Network Systems (201300179/201400431), Test 2

February 26, 2016, 13:45–15:15

With answers

- This is an open-book exam: you are allowed to use the book by Peterson & Davie and the reader that belongs to this module, and the handout about peer-to-peer communication (i.e., the part of the Kurose&Ross book distributed via Blackboard). Furthermore, use of a dictionary is allowed. Use of a simple (non-graphical) calculator is allowed.
- Other written materials, and laptops, tablets, graphical calculators, mobile phones, etc., are not allowed. ***Please remove any such material and equipment from your desk, now!***
- Although the questions are stated in English, you may answer in English or Dutch, whichever you are more comfortable with.
- You should always explain or motivate your answers, with so much detail that the grader can judge whether you understand the material; so just saying "yes" or giving a formula without explanation is not enough.
- Visiting the toilet without explicit permission of the supervisor is not allowed. During the last 30 minutes of the exam, no toilet visits are allowed.

---

1. Physical media and framing

2 pt (a) Consider a glass fiber without cladding, immersed in water. The index of refraction of the glass is 1.45, that of the water is 1.5. Is this fiber suitable for communication? Explain.

No, it isn't. Because the surrounding medium has a higher index of refraction, total internal reflection cannot occur, so the light will leak out of the glass fiber.

2 pt (b) The IPv4 header has a "length" field. That means that if we send lots of IPv4 packets one after the other, we can always count bytes to find out where the next one starts, without needing any further framing. Is this a good idea? Explain.

No. It's framing by byte count, which is known for not being robust: if the length field is received incorrectly in one frame, then not only that frame will be delineated incorrectly, but also the wrong number will be interpreted as the next frame's byte count, and so on, causing all frames from then on to be incorrect.

Surprisingly many students seemed to think this was a question about *fragmentation* rather than *framing*, and thus gave a totally unrelated (and wrong) answer.

3 pt (c) Design a framing method which uses 2 bytes for each flag; i.e., specify appropriate rules for adding flags and for doing and undoing any stuffing you deem necessary.

Say the flag is AA (two bytes, each ascii-value for A). Put those at start and end of frame. Sender goes through the frame contents from start to end; after every A, inserts a B. Receiver removes every B if preceded by an A.

Alternative: Say the flag is AB (two bytes, ascii-values for A and B). Sender replaces every occurrence of AB by ACA, and every occurrence of AC by ACC. Receiver, whenever it sees AC, replaces the latter of these two bytes by the next byte.

Alternative: Use bit stuffing, rather than byte stuffing, with 01111111 11111110 as flag, and stuff a 0 after every 13 ones.

Surprisingly many students apparently didn't read the question carefully, giving an answer involving 2 *bits* rather than *bytes*, or simply described a solution using a *one*-byte flag from the book.

Some tried to use e.g. a string of 16 1s as the flag. That doesn't work too well: what if a frame ends in 8 1s, followed by 16 1s for the flag, followed by a next frame starting with 8 1s? That results in 32 1s, and the receiver can't see where exactly is the flag itself. Similar problems can occur if your flag is two identical bytes, e.g. AA, and your stuffing rules only look at groups of two bytes.

---

2. Medium Access Control

On a cable are 4 nodes, A, B, C, and D. A and D are at the two ends of the cable. The nodes use Carrier Sense Multiple Access (CSMA).

3 pt (a) Describe a scenario where A and D transmit a packet, and where B experiences a collision between the two packets, and C not. You may use a space-time diagram (analogue to Figure 5.12 in part 5 of the reader) to describe the scenario.

A scenario where this occurs is the following. Suppose A and D start transmitting a short packet at the same time. If B is located exactly in the middle of the cable, it will hear both packets at exactly the same time, i.e., B will experience a collision. If C is colocated with D, it will hear the packet from D first, and the packet from A only after some propagation delay. If this delay is larger than the packet duration (from D), C will not experience a collision.

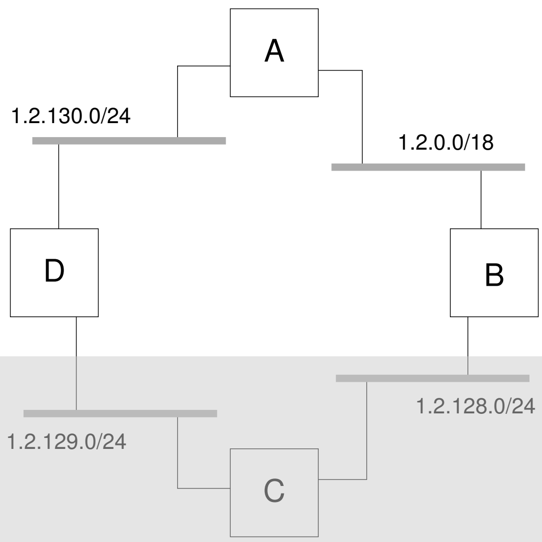
3 pt (b) To guarantee that a collision is always detected by all nodes, systems that use CSMA with collision detection use a minimum packet length. For each of the following cases describe if, how, and why this minimum packet length (in bits) should change as a result of the modification given.
(1) the cable length is doubled
(2) the number of nodes is 8 instead of 4
(3) the data rate at which the nodes are sending is increased with a factor 10.

The minimum length of the packet (in bits) equals the number of bits that can be transmitted during a roundtrip time of the medium (length / propagation speed).
(1) the minimum packet length should be doubled as well, because the roundtrip time is doubled
(2) the number of nodes does not influence the detection of collisions (as long as there are at least 2 nodes, otherwise there will not be collision)
(3) the minimum packet length should be increased with a factor 10 as well, because 10 times as many bits can be transmitted during the roundtrip time.

---

3. (Inter)networking

Consider the network sketched here, consisting of a number of Ethernet LANs (the thick gray lines), connected via "boxes" (the squares). Each LAN also has 10 computer connected to it (not shown in the figure); assume all of these computers are actively exchanging packets with each other via this network.



2 pt (a) If all of the boxes are bridges, how many entries does each of them have in its forwarding table? Explain.

40, since bridges will have separate entries for each computer in the network.

Since bridges forward the packets at the link layer, using MAC addresses, all computers in this entire network are visible to each of the bridges. The assigned IP addresses are not important.

2 pt (b) Still assume the boxes are bridges, with bridge IDs 2, 5, 9, 13 for boxes A. . . D, respectively. Which ports will be switched off, and why?

Bridge A has lowest ID, so it will become the root. Bridge C will have one port switched off, because each of the LANs connected to it has a shorter path to A, namely via D and B.

I also accepted answers saying that *both* ports of bridge C are switched of, since that's the impression one could get from how the protocol is described in the study material. However, in reality bridge C still has to keep using on one of its ports. Otherwise, if there would be an extra (fifth) LAN connected to (only) bridge C, it would be unreachable from the rest of the network.

Next, assume that the boxes are routers, and the computers on each of the LANs are assigned IPv4 addresses from the ranges indicated.

2 pt (c) How many forwarding table entries does each router have, if the forwarding is such that each LAN is reached via the smallest number of hops?

4, namely one for each LAN's IP range.
Note that the IP ranges and the topology of the network are such that no route aggregation (e.g., combining two /24s into a /23) is possible, without violating the given requirement that the smallest number of hops be used.

2 pt (d) How many entries does each of the *computers* have in its ARP table? Explain.

11, namely 1 for each of the other 9 computers on its LAN, and 2 for each router connected to its LAN.

2 pt (e) Suppose we would connect this network, consisting of four ethernets and four routers, to the world-wide Internet, keeping the address ranges assigned as in the figure. Preferably, only a single entry would be needed for all of this in the Internet forwarding tables. Give a /16 address block which covers this entire network. Is a longer prefix possible?

1.2.0.0/16. This covers everything starting with 1.2.x.x, so clearly includes all 4 ethernets. We can't make it /17 (or longer) because the most significant bit of the third byte is 0 on one subnet (1.2.0.0/18) and 1 on the other subnets.

Finally, assume the routers A—D apply the Dijkstra algorithm to find the cheapest path to each other.[1] The link costs are all 1, except for the link between A and D which has a cost of 5.

4 pt (f) Show how the Dijkstra algorithm works for node A, by giving a table in which tentative and confirmed paths are listed for each step of the algorithm.

step	confirmed	tentative
1	(A,0,–)	(B,1,B), (D,5,D)
2	(A,0,–), (B,1,B)	(C,2,B), (D,5,D)
3	(A,0,–), (B,1,B), (C,2,B)	(D,3,B)
4	(A,0,–), (B,1,B), (C,2,B), (D,3,B)	

End of this exam.

[1] In reality, the routers wouldn't be so much interested in finding paths to each other, but to the IP (sub)networks. We'll ignore that detail here.