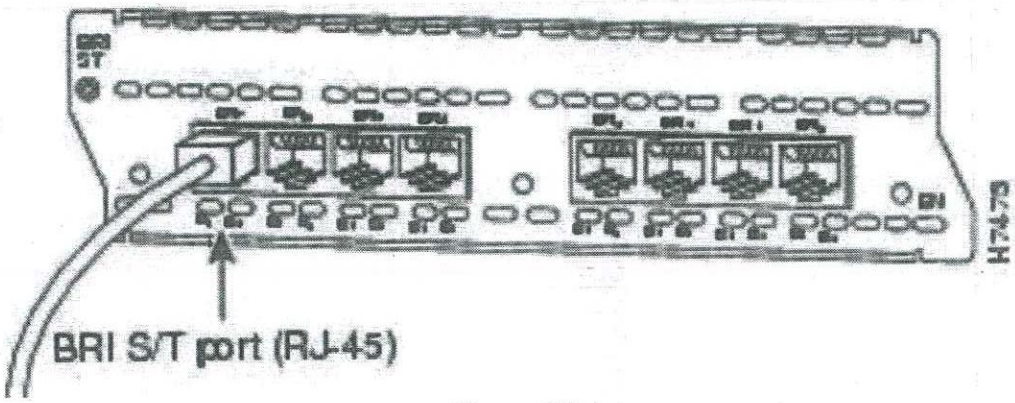

Figure Q2

Table Q3.1

Table of Equations
$f(T) = \lambda e^{-\lambda T} \quad 0 \leq T < \infty$
$P(N = n) = \frac{(\lambda T)^n e^{-\lambda T}}{n!} \qquad n = 0, 1, 2, \ldots$
$P(A/B) = \frac{P(A \cap B)}{P(B)}$

Table Q3.2

Erlang B Traffic Table

Maximum Offered Load Versus B and N
B is in %

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.0010	.0050	.0101	.0204	.0526	.1111	.1765	.2500	.4286	.6667
2	.0142	.0321	.0458	.1054	.1526	.2235	.3813	.5954	.7962	1.000	1.449	2.000
3	.0868	.1517	.1938	.3490	.4555	.6022	.8994	1.271	1.603	1.930	2.633	3.480
4	.2347	.3624	.4393	.7012	.8694	1.092	1.525	2.045	2.501	2.945	3.891	5.021
5	.4520	.6486	.7621	1.132	1.361	1.657	2.219	2.881	3.454	4.010	5.189	6.596
6	.7282	.9957	1.146	1.622	1.909	2.276	2.960	3.758	4.445	5.109	6.514	8.191
7	1.054	1.392	1.579	2.158	2.501	2.935	3.738	4.666	5.461	6.230	7.856	9.800
8	1.422	1.830	2.051	2.730	3.128	3.627	4.543	5.597	6.498	7.369	9.213	11.42
9	1.826	2.302	2.558	3.333	3.783	4.345	5.370	6.546	7.551	8.522	10.58	13.05
10	2.260	2.803	3.092	3.961	4.461	5.084	6.216	7.511	8.616	9.685	11.95	14.68
11	2.722	3.329	3.651	4.610	5.160	5.842	7.076	8.487	9.691	10.86	13.33	16.31
12	3.207	3.878	4.231	5.279	5.876	6.615	7.950	9.474	10.78	12.04	14.72	17.95
13	3.713	4.447	4.831	5.964	6.607	7.402	8.835	10.47	11.87	13.22	16.11	19.60
14	4.239	5.032	5.446	6.663	7.352	8.200	9.730	11.47	12.97	14.41	17.50	21.24
15	4.781	5.634	6.077	7.376	8.108	9.010	10.63	12.48	14.07	15.61	18.90	22.89

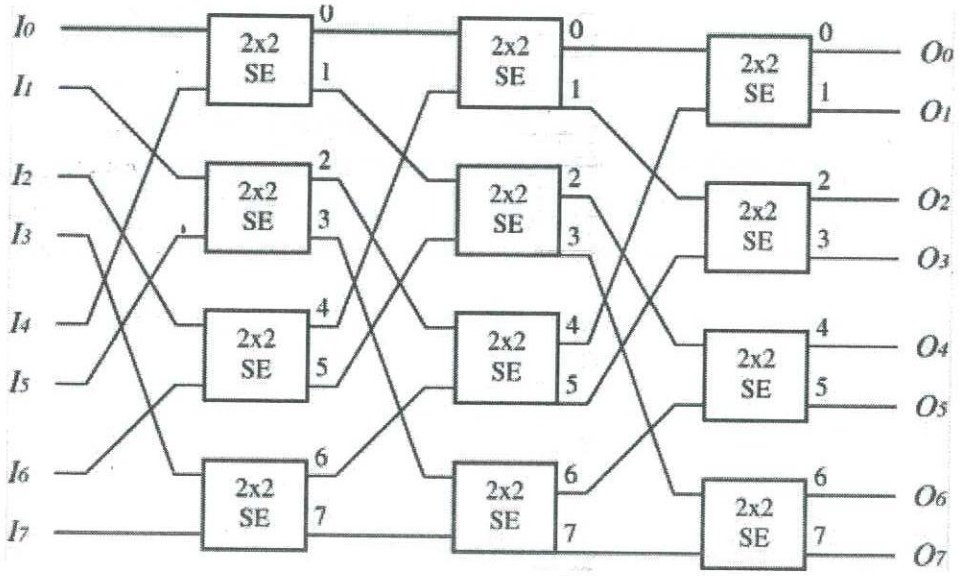

Figure Q4

Table Q4

Table of Equations
CCI = N x SC / C
TC = 2 x SC / N
C = $C_s + C_c + C_{ch}$
EUF = No of switching elements in operation when the switch is fully utilized / Total number of switching elements in the system

- End of the Question Paper -