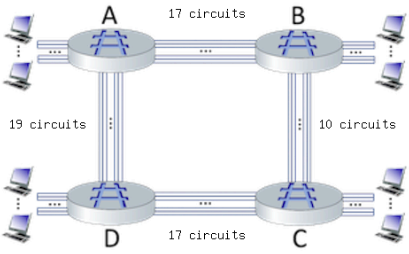
CIRCUIT SWITCHING

CIRCUIT SWITCHING

Consider the circuit-switched network shown in the figure below, with circuit switches A, B, C, and D. Suppose there are 17 circuits between A and B, 10 circuits between B and C, 17 circuits between C and D, and 19 circuits between D and A.



circ. swiching 01

1. QUESTION 1 OF 4

What is the maximum number of connections that can be ongoing in the network at any one time?

Answer 63 ✓

2 QUESTION 2 OF 4

Suppose that these maximum number of connections are all ongoing. What happens when another call connection request arrives to the network, will it be accepted? Answer Yes or No

Answer NO ✓

3 QUESTION 3 OF 4

Suppose that every connection requires 2 consecutive hops, and calls are connected clockwise. For example, a connection can go from A to C, from B to D, from C to A, and from D to B. With these constraints, what is the is the maximum number of connections that can be ongoing in the network at any one time?

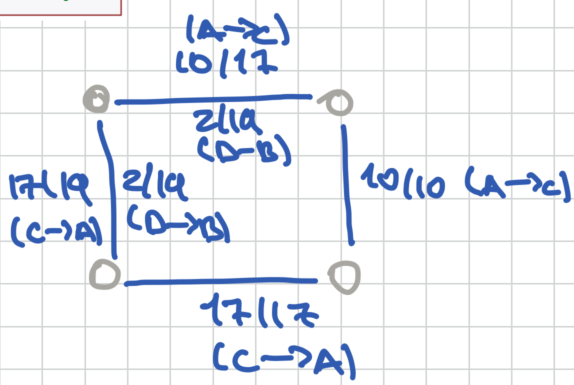
Answer 29 ✓

A -> C : 10 +

B -> D : 0 +

C -> A : 17 +

D -> B : 2 = 29

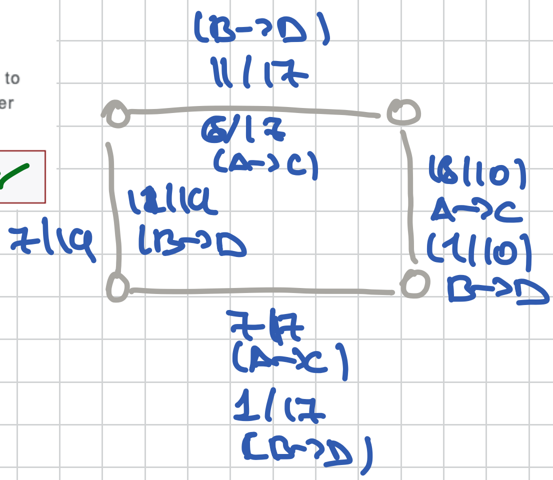


4. QUESTION 4 OF 4

Suppose that 13 connections are needed from A to C, and 12 connections are needed from B to D. Can we route these calls through the four links to accommodate all 25 connections? Answer Yes or No

Answer YES ✓

TOT CONN: 13 + 12 = 25 < 29 di prima

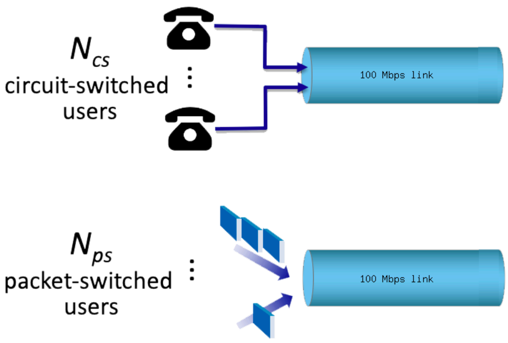


CIRCUIT VS PACKET SWITCHING

QUANTITATIVE COMPARISON OF PACKET SWITCHING AND CIRCUIT SWITCHING

This question requires a little bit of background in probability (but we'll try to help you though it in the solutions). Consider the two scenarios below:

- A circuit-switching scenario in which N_{cs} users, each requiring a bandwidth of 20 Mbps, must share a link of capacity 100 Mbps.
- A packet-switching scenario with N_{ps} users sharing a 100 Mbps link, where each user again requires 20 Mbps when transmitting, but only needs to transmit 10 percent of the time.



Round your answer to two decimals after leading zeros

1. ## QUESTION 1 OF 7

When circuit switching is used, what is the maximum number of users that can be supported?

Answer 100 Mbps/20 Mbps = 5 users

2. ## QUESTION 2 OF 7

Suppose packet switching is used. If there are 9 packet-switching users, can this many users be supported under circuit-switching? Yes or No.

Answer NO

$$9 \text{ users} \cdot \underbrace{20 \text{ Mbps}}_{\text{Band/User}} = 180 \text{ Mbps} > 100 \text{Mbps link}$$

Oppure basta usare la domanda 1: 9 Users > 5 max Users

3. ## QUESTION 3 OF 7

Suppose packet switching is used. What is the probability that a given (specific) user is transmitting, and the remaining users are not transmitting?

Answer 0.043 ✓

$$0.1 \cdot 0.9^8 = 0.043$$

4. ## QUESTION 4 OF 7

Suppose packet switching is used. What is the probability that one user (*any* one among the 9 users) is transmitting, and the remaining users are not transmitting?

Answer 0.387 ✓

$$\underbrace{0.1}_{p} \cdot \underbrace{0.9^8}_{(1-p)^8} \cdot \underbrace{9}_{9 \text{ Times}} = 0.387420489 \approx 0.387$$

Users = 9

5

QUESTION 5 OF 7

When one user is transmitting, what fraction of the link capacity will be used by this user? Write your answer as a decimal.

Answer 0.2 ✓

$$\frac{2\cancel{0}}{10\cancel{0}} = \frac{\cancel{2}1}{\cancel{10}5} =$$

6

QUESTION 6 OF 7

What is the probability that any 3 users (of the total 9 users) are transmitting and the remaining users are not transmitting?

Answer 0.045 ✓

$$\binom{9}{3}_{k}^{n} \cdot 0.1^{3^{k}} \cdot 0.9^{6^{n-k}}$$

$$\frac{9!}{3! \cdot 6!} \cdot \quad \cdot 0.1^3 \cdot 0.9^6 =$$

$$= \frac{9 \cdot 8 \cdot 7 \cdot \cancel{6!}}{3! \cdot \cancel{6!}} \quad // \quad = \frac{9 \cdot 8 \cdot 7}{3 \cdot 2 \cdot 1} \cdot 0.1^3 \cdot 0.9^6 =$$

$$= 0.04464104 \approx \boxed{0.045}$$

7.

QUESTION 7 OF 7

What is the probability that *more* than 5 users are transmitting?

Answer

$$P(X > 5) = 1 - \left[\sum_{i=1}^{5} P(X=i)\right]$$

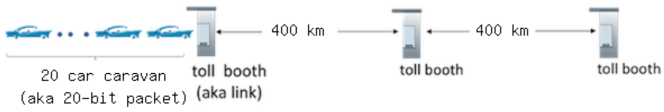
$$= 1 - P(X \leq 5)$$

- $P(X=0) = 0.9^9$
- $P(x=1) = 0.1 \cdot 0.9^8$
- $P(x=2) = 0.1^2 \cdot 0.9^7$
- $P(x=3) = 0.1^3 \cdot 0.9^6$
- $P(x=4) = 0.1^4 \cdot 0.9^5$
- $P(x=5) = 0.1^5 \cdot 0.9^4$

CARAVAN ANALOGY

CAR - CARAVAN ANALOGY

Consider the figure below, adapted from Figure 1.17 in the text, which draws the analogy between store-and-forward link transmission and propagation of bits in packet along a link, and cars in a caravan being serviced at a toll booth and then driving along a road to the next tollbooth.



Suppose the caravan has 20 cars, and that the tollbooth services (that is, transmits) a car at a rate of one car per 1 seconds. Once receiving serving a car proceeds to the next tool both, which is 400 kilometers away at a rate of 20 kilometers per second. Also assume that whenever the first car of the caravan arrives at a tollbooth, it must wait at the entrance to the tollbooth until all of the other cars in its caravan have arrived, and lined up behind it before being serviced at the toll booth. (That is, the entire caravan must be stored at the tollbooth before the first car in the caravan can pay its toll and begin driving towards the next tollbooth).

1 QUESTION 1 OF 7

Once a car enters service at the tollbooth, how long does it take until it leaves service?

Answer 1 second

2 QUESTION 2 OF 7

How long does it take for the entire caravan to receive service at the tollbooth (that is the time from when the first car enters service until the last car leaves the tollbooth)?

Answer 20 s

3 QUESTION 3 OF 7

Once the first car leaves the tollbooth, how long does it take until it arrives at the next tollbooth?

Answer 20s

$$\frac{40\cancel{0}\ \cancel{km}}{2\cancel{0}\ \cancel{km}/s} = 20\ s$$

4 QUESTION 4 OF 7

Once the last car leaves the tollbooth, how long does it take until it arrives at the next tollbooth?

Answer 20s

5 QUESTION 5 OF 7

Once the first car leaves the tollbooth, how long does it take until it enters service at the next tollbooth?

Answer 39

service 19 cars

20s + 19 = 39

6 QUESTION 6 OF 7

Are there ever two cars in service at the same time, one at the first toll booth and one at the second toll booth? Answer Yes or No

Answer NO

7 QUESTION 7 OF 7

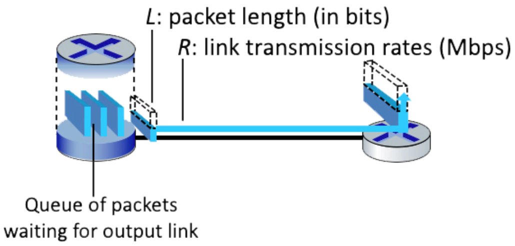
Are there ever zero cars in service at the same time, i.e., the caravan of cars has finished at the first toll both but not yet arrived at the second tollbooth? Answer Yes or No

Answer yes

COMPUTING ONE HOP TRANSMISSION DELAY

COMPUTING THE ONE-HOP TRANSMISSION DELAY

Consider the figure below, in which a single router is transmitting packets, each of length *L* bits, over a single link with transmission rate *R* Mbps to another router at the other end of the link.



Suppose that the packet length is L= 8000 bits, and that the link transmission rate along the link to router on the right is R = 1000 Mbps.

Round your answer to two decimals after leading zeros

Kilo: 10^3

Mega: 10^6

1 QUESTION 1 OF 2

What is the transmission delay?

Answer 8.E-06 ✓

$$L/R = \frac{8000 \text{ bits}}{1000 \cdot 10^6 \text{ bits/s}} = 8 \cdot e^{-6} s$$

2 QUESTION 2 OF 2

What is the maximum number of packets per second that can be transmitted by this link?

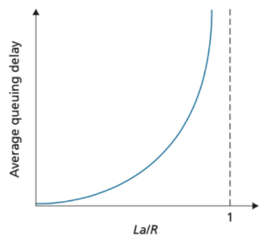
Answer 125 000

$$\frac{1000 \cdot 10^6 \text{ bits/s}}{8000 \text{ bits}} = 125\,000 ✓$$

QUEUING DELAY

QUEUING DELAY

Consider the queuing delay in a router buffer, where the packet experiences a delay as it waits to be transmitted onto the link. The length of the queuing delay of a specific packet will depend on the number of earlier-arriving packets that are queued and waiting for transmission onto the link. If the queue is empty and no other packet is currently being transmitted, then our packet's queuing delay will be zero. On the other hand, if the traffic is heavy and many other packets are also waiting to be transmitted, the queuing delay will be long.



Assume a constant transmission rate of R = 1300000 bps, a constant packet-length L = 7700 bits, and a is the average rate of packets/second. Traffic intensity I = La/R, and the queuing delay is calculated as I(L/R)(1 - I) for I < 1.

1 QUESTION 1 OF 5

In practice, does the queuing delay tend to vary a lot? Answer with Yes or No

Answer yes ✓

2 QUESTION 2 OF 5

Assuming that a = 36, what is the queuing delay? Give your answer in milliseconds (ms)

Answer ✓

$$\frac{L \cdot a}{R} = \frac{7700\,b \cdot 36}{1300000\,b/s} = 213{,}23 = \ell$$

$$\ell \cdot \left(\frac{L}{R}\right) \cdot (1-\ell) = 0{,}000{,}993\,675\,572\,144\ s$$

$$\overset{ms}{=} 0.993\,675\,572\,144\ ms$$

$$\overset{4ms}{\approx} \boxed{0.9937}$$

3 QUESTION 3 OF 5

Assuming that a = 73, what is the queuing delay? Give your answer in milliseconds (ms)

Answer ✓

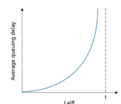
$$\frac{L \cdot a}{R} = \frac{7700\,b \cdot 73}{1300000} = 0.001\,453\,689\,864\,37\ s$$

$$\overset{ms}{=} 1.453\,689\,864$$

$$\boxed{\overset{4ms}{\approx} 1.4537}$$

QUEUING DELAY

Consider the queuing delay in a router buffer, where the packet experiences a delay as it waits to be transmitted onto the link. The length of the queuing delay of a specific packet will depend on the number of earlier-arriving packets that are queued and waiting for transmission onto the link. If the queue is empty and no other packet is currently being transmitted, then our packet's queuing delay will be zero. On the other hand, if the traffic is heavy and many other packets are also waiting to be transmitted, the queuing delay will be long.



Assume a constant transmission rate of R = 1300000 bps, a constant packet-length L = 7700 bits, and a is the average rate of packets/second. Traffic intensity I = La/R, and the queuing delay is calculated as I(L/R)(1 - I) for I < 1.

QUESTION 4 OF 5

Assuming the router's buffer is infinite, the queuing delay is 1.4537 ms, and 582 packets arrive. How many packets will be in the buffer 1 second later?

Answer

CHECK HINT SKIP

4 QUESTION 4 OF 5

Assuming the router's buffer is infinite, the queuing delay is 1.4537 ms, and 582 packets arrive. How many packets will be in the buffer 1 second later?

Answer

HINT

The number of packets left in the buffer after 1 second can be calculated with the formula: packets - (60/qdelay) rounded down

$$P - \left(\frac{second}{qDelay}\right) = \left\lfloor 582 - \left(\frac{1}{1.4537\,ms}\right)\right\rfloor = 540$$

[La risposta è 0 dal sito di Kurose]

The answer was: 0

QUESTION 5 OF 5

If the buffer has a maximum size of 932 packets, how many of the 582 packets would be dropped upon arrival from the previous question?

Answer

CHECK HINT SKIP

5. QUESTION 5 OF 5

If the buffer has a maximum size of 932 packets, how many of the 582 packets would be dropped upon arrival from the previous question?

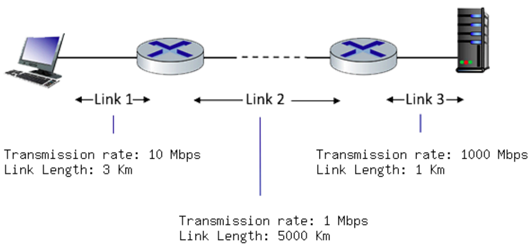
Answer 0

CHECK HINT SKIP

END-END DELAY

COMPUTING END-END DELAY (TRANSMISSION AND PROPAGATION DELAY)

Consider the figure below, with three links, each with the specified transmission rate and link length.



Assume the length of a packet is 12000 bits. The speed of light propagation delay on each link is 3x10^8 m/sec

Round your answer to two decimals after leading zeros

1 QUESTION 1 OF 10

What is the transmission delay of link 1?

Answer ✓

$$L/R = \frac{12000\ b}{10 \cdot 10^6\ b/s} = \boxed{0.0012\ s}$$

2 QUESTION 2 OF 10

What is the propogation delay of link 1?

Answer ✓

$$\frac{3\ Km}{3 \cdot 10^8\ m/sec} = \frac{3 \cdot 10^3\ \cancel{3000\ m}}{3 \cdot 10^8\ \cancel{m}/s} = \frac{1}{10^5}\ s = \boxed{1E\text{-}05\ s}$$

3 QUESTION 3 OF 10

What is the total delay of link 1?

Answer ✓

$$0.0012s + 1E\text{-}05s = \boxed{0.0012}1$$

4 QUESTION 4 OF 10

What is the transmission delay of link 2?

Answer ✓

$$L/R = \frac{12000\ b}{1 \cdot 10^6\ b/s} = \boxed{0.012\ s}$$

5. QUESTION 5 OF 10

What is the propogation delay of link 2?

Answer ✓

$$\frac{5000\,km}{3\cdot10^8\,m/s} = \frac{5000\cdot10^3}{3\cdot10^8\,m/s} = \frac{5\cdot10^6\,m}{3\cdot10^8\,m/s} = \frac{5}{3\cdot10^2} = 0.016666\ldots \boxed{\cong 0.017}$$

6 **QUESTION 6 OF 10**

What is the total delay of link 2?

Answer ✓

$$\frac{5}{3\cdot10^2} + 0.012 = 0.0286666666\ldots \boxed{\cong 0.029}$$

7 **QUESTION 7 OF 10**

What is the transmission delay of link 3?

Answer ✓

$$L/R = \frac{12000\,b}{1000\cdot10^6\,b/s} = \frac{1.2\cdot10^4}{10^9} = \frac{1.2\cdot}{10^5} = \underline{1.2E-05s}$$

8 **QUESTION 8 OF 10**

What is the propogation delay of link 3?

Answer

$$\frac{10^3\,m}{3\cdot10^8\,m/s} = \frac{1}{3\cdot10^5\,m/s} = \underline{3.33E-06}$$

9 **QUESTION 9 OF 10**

What is the total delay of link 3?

Answer ✓

$\boxed{\underline{1.533E-05}}$

10 **QUESTION 10 OF 10**

What is the total delay?

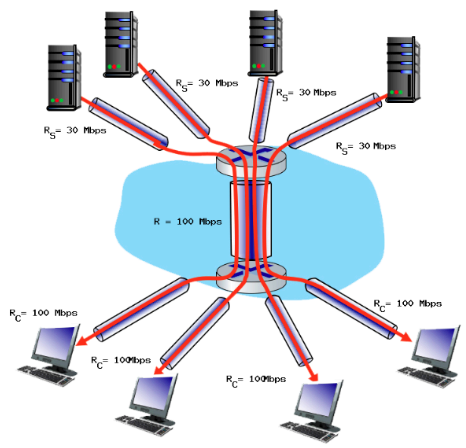
Answer ✓

Somo tutto: $\underline{0.030215\ldots s}$

THROUGHPUT & BOTTLENECK

END TO END THROUGHPUT AND BOTTLENECK LINKS

Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 100 Mbps. The four links from the servers to the shared link have a transmission capacity of R_S = 30 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 100 Mbps.



You might want to review Figure 1.20 in the text before answering the following questions

1 QUESTION 1 OF 5

What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fairly shared (divides its transmission rate equally)?

Answer

$100/4 = 25$ Mb/s $R/4$

$= \min\{30, 25, 100\} = 25$ Mb/s

2 QUESTION 2 OF 5

Which link is the bottleneck link? Format as Rc, Rs, or R

Answer R ✓

3 QUESTION 3 OF 5

Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the server links (R_S)? Answer as a decimal

Answer ✓

$$\frac{100}{30\cdot 4} = \frac{100}{120} = 0.833$$

4. QUESTION 4 OF 5

Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the client links (R_C)? Answer as a decimal

Answer ✓

$$\frac{100}{100\cdot 4} = \frac{100}{400} = \frac{1}{4} = 0.25$$

5 **QUESTION 5 OF 5**

Assuming that the servers are sending at the maximum rate possible, what is the link utilizations for the shared link (R)? Answer as a decimal

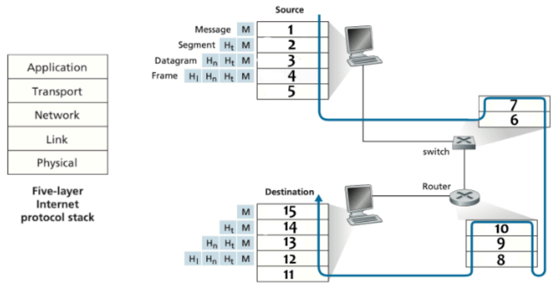
Answer

$$\frac{100}{25 \cdot 4} = 1$$

IP STACK & LAYERING

THE IP STACK AND PROTOCOL LAYERING

In the scenario below, imagine that you're sending an http request to another machine somewhere on the network.



1. **QUESTION 1 OF 20**

What layer in the IP stack best corresponds to the phrase: 'handles messages from a variety of network applications'

Answer application ✓

2. **QUESTION 2 OF 20**

What layer in the IP stack best corresponds to the phrase: 'handles the delivery of segments from the application layer, may be reliable or unreliable'

Answer transport ✓

3. **QUESTION 3 OF 20**

What layer in the IP stack best corresponds to the phrase: 'bits live on the wire'

Physical Layer ✓

4. **QUESTION 4 OF 20**

What layer in the IP stack best corresponds to the phrase: 'moves datagrams from the source host to the destination host'

Answer Network Layer ✓

5. **QUESTION 5 OF 20**

What layer in the IP stack best corresponds to the phrase: 'passes frames from one node to another across some medium'

Answer Link Layer ✓

6. **QUESTION 6 OF 20**

What layer corresponds to box 1?

Application Layer

7. **QUESTION 7 OF 20**

What layer corresponds to box 2?

Transport Layer

8. **QUESTION 8 OF 20**

What layer corresponds to box 3?

Network Layer

QUESTION 10 OF 20

What layer corresponds to box 5?

Physical Layer

QUESTION 11 OF 20

What layer corresponds to box 6?

Physical Layer

QUESTION 12 OF 20

What layer corresponds to box 7?

Link

~~Transport~~ Layer