Computer Communication
Exam: EDA344, DIT423, LEU062; Re-exam EDA343

Time and Place: Wednesday 16/3, 2022, 14.00-18.00

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Grading:
CTH - EDA344, EDA343, LEU062: 30-40, 41-50, 51-60 → 3, 4, 5
GU - DIT423: 30-45, 46-60 → G, VG

Allowed material:

- English-X (X can be French, German, Swedish, etc) dictionary
- *No other books, no notes, no calculators, no electronic devices.*

Instructions

- **Write clearly your course-code (EDA344/DIT423/LEU062/EDA344)**
- **Start answering each assignment on a new page; use only one side of each sheet of paper; please sort the sheets according to the question-ordering and number them.**
- Write in a **clear manner** and **motivate** (explain, justify) your answers. If it is not clear what is written for some answer, it will be considered wrong. If some answer is not explained/justified, it will get **significantly** lower marking.
- If you make any **assumptions** in answering any item, do not forget to clearly state what you assume.
- A good rule-of-thumb for the extent of detail to provide, is to include enough information/explanation so that a person, whose knowledge on computer communication is at the level of our introductory lecture, can understand.
- Please answer in English, if possible. If you have large difficulty with that (with all or some of the questions) and you think that your grade might be affected, feel-free to write in Swedish.
- Inspection of exam: date and time will be announced on the front page of the course in the canvas system

Good Luck !!! Lycka till !!!!

1. Computer networks (5p)

   Consider the following outcome to the execution of the `traceroute` program (working analogously to the `tracert` program):

```
traceroute to www.uva.nl (145.18.12.42), 30 hops max, 60 byte packets
 1  cth29a-gw.chalmers.se (129.16.29.1)  0.292 ms  0.283 ms  0.278 ms
 2  core1-hall-gw.chalmers.se (129.16.2.113)  0.369 ms  0.400 ms  0.461 ms
 3  cth-r1.sunet.se (130.242.6.8)  0.438 ms  0.427 ms  0.412 ms
 4  goteborg-gbg7-r1.sunet.se (130.242.4.172)  0.501 ms  0.509 ms  0.516 ms
 5  halmstad-hsd1-r1.sunet.se (130.242.4.49)  2.287 ms  2.259 ms  2.238 ms
 6  lund-lnd88-r1.sunet.se (130.242.4.73)  4.179 ms  4.103 ms  4.085 ms
 7  dk-esbj.nordu.net (109.105.97.3)  10.505 ms  10.513 ms  10.497 ms
 8  dk-bal2.nordu.net (109.105.102.2)  18.216 ms  16.856 ms  16.881 ms
 9  uk-hex.nordu.net (109.105.97.127)  23.946  ms  24.299 ms 26.197  ms
10  asd001a.surf.net (145.145.24.118) 27.127 ms asd001b.surf.net
(145.145.24.114) 27.121 ms asd001c.surf.net (145.145.24.224) 25.495 ms
11  uva-router.customer.surf.net (145.145.19.230)  28.660 ms 30.490 ms  30.482 ms
12  145.18.12.42 (145.18.12.42)  31.857 ms *  31.858 ms
```

   (a) (1p) What is the IP address of `www.uva.nl`?

   (b) (2p) Explain the different fields of line 1.

   (c) (2p) Explain the different fields of line 10.

   Hints:

   (a) 145.18.12.42

   (b) 1 cth29a-gw.chalmers.se (129.16.29.1) 0.292 ms 0.283 ms 0.278 ms means the first-hop router is cth29a-gw.chalmers.se and round-trip latency on the link is 0.278-0.292 ms

   (c) for line 10, 3 different routers were found, that means that the route towards www.uva.nl changed each time using a different router. All routers have similar IPs and latency measurements 25-27ms.

2. Application layer (7p)

   Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; this incurs an RTT of D_1 per DNS. Further suppose that the Web page associated with the link contains m very small objects (on same domain). Let RTT D_2 denote the RTT between the local host and the server for each object. Assuming negligible transmission time of each object, explain, using time-space diagrams, how you can estimate how much time elapses from when the client clicks on the link until the client receives all the objects. Consider the following 3 cases:

   (a) (2p) Persistent HTTP.

   (b) (2p) Nonpersistent HTTP with no parallel TCP connections.

   (c) (3p) Nonpersistent HTTP with the browser configured for m parallel connections.

   Hints:
   the first summation factor is the dns latency, the rest is what differs in each option: (a) $n * D_1 + (m + 2) * D_2$ one connection set-up, all downloads sequential;
   (b) $n * D_1 + (m + 1) * 2 * D_2$ all connection set-ups and downloads sequential;
   (c) $n * D_1 + 2 * D_2 + 2 * D_2$ m downloads are parallel; .

3. Transport layer, reliable data transfer and congestion control (12p)

(a) (2p) Is it possible to have reliable data transfer over UDP? How or why not?

(b) (2p) In reliable data transfer, show why we need sequence numbers when the sender may retransmit due to timeouts.

(c) (4p) Consider TCP's fast retransmit behavior.

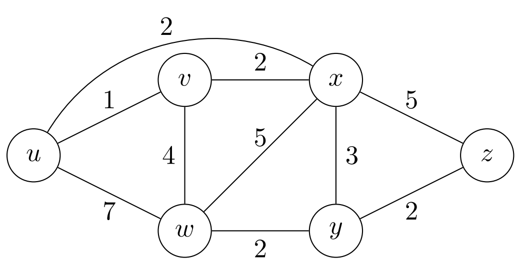
  i. Why does TCP do fast retransmit upon a 3rd acknowledgment and not a 2nd?

  ii. Why might TCP reduce its sending rate upon a 3rd acknowledgment and what is the mechanism through which such a reduction is implemented?

(d) (4p) Consider a pipelined protocol for reliable data transfer between two hosts that are far apart (for simplicity we assume that they are directly connected with each other using a long cable). Show how to compute the sending window size in order to have channel utilization greater than 80%, supposing that the packet size is 1000 bytes (including data and all headers), that transmission rate is 10000 bits/sec, the one-way propagation delay is 0.6 sec and that we neglect the size of acknowledgments (as if they were 0 bytes long). Make sure to also use a time-space diagram to explain your answer.

Hints:
a - Applications can provide that; discuss also UDP + QUIC
b - e.g. show scenario where, without the numbers, the same packet can be delivered twice to the receiving application, if it is re-transmitted
c - Duplicate ack can be due to datagram routing and out-of order arrival of consecutive segments; 3 acks indicate loss, hence TCP retransmits + assumes that the loss is due to congestion in the network; hence also reduces rate i.e. the sender's congestion window is adjusted, following the AIMD rule.
d - similar ex. done in exercise session: transmission time A for 1 packet is A = 1000 * 8 / 10000 = 8000/10000 = 0.8 sec. channel utilization U = (WindowSize * A) / (A + RTT) (= 0.8); solving for WindowSize we get 2 packets

4. Routing (12p) Consider the following network topology and assignment of IP addresses:



Router	IP address
u	129.16.22.10
v	129.16.22.64
w	129.16.22.65
x	129.16.22.40
y	129.16.22.42
z	129.16.22.44

As in the figure, the routers (or nodes) are connected to each other by links whose cost is indicated beside. Also, consider the following as reminder:

Decimal	Binary
10	00001010
40	00101000
42	00101010
44	00101100
64	01000000
65	01000001

(a) (4p) Consider the above is part of a subnet. What is the smallest Classless Inter-Domain Routing (CIDR) address block (in number of IP addresses) for this subnet? How many addresses does the CIDR block contain?

(b) (4p) Execute Dijkstra's algorithm on the above, to find the shortest path (with minimal cost) from node u to all other nodes. Show the execution of the algorithm step by step, indicating the updates at each step. Provide the routing table from u based on these results.

(c) (4p) Summarize the calculated routing table by aggregating addresses with a common prefix (longest prefix matching). Entries may be given in binary or in CIDR notation.

Hints:

(a) Smallest CIDR block is 129.16.22.0/25 that contains 128 addresses

(b) Execution of Dijkstra (" = "did not change"):

Processed Node	D(v) — p(v)	D(w) — p(w)	D(x) — p(x)	D(y) — p(y)	D(z) — p(z)
u	1 — u	7 — u	2 — x	∞ — None	∞ — None
v	"	5 — v	"	"	"
x	"	"	"	5 — x	7 — x
w	"	"	"	5 — x	"
y	"	"	"	"	"
z	"	"	"	"	"

Which gives the following routing table:

Destination	Next-hop
u	u (localhost)
v	v
w	v
x	x
y	x
z	x

(c) Summarized routing table:

Destination	Next-hop
129.16.22.10/32	u (localhost)
129.16.22.64/26	v
129.16.22.0/25	x

5. Network core and Software-Defined Networking (SDN) (12p)

(a) (3p) What is an Autonomous System (AS)? Mention two commonly used intra-AS routing protocols in Internet and the routing methods they use.

(b) (3p) What is the purpose of Internet Control Message Protocol (ICMP)? Give 2 network programs that rely on ICMP to function.

(c) (6p) Describe what is packet forwarding, what is destination-based forwarding and what is generalized forwarding. What is a classic-Internet destination-based forwarding table and what is a flow table? Provide examples of such tables and show an example of something that is possible to do with the generalized forwarding but not with destination-based forwarding.

Hints:
a - NW admin domain; OSFP link-state, RIP distance vector
b - ctrl messages between routers; ping, traceroute
c - moving the packet to the proper output link inside a router; classic: decision based on the packet destination IP; flow table: decision based on multiple fields (source, destination IP/MAC addresses, etc); can balance traffic, filter, apply firewall rules (slides 37, 40 lecture 12)

6. Data link layer, wireless and mobility (12p)

(a) (2p) Suppose that error detection is handled in some link layer by adding some cyclic redundancy check bits R to a datagram D. An error is detected on reception while no errors occurred within the transmitted bits corresponding to the D datagram. Is this situation possible, and why?

(b) (6p) What are the approaches taken to handle (i) bit errors and (ii) medium sharing in Ethernet and Wifi (802.11) link layers? Compare and justify briefly the choices made in each case.

(c) (4p) Give a short description of the way mobility is handled by direct and indirect routing. Compare the pros and cons of the two approaches.

Hints:
a -the error is in R
b - bit errors: in Ethernet, few errors so only CRC; in Wifi, higher bit error rates, so CRC + retransmission
- MAC protocol: in Ethernet, CSMA/CD (sensing+collision detection); in Wifi, CSMA/CA (sensing+collision avoidance) as CD is not feasible in Wireless environments (expensive, hidden terminal, fading)
c - description: see section 7.5 in the book; indirect routing better handles mobility but causes "triangle routing problem"; direct routing solves triangle routing but needs extra mechanism to handle mobility.