Problem 1: True/False (20 points, 1 pt per question) (T)rue / (F)alse

1. TCP/IP is the most prevalent network layer of the Internet

2. The stop-and-wait protocol is efficient when the bandwidth-delay product is small

3. Another name for a retransmission scheme is Forward Error Correction (FEC)

4. Statistical multiplexing is better suited to data networks than static multiplexing because data traffic is bursty

5. Contention-free MACs like rings are most efficient at low-load

6. The bridge spanning tree algorithm computes a separate spanning tree for each source

7. Distance-vector routing is more scalable than link-state routing

8. Routing is a local decision for each node, forwarding is a network-wide decision

9. IP addresses can be automatically assigned with ARP

10. A key feature of BGP that distinguishes it from intradomain routing is support for multiple parties

11. Congestion avoidance is designed to reduce both latency and loss

12. In the additive increase phase, TCP increases the congestion window by one packet for each packet received

13. Token buckets constrain both the average bandwidth and bursts of traffic

14. DiffServ can help to isolate VoIP traffic from the effects of P2P traffic

15. Weighted fair queuing provides absolute bandwidth guarantees to flows

16. HTTP can be run directly on top of either TCP or UDP

17. The DNS protocol uses ARQ for reliability

18. TCP sets up and tears down connections with a three-way handshake

19. A key problem that must be addressed by internetworking protocols is network heterogeneity
Problem 2: IP prefixes and BGP (20 points, 6 / 6 / 8 pts per part)

A university has been allocated the prefix 18.31.0.0/16. It has colleges of Engineering, Art & Science and Medicine. Engineering needs at least 32000 IPs, A&S needs at least 16000 and Medicine needs at least 8000 IPs. The university also connects to two ISPs. The overall network is as shown below.

2a) Your job is to allocate the /16 to the colleges with a minimum of prefixes. Tell us what prefix you allocate to each of the Engineering (E), Art & Science (A&S) and Medicine (M) colleges. Give us the forwarding table at R1. Use table entries of the form, e.g., 1.2.3.4/8: link-R1-ArtScience.

2b) Suppose the university uses BGP to announce 18.31.0.0/16 from R1 to ISP 1 and the same 18.31.0.0/16 from R2 to ISP 2. For traffic from the Internet to hosts inside the university, explain in terms of BGP how this arrangement will improve (i) reliability and (ii) performance.

2c) It turns out that traffic makes poor use of the connections to the two ISPs. You know that the incoming traffic for Engineering can fit on the link from ISP 1, and the incoming traffic for Art & Science and Medicine combined can fit on the link from ISP 2. Say what prefixes should be announced from R1 and R2 for best performance and reliability assuming as much prefix aggregation as possible. Give us the forwarding table at R3.
Problem 3: DNS Arrangements (20 points, 6 / 6 / 8 pts per part)

Most home computers resolve DNS names by using an ISP nameserver that is configured by DHCP. You and a friend each try out an alternative. Your friend installs a DNS nameserver directly on their home computer and configures the computer to use it. You don’t install your own nameserver and instead configure your home computer to use IP 8.8.8.8, the Google Public DNS service, as a nameserver instead of the ISP nameserver.

3a) Draw a picture of the DNS messages sent to resolve www.fool.com in your setup assuming that only www.amazon.com has previously been resolved and cached by the Google nameserver. Number the messages and label them with the request or response.

3b) Draw a picture of the DNS messages (number them) sent to resolve www.fool.com in your friend’s setup assuming that only www.amazon.com has previously been resolved and cached by your friend’s nameserver. Number the messages and label them with the request or response.

3c) After some further surfing you find that your DNS configuration resolves names faster. Give two reasons why this is likely to be the case.
Problem 4: Triangle routing (20 points, 5 pts per part)

A triangle route from host A to host B is one that does not take the direct path given by Internet routing, but is instead sent via a third host C (e.g., A sends to C using Internet routes, then C sends to B using Internet routes). Perhaps surprisingly, triangle routes can often be found that are lower latency than direct Internet routes. You are designing a system to compute low-latency triangle routes for a stock quote application that has latency-sensitive traffic. Your job is to compare distance-vector and link-state approaches to the problem. There are N sites, where each site is small business or home, and the topology over which your algorithm runs has each site directly connected to each other site (i.e., it is a mesh) via the Internet.

4a) For a distance-vector approach, say as an order of N how much information each site must send and receive, and how much computation each site must perform.

4b) Similarly, for a link-state approach, say as an order of N how much information each site must send and receive, and how much computation each site must perform.

4c) Which design option do you prefer and why? Explain your answer based on the above characterization and any other key considerations.

4d) You build a protocol called Triangle that runs at the sites to send packets along the routes that you find, e.g., from site A to site B via site C. It works with unmodified applications that run on top of TCP. Draw the layered protocol stack diagram for A, B, and C showing where the protocols TCP, IP, and Triangle sit relative to each other. Then consider a packet on the leg from C to B and draw it to show the order of the TCP, IP and Triangle headers and the source and destination Triangle and IP addresses it carries.
Problem 5: The Slow Web (20 points, 8 / 6 / 6 pts per part)

You are surfing popular websites on your laptop at home. You know the network path has high capacity – the 802.11 wireless network is fast, you have 25Mbps Verizon FIOS Internet, and the ISPs and datacenters are over-provisioned – yet performance is *really* slow. You are fairly sure that the Web servers themselves are fast machines with modern software since they work very well when you surf from work. Thus you believe that the problem has to do with either poor software on your old laptop or the properties of your ISP or network path. For each protocol below, explain what might be the problem in terms of the mechanisms we studied in class (be specific!) and what if anything can be done to fix it by tweaking the protocols and their configurations but not changing the underlying IP network.

5a) For TCP, list two possible problems and fixes.

5b) For DNS, list two possible problems and fixes.

5c) For HTTP, list two possible problems and fixes.