527 — Computer Networks and Distributed Systems — Network Layer

Note that the solution notes below only briefly list (some of) the key points that should be included in an answer. They are by no means complete. In an exam, you are expected to spell out the solution more fully and include a detailed explanation of your reasoning.

Question: Network Design

Imagine that you are the network administrator for this $10\,\mathrm{Mb/s}$ shared LAN:

This network is used within an office. The users at nodes A and B are engaged in a video conference, while the boss' children are playing a graphical networked game on nodes C and D. All are finding that their applications are slow and jumpy.

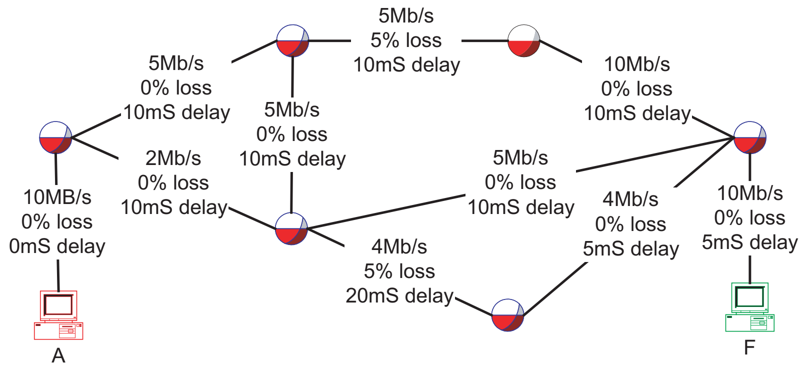
1. What is the likely cause of the problems?
2. Briefly describe three technical solutions to enable users at A and B to obtain improved network performance. Consider:
   (a) how the solution causes improvement.
   (b) where in the OSI network model the solution operates.
   (c) what change will each pair of users experience.
   (d) the costs, implementation complexity and flexibility of the solution.

1. • Contention for network access: repeated back-offs/collisions cause jitter
   • Slowness may also be simply due to the 10Mb/s network
2. Listed below are 3 possible solutions:
   (i) *Segment network* using transparent bridge between A/B and C/D
      • Reduces contention between competing pairs
      • Operates at data link layer
      • Both pairs of users experience an improvement
      • Quite cheap (hardware, cabling, stations, admin)
      • Lacks flexibility and scalability
   (ii) Use *switched network* rather than shared bus
      • Reduces contention between competing pairs
      • Operates at data link layer
      • Both pairs of users experience an improvement
      • Hardware cheap, cabling expensive, no change at stations
      • Flexible
   (iii) Use *higher speed wiring*, e.g. 100Base-T
      • Transmit more data per second so reduces contention
      • Operates at physical layer

- Both pairs of users experience an improvement
- New cabling, new NICs on stations
- Flexible but only somewhat scalable

Question: Routing

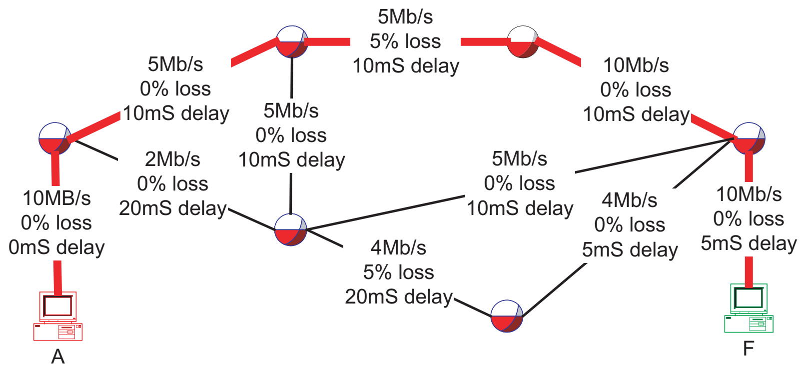
You are given a network topology with the following characteristics:



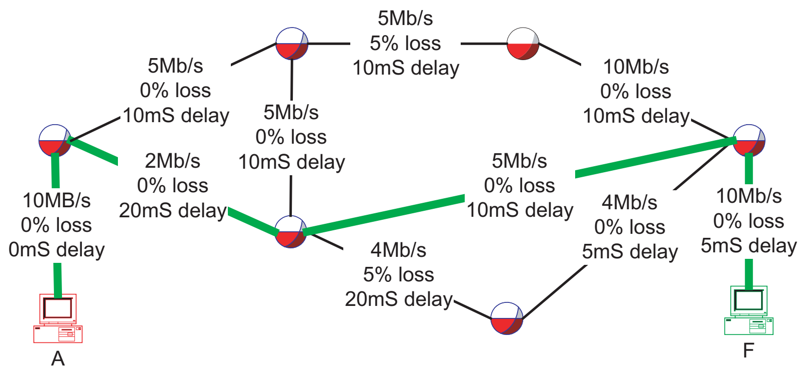
Show the best route (while explaining your reasoning) from node A to node F for

1. delay and jitter sensitive but loss insensitive traffic, e.g. streamed audio.
2. bandwidth and loss sensitive traffic, e.g. file downloads.

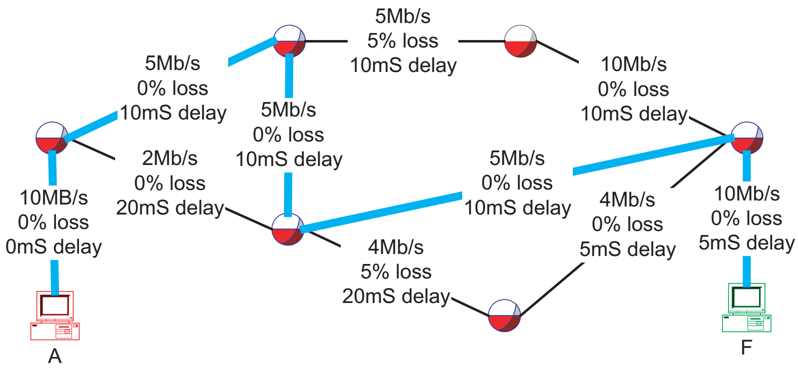
1. The delay matters but there are several choices with lowest delay
   - 35ms but loss (5%) will cause jitter



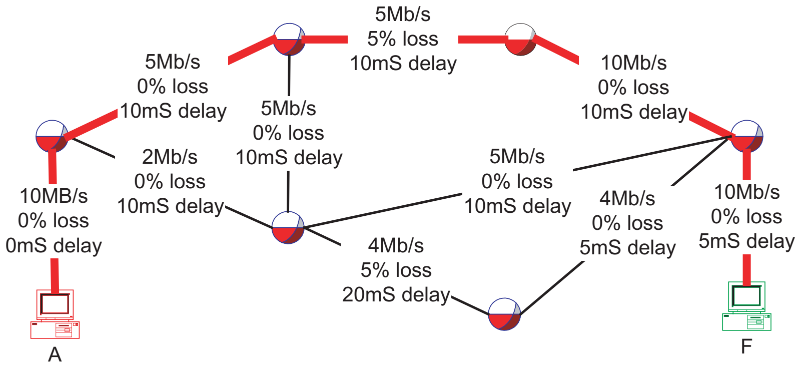
   - 35ms but slow (2Mb/s) hop will add delay and may get congested



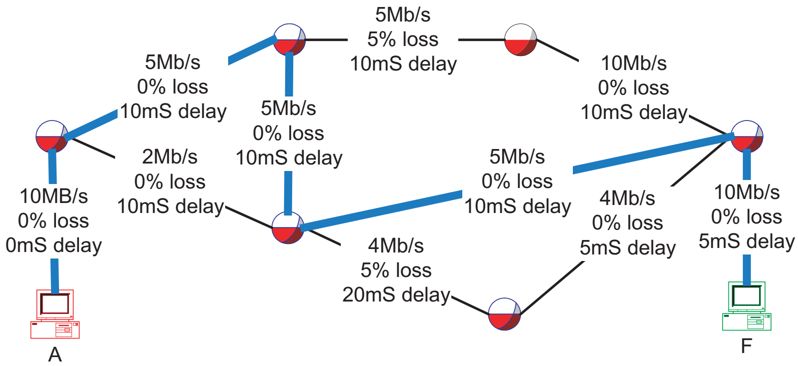
   - 35ms with faster links than above and no loss is best choice



2. The bandwidth on the path matters and there are two choices
   - 5Mb/s minimum bandwidth on path, so maximum achievable, but loss will give effectively lower bandwidth



   - 5Mb/s achievable with no loss, so will be fastest actual throughput



p.t.o.

Question: Routing Algorithms

You are given the following network topology where A, B, C, D are routers and L_{1-3} are the links between them. The routers execute the *distance vector* routing protocol, exchanging distance vectors simultaneously every T seconds. Distance is measured in number of hops.

1. Initially link L_1 is down. Write down the routing tables maintained by the routers after they reached a steady state.
2. Link L_1 comes back up. Write down how the cost to router A changes from the perspective of the other routers after each T second period. How long does it take until all routers have reached a steady state again?
3. Now link L_1 goes down again. How long does convergence take in this case? Discuss the difference when compared to the previous case.
4. Suggest a solution to the problem.

1. The steady state routing tables are as follows:

	A	B	C	D
A	0	∞	∞	∞
B	∞	0	1	2
C	∞	1	0	1
D	∞	2	1	0

2. The perceived cost to router A changes as shown below. A steady state is reached after $3T$ seconds.

time period	B	C	D
0	∞	∞	∞
T	1	∞	∞
$2T$	1	2	∞
$3T$	1	2	3

3. In this case, a steady state is never reached but rather the remaining routers slowly increment the cost to router A to ∞.

   This happens because the knowledge of the link failure only slowly propagates through the network. Each router constantly switches to a slightly more expensive route to A via its other neighbour, not realising that it is actually part of this "new" route to A.

time period	B	C	D
0	1	2	3
T	3	2	3
$2T$	3	4	3
$3T$	5	4	5
$4T$	5	6	5
$5T$	7	6	7
...	...	...	...

4.
   - Use *link state* routing
   - Define ∞ to be the network diameter + 1, i.e. 4 in this example
   - Include the paths taken in the distance vector messages (which is what BGP does)

IP Subnetting

You have one class C network 194.16.3.0 but want to use five networks.

1. How would you do this?
2. How many hosts can you have on each network?
3. What would the subnet mask be?

1. Subnets must be a power of 2
   3 bits give $2^3 = 8$ subnets

2. 5 bits for hosts on each subnet, again without all 0s or 1s
   $2^5 - 2 = 30$ hosts per subnet
3. Subnet mask is given with 1s over network number
   Top 3 bits give $128 + 64 + 32 = 224$
   Whole subnet mask is 255.255.255.224

IP Address Allocation

An IP address can be permanently allocated to a specific hardware address or dynamically allocated on request. What circumstances are appropriate for each?

Permanent IP address is good for machines that

- are on all the time, on the same network
- provide services that do not move

Dynamic IP address save on manual reconfiguration and are good for machines that

- connect intermittently
- connect at different times to each other
- connect to different networks

IP Packets and Routing

Which fields of an IP packet header would a router change as it forwards it, how do they change and why?

Time to Live: Decremented at each router to stop packets from circulating forever in the network.

Total Length / Flags / Fragmentation Offset: Changed to reflect fragmentation of packet if travelling over network with smaller maximum transfer unit (MTU).

Checksum Recomputed by each router as at least the TTL will have changed.