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MODEL ANSWER and MARKING SCHEME

First Examiner	J. BARRIA	Paper Code	E3.17
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Q1(a) a

Home system: Network to which mobile user's permanent phone number belongs

Home MSC / Location Reg. HLR: MSC: point of contact to obtain address of mobile user; HLR: database in home system containing permanent information of mobile user

Visited system: Network other than home system where mobile user is currently residing

Visited MSC / Visitor Location Reg. VLR: MSC: responsible for setting up calls to/from mobile nodes; VLR: temporary database entry in visited system for each visiting mobile user

Mobile station Roaming Nr. (MSRN): routable address for telephone call segment between home MSC and visited MSC — 5

Q1(b) a

Home system ⟷ Home network

Home MSC/HLR ⟷ Home agent

Visited system ⟷ Visited Network

Visited MSC/ Visitor location Reg VLR ⟷ Foreign Agent

Mobile station Roamng Nr (MSRN) ⟷ Care of address — 3

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Q1 i) Broadcast networks: Data transmitted by one station received by many.
Stations share common transmission media
Media Access Control (MAC) mechanism needed
point to point link: one sender, one receiver, one link.
No Media access control (MAC) mechanism 4

Channel partitioning: Allocate capacity of media to a node exclusively: Examples: time division multiplexing and frequency division multiplexing.
Round Robin: Node take turns to access media. Examples: Token ring (~~IEEE~~ 802.5)
Random Access: There are contention mechanisms. The MAC protocol must specify How to detect collisions, & How to recover & from collisions. Examples: CSMA, CSMA-CD, CSMA-CA 4

Flow control
- Assures that a sender station does not overwhelm a receiver station
Examples:
- Stop and wait ARQ
- Selective repeat ARQ
- Go Back N ARQ
Introduction to window based

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Q2

a)

$$T = x(1) + x(2)^2$$

$$R = x(1) + x(2)$$

$$\frac{\partial T}{\partial x(1)} = \frac{\partial T}{\partial x(2)} \qquad 1 = 2\,x(2)$$ 4

$\frac{\partial T}{\partial x(1)} = 1$. This means that link 1 has the same cost regardless of how much flow is assigned to it.

$\frac{\partial T}{\partial x(2)} = 2x(2)$. link 2 has a cost that is proportional to the flow 4

$$1 = 2x(2) \implies x^*(2) = \frac{1}{2}$$

$$x^*(1) = R - \frac{1}{2}$$

4

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Q2 b) Reliable data transfer sequence : Stop and Wait

L = length of segment in bits
R = transmission rate of channel in bps
RTT = Round Trip time in s — 2

$$U = \frac{L/R}{RTT + L/R}$$ 2

$$U = \frac{0.009}{20 + 0.009} = \frac{0.009}{20.009} = 0.00045$$ 2

Sliding windows protocols :
sender is allowed to send multiple packets without acknowledgement
For example if we allow for three packet without acknowledgement the Utilization is given by :

$$U = \frac{3 \times 0.009}{20.009} = 0.0135$$ 2

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Q3

a) Network assisted congestion control:

- Routers provide feedback to end system. For example single bit indicating congestion or explicit rate for sender to send at.

End to End congestion control:

- No explicit feedback from e.g. network routers
- congestion inferred from end-system observed loss or delay

This is the approach taken by TCP protocol. 4

TCP congestion control

Additive increase and multiplicative decrease

- sender increases transmission rate (window size), probing for usable bandwidth until loss occurs
- TCP slow start: when connection begins, increase rate exponentially until first loss event
- If a loss event is detected, the congestion window is decreased to 1 MSS (maximum segment size); or the window is reduce to half window size previous loss. 3

Fairness goal: If K TCP session share same bottleneck link of bandwidth R each should have given an average rate of R/K. 3

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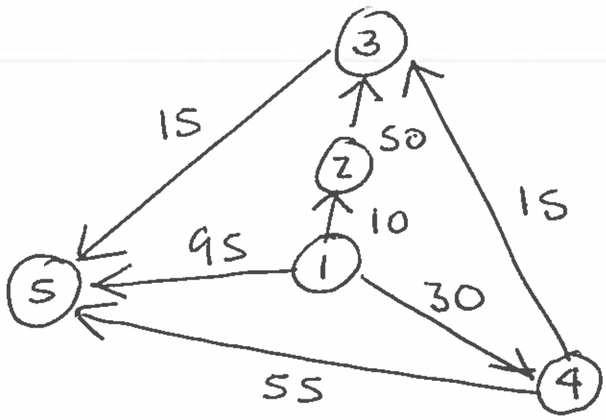
Q3 a)



$i=0$ $S=\{1\}$, $D(2)=10$, $D(3)\ \infty$, $D(4)=30$, $D(5)=95$

$i=1$ $S=\{1,2\}$

$D(3)=60=\min(\infty, D(2)+c(2,3))$
$D(4)=30=\min(30, D(2)+c(2,4))$
$D(5)=95=\min(95, D(2)+c(2,5))$ 5

$i=2$ $S=\{1,2,4\}$

$D(3)=45=\min(60, D(4)+c(4,3))$
$D(5)=85=\min(95, D(4)+c(4,5))$

$i=3$ $S=\{1,2,4,3\}$

$D(5)=60=\min(85, D(3)+c(3,5))$

$i=4$ $S=\{1,2,4,3,5\}$

5

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Q4 a) i)

MPLS separate networks in their own right:
MPLS - Integrates layer 2 switching with layer 3 routing. It operates multiple layer 2 technologies
MPLS does not define another QoS architecture
- MPLS uses DiffServ architecture
- MPLS scalability: aggregation of traffic at edge router. At core router processing of aggregate of traffic only. 3

ii)

Routing protocol, Routing table } control plane
↓
Forwarding Tables, Switching Fabric } Forwarding plane

Key feature in MPLS is the separation of control plane and forwarding data plane
control plane: set up router through data plane
data plane: carries information 3

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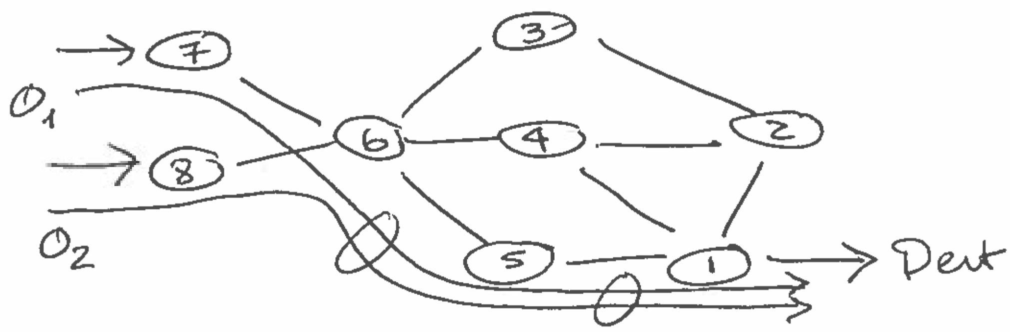
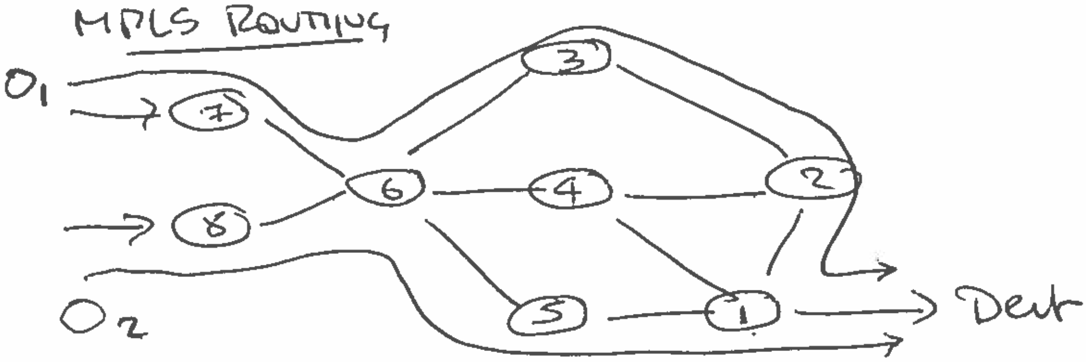
Q4 a iii)

IP ROUTING



IP Routing: path to destination is determined by destination address alone 2

MPLS ROUTING



MPLS Routing: path to destination can be based on source and destination address

For example: pre-store back up route in case of link failure 2

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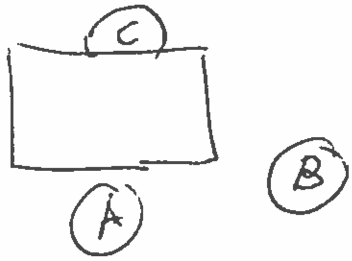
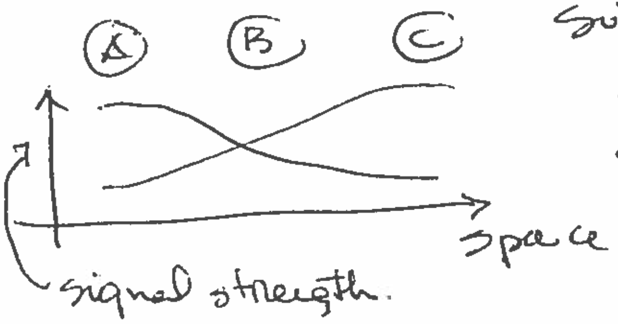
Q4 b) i)



Hidden Terminal Problem:
stations A & B hear each other
stations B & C hear each other
But stations A & C cannot hear each other.

Therefore, station A and C are unaware of their interference at B. 2



Signal attenuation:
stations A & B hear each other
Stations B & C hear each other

But station A & C cannot hear each other. interfering at station B. 2

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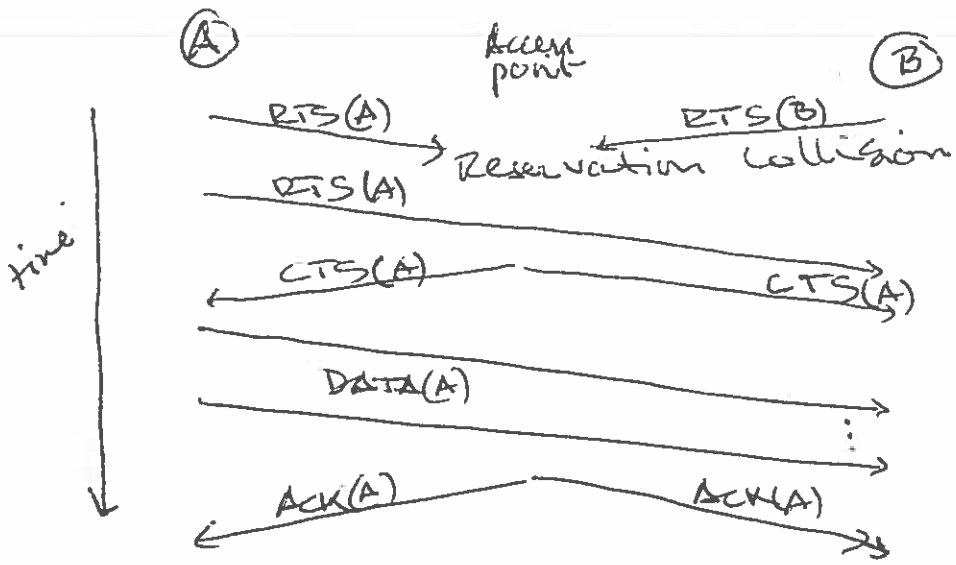
Q4 b ii)



3

The idea is to allow the sender to reserve the channel

- Senders first transmits a small request-to-send (RTS) packet to the Access point (Base station) using carrier sense multiple access technique
- If the request was successful the Access point (Base station) broadcast a clear-to-send (CTS) packet. This CTS packet is heard by all nodes
- Sender transmit data frame.
- All other stations defer transmissions 3