Problem 2 (4.4 Stallings)

Circuit switching:

\[
\text{Total delay} = \text{call setup time} + \text{total propagation delay} + \text{message transmission time}
\]

\[
= S + (N + D) + (L/E)
\]

\[
= 0.2 + (4*0.001) + (3200/600) = 0.537 \text{ sec.}
\]

Virtual circuit:
Note: Let a packet transmission time be \( T_p = N \cdot (P/R) \)
and let the number of packets to be \( N_p = \left\lfloor \frac{L}{(P-H)} \right\rfloor \)

Total delay = (call setup time) + (time for 1st packet to reach destination) + (transmission time for the rest of packets on one hop)

\[
= S + [ND + T_p] + [(Np-1) \cdot (P/B)]
\]

\[
= S + [ND + N \cdot (P/B)] + [(Np-1) \cdot (P/B)]
\]

\[
= S + ND + (N+Np-1) \cdot (P/B)
\]

where \( N_p = \left\lfloor \frac{L}{(P-H)} \right\rfloor \)

\[
= 0.2 + (4 \cdot 0.001) + (4 + \left\lceil \frac{3200}{(1024-16)} \right\rceil) \cdot 1 \cdot \frac{1024}{9600}
\]

= 0.9507 sec.

**Datagram:**

Total delay = (time for 1st packet to reach destination) + (transmission time for the rest of packets on one hop)

\[
= [ND + T_p] + [(Np-1) \cdot (P/B)]
\]

\[
= [ND + N \cdot (P/B)] + [(Np-1) \cdot (P/B)]
\]

\[
= ND + (N+Np-1) \cdot (P/B)
\]

where \( N_p = \left\lfloor \frac{L}{(P-H)} \right\rfloor \)

\[
= (4 \cdot 0.001) + (4 + \left\lceil \frac{3200}{(1024-16)} \right\rceil) \cdot 1 \cdot \frac{1024}{9600}
\]

= 0.7507 sec.

**In general form:**

**Circuit Switching:**
Total delay = \( S + (N \cdot D) + (L/B) \)

**Virtual Circuit:**
Total delay = \( S + ND + (N+Np-1) \cdot (P/B) \)

where \( N_p = \left\lfloor \frac{L}{(P-H)} \right\rfloor \)

**Datagram:**
Total delay = \( ND + (N+Np-1) \cdot (P/B) \)

where \( N_p = \left\lfloor \frac{L}{(P-H)} \right\rfloor \)

**Condition which Circuit Switching delay is equal to Virtual Circuit delay:**
\( L = (N+Np-1) \cdot P \)

**Condition which Virtual Circuit delay is equal to Datagram delay:**
\( S \) of Virtual Circuit must be very small (\( \approx 0 \))

**Condition which Circuit Switching delay is equal to Datagram delay:**
\( L = ((N+Np-1) \cdot P) - (S \cdot B) \)
1. **X.25 vs. Frame Relay**

   Based on Functionality.

   Frame Relay implements that concept.
   - The Frame Relay has separate logical channel for the call control.
   - The multiplexing and logical connection takes place at the second layer and eliminates one entire layer of processing.
   - There is no hop-by-hop error and flow control, since nowadays the link reliability is much better than in the past as a result of improved technology. Because of that, there isn’t a need for multiple flow and error control, both in the second and the third layer, which involve in extra overhead.
   - The disadvantage of Frame Relay is that it lost the ability to control the error and flow link – by – link. The main advantage is that it has higher throughput and fewer delays.

   Based on OSI reference model.
   X.25 is an interface between a host system and a packet switching network. The functionality of this interface is in the first 3 layers of the OSI reference model. In the first layer (physical) there is overhead, flow and error control are performed, the physical layer is X.21 or EIA-232. In the link layer there is additional flow and error control (LAPB) Virtual circuits implement the network layer.

   In the Frame Relay model, there are only 2 layers, with the intermediate hosts implementing a minimum set of features.

2. **Connection –Oriented vs. Connectionless**

   Both connections – oriented and connectionless are techniques used in packet switching networks.
In the **Connectionless** approach each packet of information is treated and sent independently with no reference to the packets that have gone before. Packets with the same destination address, which are sent from the same source do not necessarily, follow the same route. As a result, packets of information can arrive at the destination point out of sequence. For example, given sequential packets 1,2,3,4 and nodes are: source,11,22,33,44,destination. A possible scenario can be:

Packet #2 arrives first at the destination followed the route S-11-33-44-D.
Packet #1 arrives second followed the route S-11-44-22-D.
Packet #3 arrives third followed the route S-11-44-22-D.
Packet #4 arrives fourth followed the route S-11-44-22-D

In the **Connection-Oriented** approach the route is preplanned and all the packets follow the same route. In this aspect, it is similar to circuit switching. It is different from the circuit-switching network by the fact that the path is not actually dedicated, only the virtual route is pre-determined. It is a packet-switching method and has the characteristics of one, such as buffering each packet in each node in the route.

Because the packets follow the same route the sequence of arriving at the destination is the same as the sequence of transmission.


**Circuit – Switching:** The principal of C-S is that if a message has to be transmitted from S to D through a network, a dedicated path of transmission facilities would be established, all these facilities will be held for the duration of the transmission. Even if the network is idle the path is still dedicated to the transmission.

**Message – Switching:** The concept of M-S: a message is sent from the source to the destination in stages. The first part of the network is seized for the transmission (S to 1) then the transmission is performed and the message is stored in 1. Then the first facility is released (S to 1) and the next facility of
the network is seized (1-2) and so forth until the message arrives at the destination (D).

**Packet – Switching**: The P-S is a special case of the M-S. The packet is limited in size, so in case the information is larger than the maximum packet size, it is broken to packets. When the packets arrive at the switch points they are stored in high speed random access memory.

In P-S the delay is much shorter, the delay of the first packet will be only the transmission time of the first packet times the hops in the path used. The subsequent packets will follow in sequence immediately behind.

4. **BRI (Basic Rate Interface) vs. PRI (Primary Rate Interface)**

Both interfaces are used in ISDN networks.

**BRI** consists of two full-duplex 64 kbps B channels and a full duplex D channel. The total bit rate is 192 kbps.

**BRI** was designed to meet the individuals and small businesses needs. It enables the use of on-line computer and telephone channel at the same time (using the same line).

**PRI** was designed to meet the needs of users with greater capacity requirements such as businesses with LAN networks. The standard capacity of PRI in America is 1.544 Mbps and in Europe is 2.048 Mbps. A typical PRI in America includes 23 B channels + 64 kbps D channel. The mixture of the channels can vary, and can support H channels as well.

5. **Encapsulation** is the term, which is used to describe the process of adding the control information in each layer of the protocol. We can illustrate it by taking the X.25 as an example.

In layer #3 (Network level) a header is added to the information (data) packet for control. In the data link layer (layer #2) another overheads are added including flags and frame control & address. In the first layer (physical) another overhead is added, which includes the header and the trailer.
Encapsulation is related to the OSI reference model by the fact that each layer of OSI model has to communicate with the same layer in the other end of the communication channel. This is done by having control information that the other side can understand.

6. Packet Switching Network can be defined as a network of queues. The idea of Congestion control is to maintain the number of packets within the network below a level at which queuing delays become excessive.

The congestion occurs when the packets, which arrive at a node, exceed the rate which packets are transmitted from. In a packet – switching network the information is stored in each node, and the node is shared by other transmissions as well (not dedicated).

Not like the Packet-Switching Network a Circuit-Switching Network dedicates a channel to a transmission and the information is not stored in the nodes in the route. This is the reason that congestion is eliminated in the Circuit-Switching Networks.

Some students said that congestion control, in circuit-switching networks, is implemented in the form of finding alternate routes. This would be more of a routing issue. Also a call is blocked if the network does not have the resources to dedicate to this call. Hence, the network is never overloaded.