**Performanc:**

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And since

a = propagation delay / transmission delay = DR/L = dR/vL = B/L

B = Stop-and-Wait Utilization U =

N = number of hops, P = fixed packet size in bits, H = overhead (header), bits per packet, S = call setup time (circuits switching or virtual circuit) in seconds, D = propagation delay per hop in seconds.

For N=4, L=3200, B=9600, P=1024, H=16, S=0.2, D=0.001, compute the end-to-end delay for circuit switching, virtual circuit packet switching, and datagram packet switching. Assume that there are no acknowledgments. Ignore processing delay at nodes.

**Circuit switching:**

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**Datagram Packet Switching**

T = D1 + D2 + D3+D4 where

D1= Time to Transmit and Deliver all packets through first hop

D2 = Time to Deliver last packet across second hop

D3= Time to Deliver last packet across third hop

D4= Time to Deliver last packet across fourth hop

There are P – H = 1024 – 16 = 1008 data bits per packet. A message of 3200 bits requires four packets (3200 bits/1008 bits/packet = 3.17 packets which we round up to 4 packets). D1= 4 × t + p wherex

t = transmission time for one packet

p = propagation delay for one hop

D1= 4 (P/B) + D2= 4 (1024/9600) + 0.001 = 0.428

D2= D3= Dx`= t + p= (P/B) + D= (1024/9600) + 0.001 = 0.108

**Virtual Circuit Packet Switching**

T = V1 + V2where V1= Call Setup Time, V2= Datagram Packet Switching Time. T = S + 0.752 = 0.2 + 0.752 = 0.952 sec

**Circuit Switching vs. Diagram Packet Switching**

Tc = End-to-End Delay, Circuit Switching

Tc = S + N D + L/B

Td= End-to-End Delay, Datagram Packet Switching

Np = Number of packets =

Td = D1 + (N – 1)D2

D1 = Time to Transmit and Deliver all packets through first hop

D2 = Time to Deliver last packet through a hop

D1 = Np(P/B) + D, D2 = P/B + D

T = (Np + N – 1)(P/B) + N x D

T = Td so S + L/B = (Np + N – 1)(P/B)

**Circuit Switching vs. Virtual Circuit Packet Switching**

TV = End-to-End Delay, Virtual Circuit Packet Switching

TV = S + Td, TC = TV so L/B = (Np + N – 1)(P/B)

**Datagram vs. Virtual Circuit Packet Switching**: Td = TV – S

What value of P, as a function of N, L and H, results in a minimum end-to-end delay on a datagram network? Assume that L is much larger than P, and D is zero.

From Problem 1, we have

Td= (Np + N – 1)(P/B) + N × D

For maximum efficiency, we assume that Np = L/(P – H) is an integer. Also, it is assumed that D = 0. Thus

Td = (L/(P – H) + N – 1)(P/B)

To minimize as a function of P, take the derivative:

0 = dTd/(dP), 0 = ()()+ N – 1) - ()

0 = L(P – H) + (N – 1) (P – H)2 - LP

0 = –LH + (N – 1)(P – H)2

(P - H)2 = P = H +

The inclusion of a parity bit extends the message length. There are more bits that can be in error since the parity bit is now included. The parity bit may be in error when there are no errors in the corresponding data bits. Therefore, the inclusion of a parity bit with each character would change the probability of receiving a correct message.

In calculating the even parity bit.

A Transmit: 10101010

A computes even parity bit value: 1^0^1^0^1^0^1^0 = 0

A adds parity bit and sends: 10101010**0**

\*\*\* TRANSMISSION ERROR \*\*\*

B receives: 10011010

B computes even overall parity: 1^0^0^1^1^0^1^0 = 0

B observes even parity, as expected, thereby failing to catch the two bit errors. This result will be wrong as there was a transmission error that occurred during transmission.

Any arithmetic scheme will work if applied in exactly the same way to the forward and reverse process. The modulo 2 scheme is easy to implement in circuitry. It also yields a remainder one bit smaller than binary arithmetic.

Consider a frame consisting of two characters of four bits each. Assume that the probability of bit error is 10-3 and that it is independent from each bit.

a.) What is the probability that the received frame contains at least one error?

We have:

Pr [single bit in error] =

Pr [single bit not in error] =

Pr [8 bits not in error] =

Pr [at least one error in frame] =

b.) Now add a parity bit to each character. What is the probability?

Pr [at least one error in frame] =

For P = 110011 and M = 11100011, find the CRC



Considering a half-duplex point-to-point link using a stop-and-wait scheme, in which a series of messages is sent, with each message segmented into a number of frames. Ignore error and frame overhead.

a.) What is the effect on line utilization of increasing the message size so that fewer messages will be required? Other factors remain constant? Because only one frame can be sent at a time, and transmission must stop until an acknowledgment is received, there is little effect in increasing the size of the message if the frame size remains the same. All that this would affect is connect and disconnect time.

b.) What is the effect on line utilization of increasing the number of frames for a constant message size? Increasing the number of frames would decrease frame size (number of bits/frame). This would lower line efficiency, because the propagation time is unchanged but more acknowledgments would be needed.

c.) What is the effect on line utilization of increasing frame size? For a given message size, increasing the frame size decreases the number of frames. This is the reverse of (b).

A channel has a data rate of 4 kbps and a propagation delay of 20 ms. For what range of frame size does stop-and-wait give and efficiency of at least 50%?

Let *L* be the number of bits in a frame.

= =

= ≥ 0.5

Therefore, an efficiency of at least 50% requires a frame size of at least 160 bits.

Consider the use of 1000-bit frames on a 1-Mbps satellite channel with a 270-ms delay. What is the maximum link utilization for

a.) Stop-and-wait flow control?

b.) Continuous flow control with window size 7?

c.) Continuous flow control with window size 127?

d.) Continuous flow control with window size 255?

In Figure 7.10 frames are generated at node A and sent to node C through node B. Determine the minimum date rate required between node B and C so that the buffers of B are not flooded, based on the following.

* The date rate between A and B is 100 kbps.
* The propagation delay is 5 µs/km for both lines.
* There are full duplex lines between the node.
* All data frames are 1000 bits long. ACK frames are separate frames of negligible length.
* Between A and B, a sliding window protocol with a window size of 3 is used.
* Between B and C, Stop-and-wait is used.
* There are no errors.

*Hint:* In order not to flood the buffer of B, the average number of frames entering and leaving B must be the same over a long interval.

Propagation time =

Transmission time per frame =

Propagation time =

Transmission time per frame =

R = data rate between B and C (unknown)

A can transmit three frames to B and then must wait for the acknowledgment of the first frame before transmitting additional frames. The first frame takes 10 msec to transmit; the last bit of the first frame arrives at B 20 msec after it was transmitted, and therefore 30 msec after the frame transmission began. It will take an additional 20 msec for B's acknowledgment to return to A. Thus, A can transmit 3 frames in 50 msec.

B can transmit one frame to C at a time. It takes 5 + x msec for the frame to be received at C and an additional 5 msec for C's acknowledgment to return to A. Thus, B can transmit one frame every 10 + x msec, or 3 frames every 30 + 3x msec.

Thus:

Two stations communicate via a 1-mbps satellite link with a propagation delay of 270-ms. The satellite server merely to retransmit data received from one station to another, with negligible switching delay. Using HDLC frames of 1024 bits with 3-bit sequence numbers what is the maximum possible data throughput: that is, what is the throughput of data bits carried in HDLC frames?

Let t1 = time to transmit a single frame

The transmitting station can send 7 frames without an acknowledgment. From the beginning of the transmission of the first frame, the time to receive the acknowledgment of that frame is:

During the time t2, 7 frames are sent.



