Name ______________________________

Number ______________________________

Signature ______________________________

Dear All, you have **90 minutes**. Please note that there are 6 questions for a total of 17 points on 3 page(s). One-double-sided A4 cheat sheet is allowed. Success.

1. [4 points] In a store-and-forward packet switching network, packets are routed from source to destination along a single path having two intermediate nodes. The capacity of all links are the same; $C = 10^3$ bps. Do not consider propagation delay. If the message size is 192 bits and each packet contains a header of 24 bits, then what is the **optimum** payload size? **Show all your work!**

Optimal Packet Size is P+H , where P = ((H*M) / (K-1)) ^ 1/2
H is header byte , K is the number of hops, M is message bytes
H = 24
M = 192 P = (24*192 / (3-1)) ^ 1/2 = 48.
K = 3 48 + 24 = 72.

2. [3 points] A datagram network allows routers to drop packets whenever they need to. The probability of a router discarding a packet is 0.1. Consider the case of a source host connected to the source router, which is connected to the destination router, and then to the destination host. If either of the routers discards a packet, the source host eventually times out and tries again. If both host-router and router-router lines are counted as hops, what is the expected number of hops a packet makes per transmission? **Show all your work!**

There is the case in which the connection comprises host-router, then router-router, and finally router-to-destination host.
Since a packet can create 1, 2, or 3 hops
So the probability of creating 1 hop = p
The probability of creating 2 hops = p(1-p)
The probability of creating 3 hops = (1-p)^2
Therefore, the average number of probabilities for creating hops is,
(1 X probability of 1hop) + (2 X probability of 2 hops) + (3 X probability of 3 hops)
= p + 2p(1-p) + 3(1-p)^2
= p + 2p - 2(p^2) + 3(1 + p^2 - 2p)
= p^2 - 3p + 3
Hence, the mean number of hops a packet creates per transmission = p^2 - 3p + 3
= (0.1)^2 - 3(0.1) + 3

3. [3 points] Suppose you wanted to do a transaction from a remote client to a server **as fast as possible**. Would you use UDP or TCP? Why?

If speed is the top priority for a transaction from a remote client to a server, UDP is preferable over TCP. UDP has lower overhead, no connection establishment delays, and is suitable for real-time applications where minor data loss is acceptable for faster communication. TCP's reliability features, while important, can introduce additional latency. The choice depends on the specific requirements and trade-offs between speed and reliability for the given application.

4. [3 points] Consider sending real-time voice from Host A to Host B over a packet-switched network. Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 52-byte packets. There is one link between Hosts A and B; its transmission rate is 2 Mbps and its propagation delay is 10 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)? **Show all your work!**

Since this is a packet switched network, the data will be transmitted packet by packet. A packet is 52 byte and the analog to digital conversation rate is 64 kbps, thus the preparing time Tp for a packet is :
(52*8)/(64*1000) = 0.0065 s = 6.5 ms.
The transition time Dtrans for a packet is (52*8)/(2*1000*1000) =0.000208 s = 0.208 ms.
Tprop = 10ms
Finally, the total time elapses from the time a bit is create until the bit is decoded is
Tp+Dtrans+Tprop= 6.5 +0.208 + 10 = 16.708 ms

5. [2 points] For a digital communication system, you are allowed to use the frequency band between 913 and 914 MHz. The allowed signal power is $P = 60$ dB-power-units. The noise in the band is additive white Gaussian noise with single-sided power spectral density $N_0 = 1$ power units per Hz. What is the Shannon limit on the achievable capacity C in bits per second (b/s)? **Show all your work!**

6. [2 points] Write down each layer in the Internet (5-layer) reference model and **briefly** describe the main functionality of each layer.

1) Application Layer:
Functionality: This is the top layer that interacts directly with end-user applications. It provides network services such as email (SMTP), file transfer (FTP), and web browsing (HTTP). The application layer protocols facilitate communication between software applications.
2) Transport Layer:
Functionality: Ensures reliable end-to-end communication. It manages flow control, error correction, and retransmission of lost or corrupted packets. Two commonly used transport layer protocols are TCP (Transmission Control Protocol), which provides reliable communication, and UDP (User Datagram Protocol), which offers a faster but less reliable option.
3) Network Layer:
Functionality: Manages the routing of data packets between devices across different networks. It handles logical addressing, like IP addresses, and determines the optimal path for data to travel from the source to the destination.
4) Link Layer:
Functionality: Creates a reliable link between directly connected nodes over a physical layer. It deals with issues such as framing, addressing, and error detection within the local network segment.
5) Physical Layer:
Functionality: Deals with the physical connection between devices. It specifies the characteristics of the hardware, such as cables, connectors, and signaling methods, used for transmitting raw binary data.