EE122 Midterm Exam
UC Berkeley, Spring 1999

Problem 1: (10 points)
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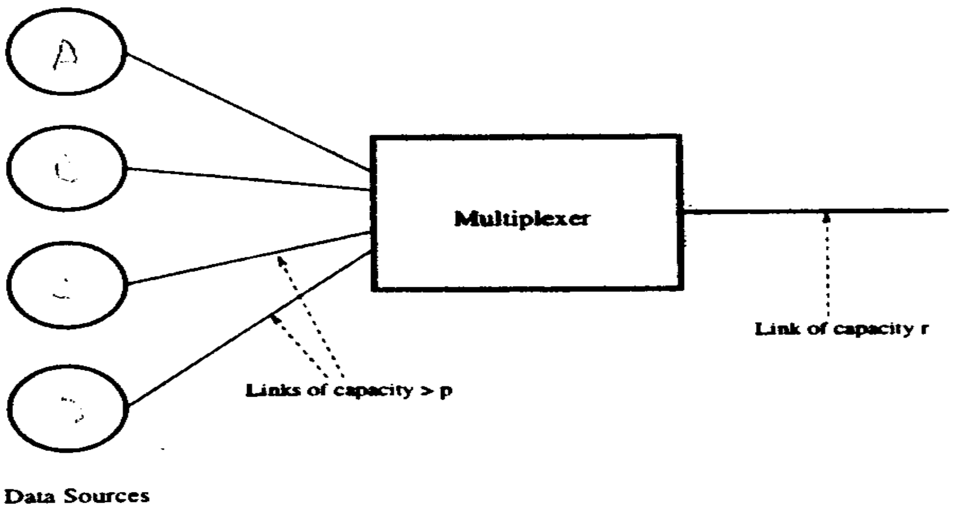

Figure 2: A multiplexer

ime-division multiplexing (TDM) and statistic

(a)(1) briefly define time-division multiplexing (TDM) and statistical multiplexing
(b)(2) assume 4 data sources each have a peak rate p and mean rate m. They are each attached to a multiplexer using links of capacity greater than *p.* A single output link of capacity *r* serves all 4 sources. To avoid any loss of data, what relationship must r have relative to *p* and *m*?
(c)(2) assume we know $m<p$, what is a reasonable lower bound for *r*?
(d)(3) as we reduce *r* to be closer to the value computed in 1c, what must we add to the multiplexer? In what ways does this affect the delivery of the sources' traffic?
(e) (2) assume 2 sources go completely idle and $r = 2p$. During peak periods, the other sources will drive the outgoing link to what maximum instantaneous utilization (assuming TDM)? Using statistical multiplexing?

Problem 2: (12 points)
(a)(1) During the 1980's there was a large effort to produce the ISO standard protocols, which were envisioned to replace TCP/IP. The idea was to use TCP/IP until the ISO porotocols were available, and simply switch to those. This effort, for the most part, was a failure. What network protocol desing principal was violated here?
(b) (3) In classs we have discussed how various link layers (e.g. Ethernet) contain an error checking code (e.g. CRC). In the second half off the semester we will see that both UDP and TCP contain data checksums. Are these checksums redundant? Why or why not?
(c)(2) Not only does TCP and UDP have a checksum, we learned that IP also has a check sum. What does it protect?
(d)(3) We have seen a number of protocols that associate timers with received data and require periodic refreshes to keep the data current. What is this called and what nice property does it have? Give an

example.
(e) (3) State two main goals in the design of the Internet. What is its fundamental service model? What service requirements does IP place on the underlying link layer carrying it?

Problem 3: (10 points)
(a)(2) a conventional analog "plain old telephone service" (POTS) line provides 3kHz of bandwidth. Assuming noiseless conditions and infinite precision pulse amplitude modulation (PAM), what sampling frequency is required to fully encode this signal digitally?

The **mu-law characteristic** is defined as follows:
$F_{mu}(x) = sgn(x)[ln(1 + mu|x|)/ln(1 + mu)]$

-1 <= x <= 1
sgn(x) is the polarity *of x*
ln(x) is the natural logaritm of *x*
In the United States and Japan this encoding, with mu = 255, is used to express PCM signals for telephony.
(b)(3) Assuming 1 >= x >= 0, prove this encoding is nonlinear for mu = 255.
(c)(3)Again assuming 1>= x >= 0, prove whether it is linear of non-linear for the limiting case of mu=0.
(d)(2) What advantage can teh mu-lave characteristic provide over a simple linear code?

Problem 5: (14 points)
(a)(2) Ethernet has a minimum frame size of 64 bytes. Why does it have a minimum frame size at all?
(b)(2) Ethernet has a maximum frame size of 1518 bytes. Why does it have a maximum frame size at all?
(c)(3) 10Mb/s Ethernet used Manchester encoding. What advantages and disadvantages does this form of coding have? Fast Ethernet (100Mb/s) went to 4B/5B. What does 4B/5B mean? Is it more efficient than Manchester? Why?
(d)(2) Newer Ethernet technology provieds for full-duplex operation. These systems require buffering in switches, becaue the media is no longer shared. What circuitry would a full duplex Ethernet include that a half-duplex Ethernet lacks [or vice-versa]?
(e)(2) describe the capture effect

Problem 6: (8 points)
(a)(2) why do most switch designs avoid input buffering?
(b)(2) what interesting property does a Banyan provide? Why is it useful to combine a Batcher with a Banyan?
(c)(4) in the extended LAN (bridged network) below, indicate the links on the spanning tree, each bridge's root ports, and the root bridge

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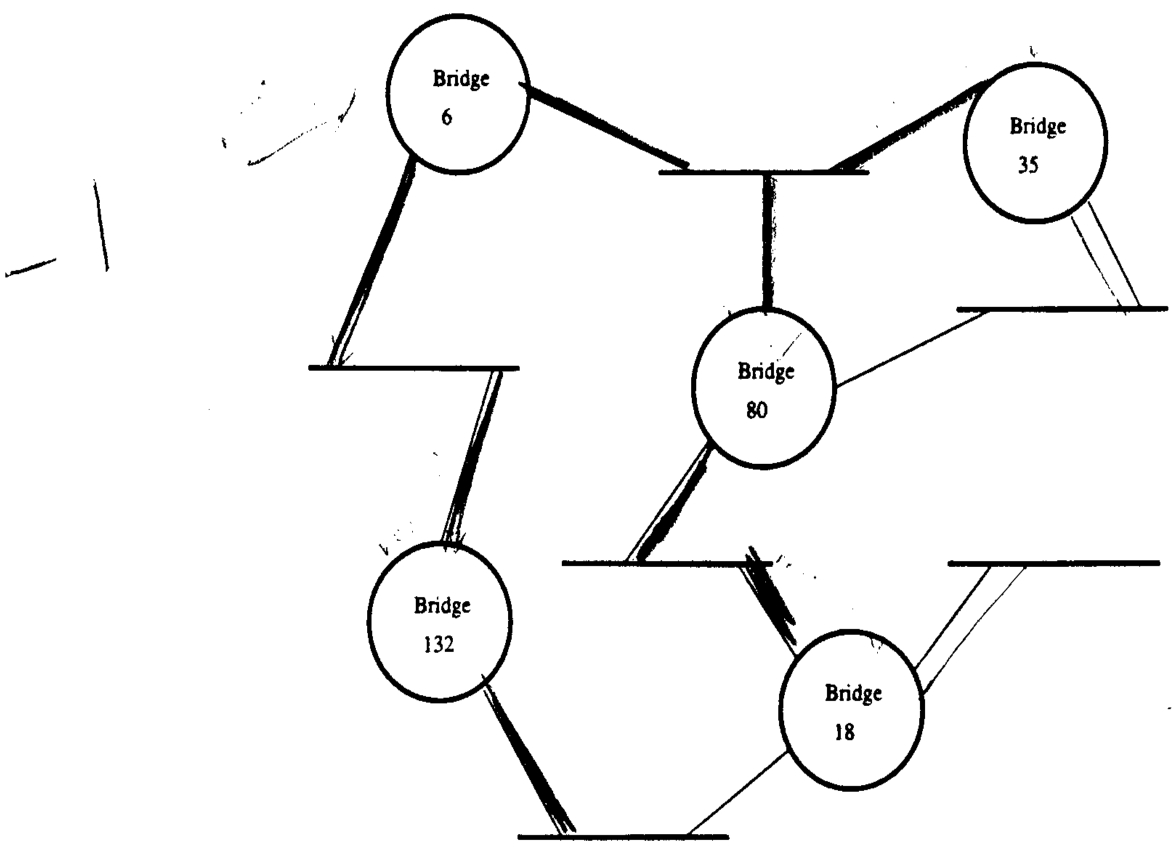

Problem 7: (8 points)
(a)(1) The address resolution protocol (ARP) may be used to map IP addresses to link layer addresses. What facility does ARP depend on that is not available on all link layer network technologies?
(b)(2) What majjor benefit results from requiring IP addresses of machines on the same subnet to share the same network prefix?
(c)(5) What happens when an IP packet of size S attempts to enter a network with an NTU size of M where (M<S)? Give an example using a packet of size S = 4000 and M = 1500 and showing all relevant IP header fields.

Problem 8: (6 points)
(a)(2) name at least 3 ways an Internet host's routing table can be changed
(b)(4) Name two things that happen when an unicast IP packet's TTL field becomes zero during transit? How can one of these be useful to the **traceroute** program?

Problem 9: (12 points)

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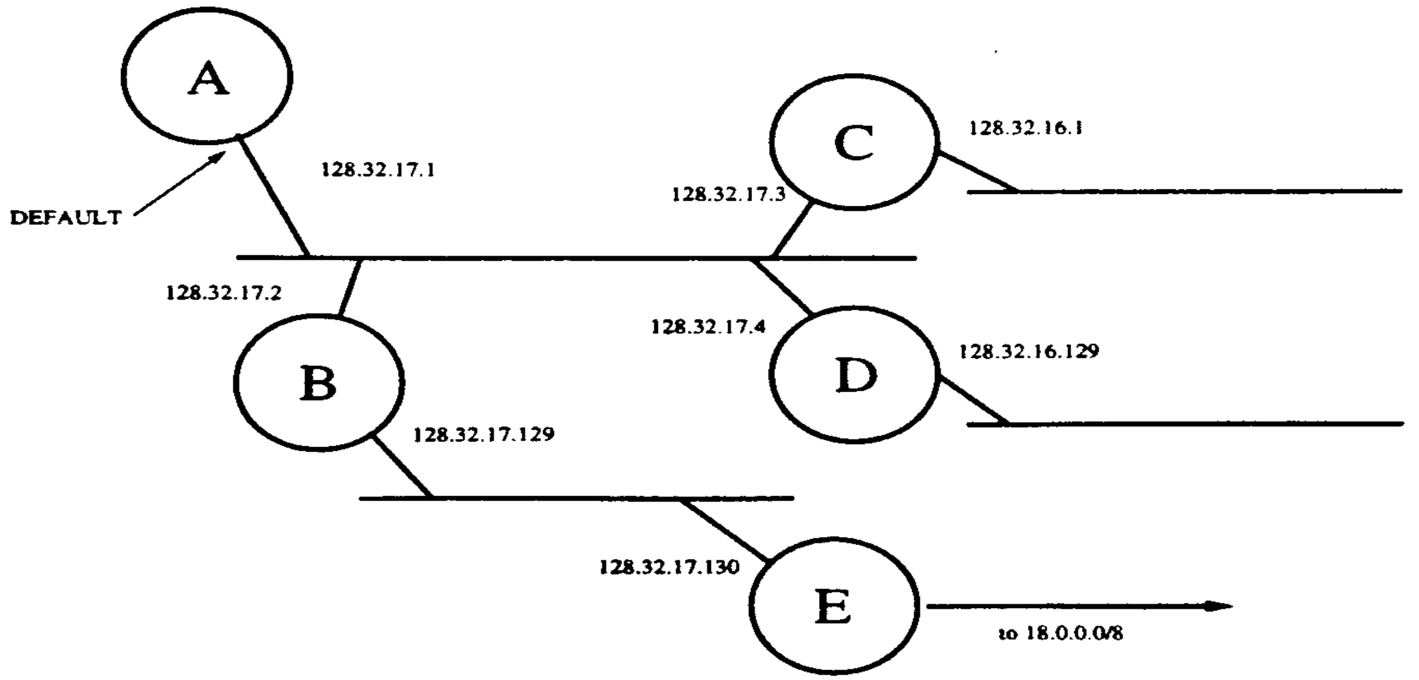

Figure 4: A Sample internet

Entry Number	Mask	Destination	Next-hop
1			
2			
3			
4			
5			
6			
7			

onstruct a reasonable forwarding table for router B in the internetw

(a)(4) construct a reasonable forwarding table for router B in the internetwork pictured above by filling in the forwarding table. Include entries for local delivery.

(b)(3) draw a Patricia "trie" used to hold this table

(d)(5) Assume a packet enters this internet through router A destined for address 18.1.2.3. Indicate the addresses used in the link and network layer source and destination addresses used on the networks joingin {A,B,C,D} and {B,E}. You may assume Ethernet is used for each joining segment and fragmentation is not required. In addition, you may use the notation M(a) to indicate the MAC-layer address corresponding to the IP address a. Be sure to illustrate the frame encapsulation (i.e. where the link layer header is located relative to the network layer header in a frame).

Problem 10: (8 points)
(a)(1) In IP multicast, a sender, by definition, is a member of the IP multicast group it is sending to. [True or False]
(b)(3) Indicate the links on the source-based tree from the source S to receivers R_1 ... R_4 using Reverse Path Multicasting (RPM). Assume unit link costs and hop counts are used as the routing metric.

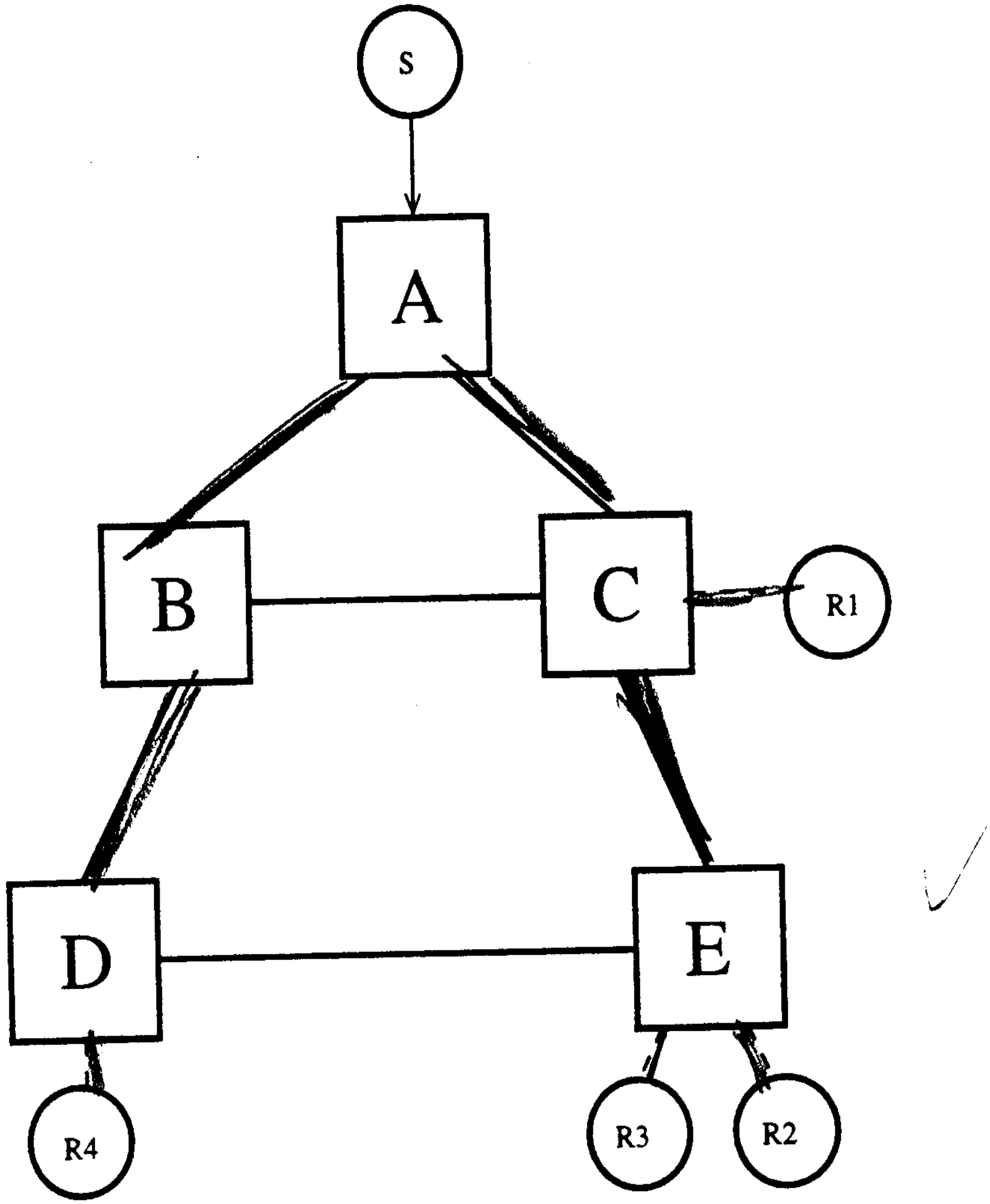

Figure 5: Example Multicast Network

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(c)(4) With RPM, explain what happens when R_4 leaves the group.

Problem 11: (5 points)

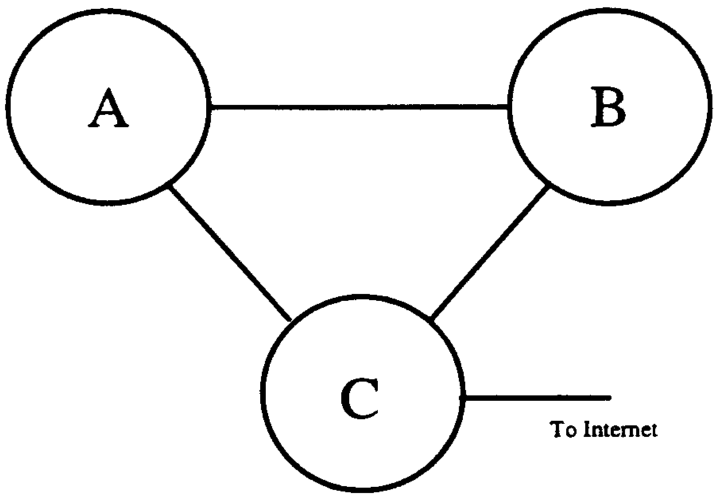

Figure 6: Sample Network Topology

(a)(1) In lollipop sequence sequence space, what do negative values typically indicate?
(b)(4) for the network topology in the figure above, assume a distance vector routing protocol with split horizon is in use. Is the count to infinity problem solved? If so, exploain why. If not, explain how the problem can occur.
