Remarks: Keep the answers compact, yet precise and to-the-point. Long-winded answers that do not address the key points are of limited value. Binary answers that give little indication of understanding are no good either. Time is not meant to be plentiful. Make sure not to get bogged down on a single problem.

PROBLEM 1 (40 pts)

(a) Today's Gbps networks are architected as broadband networks. What is the prime distinguishing trait of broadband vs. baseband technology? In what sense are broadband networks faster than baseband networks? Are radio stations (AM and FM) that transmit analog information baseband or broadband?

(b) Ethernet uses Manchester encoding—a method that expends two bauds per bit—to transmit digital data, when by simply switching to NRZ it could increase bandwidth two-fold (e.g., 100 Mbps Ethernet could run at 200 Mbps). Why is this inefficiency introduced? What is an encoding method that achieves the same objective as Manchester (almost) but uses 1 baud per bit?

(c) Two popular forms of ARQ are stop-and-wait and sliding window. In what way is sliding window superior than stop-and-wait? You should frame your answer such that link bandwidth, link latency (in the form of RTT), and frame size enter into your reasoning. Sequence numbers are needed in sliding window. Are sequence numbers needed in stop-and-wait? If so, why?

(d) What are the top 4–5 "killer applications" that drive networking/communication technology today? An application has to have at least 10 years of proven track record of everyday commercial use to quality in this stellar category. Which of these apps are suited to broadcast technology (mainly satellite networking) and which are suited to point-to-point on-demand technology? Would it make technical sense for Blockbuster to use satellite networking as its future instant on-demand video distribution technology? Explain your reasoning.

PROBLEM 2 (30 pts)

(a) Suppose you've decided to introduce an on-demand TDM technology to compete with regular TDM, FDM, and CDMA technology for providing both IP and cellular network service. On-demand TDM is supposed to eliminate the inefficiency of TDM where time slots that are pre-allocated to an admitted user may not be utilized by that user and hence go wasted. Supposing your technology is a simple, pure form of multiple access (MA)—think of ALOHA—where each user is allowed to grab a slot with probability p, how should p be set to minimize the chances of collision, i.e., more than one user attempting to grab the same slot? You may assume that each user knows how many other users (n) are currently sharing the on-demand TDM network. Is your answer still valid if the n users don't have much data to send, i.e., only occasionally transmit packets? How would you modify your original multiple access protocol to reflect different traffic demand situations?

(b) What is a switched Ethernet and how is it different from the classical non-switched Ethernet? Given that in CSMA/CD Ethernet the length of the wire has to shorten by approximately the same factor as an increase in bandwidth, how is it possible to have long-haul Ethernets spanning hundreds of miles? Supposing IBM won the LAN technology battle in the late 70s/early 80s making token ring the dominant LAN technology today, would CSMA/CD still be needed in a newly introduced switch-based LAN technology? Comparing contention-free token ring with contention-based CSMA/CD, what are their main pros and cons? How does switched technology fare against both?

PROBLEM 3 (30 pts)

(a) Suppose you work at a venture capital company, responsible for evaluating new network technology proposals. Suppose a company comes along that proposes to use satellite networking for residential Internet access service to compete against DSL and cable based Internet access service. Suppose the proposal specifies use of the 10 GHz–11 GHz frequency range with half the frequency band for uplink and the other half for downlink, and FDM is used with carrier frequencies spaced 1 MHz apart. Assuming one on-line user is allocated one carrier frequency—no further TDM is done on top of FDM—how many simultaneous users in total can the system support? Assuming baseband encoding is proposed where 1 baud is expended to transmit 1 bit, what is the bandwidth (bps) allotted to a user? Given that a single satellite covers a large area (at least hundreds of square miles), would this make sense for metropolitan Internet access service? How about Internet service in the Sahara desert? Suppose a second proposal has come along that proposes to use the same satellite based system for Internet access service in metropolitan areas, with the difference that CSMA is proposed to be used in place of FDM. Does this proposal make any sense? Comparatively speaking, which one is more feasible from a technical standpoint and why?

(b) Discuss what you feel are the essential differences between wired and wireless networks at the physical level and the link layer level, respectively. Given that wired optical networks operate at the THz range providing Tbps bandwidth, even with baseband technology, what is the principal technical limitation that prevents using THz spectrum for wireless networking? Can wireless LANs migrate to a "switched design" as wired CSMA/CD has done in the early–mid 1990s or is this technically infeasible? Explain your reasoning.

BONUS PROBLEM 4 (10 pts)

Given that link layer devices (e.g., Ethernet cards) have unique 48-bit addresses, it is possible to build extremely large networks without using network layer entities (e.g., IP). If you had to design a global internetwork from scratch today, what reasons would you find to define another naming layer on top of the link layer? If you don't see such a need, argue why not.