Computer Communication
EDA344, DIT423

Time and Place: Wednesday 20 March, 2019, 14.00-18.00 SB

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Allowed material:

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

Grading:
CTH (EDA344): 3: 30-40 p, 4: 41-50 p, 5: 51-60 p
GU (DIT 423): Godkänd 30-45, Väl godkänd 46-60 p

Instructions

- **Write clearly your course-code (EDA344/DIT423)**
- **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. Overview (12 p)

   (a) (3 p) Explain the term data encapsulation in layered communication. Provide an example.

   Hint: The sender puts the data (payload) for the horizontal, logical communication between peer protocols, in an "envelope" with appropriate header. The receiver opens the envelope and finds the payload. Example in lecture 1 slides, p. 26

   (b) (2 p) How does an end-host know the IP addresses of its first-hop router and its local DNS server?

   Hint: DHCP

   (c) (7 p) Consider an end-host connecting to a LAN and placing a request to get its favourite song "Boulevard of Broken Dreams", through a streaming provider application at www.BestSongs.com that relies on www.AlmostBestCDN.com for content distribution. List the network protocols that are involved and their role in making this scenario happen. Support you list with a figure that shows the main nodes (host(s), router(s), server(s)) and the steps associated with the protocols' use.

   Hint: DHCP using UDP to et IP address, ARP to get MAC address of 1st hop server, DNS using UDP and OSFP/BGP to request IP address of www.BestSongs.com, HTTP to get film's URL, DNS to resolve address for film's URL that directs it to www.BestCDN.com/somepath, DNS to get the IP adddress for the latter xx.yy.zz.ww, HTTP and DASH to request the appropriately encoded stored film at the appropriate location. Diagrams/figure examples in lectures 11, 15

2. Performance and Security (12 p)

   (a) (4 p) Consider a pipelined protocol, between 2 hosts, A and B, connected with a channel whose transmission rate (R) is 1 Gbps and Round Trip Time (RTT) 30 msec, while the packet-size (L) is 1500 bytes, including both header fields and data. How big should the window size have to be for the channel utilization to be greater than 98 percent?

   Hint: Exercise session 2, problem 15

   (b) (4 p) Usage of small packets for Voice-over-IP (VoIP) applications: One drawback of a small packet size is that a large fraction of bandwidth is consumed by overhead bytes. Suppose that the packet consists of L bytes of data. Consider sending a digitally encoded voice source directly. Suppose the source is encoded at a constant rate of 128 kbps. Assume each packet is entirely filled before the source sends the packet into the network. The time required to fill a packet is the packetization delay. (i) In terms of L, determine the packetization delay in milliseconds. (ii) Determine the packetization delay for L = 1500 bytes (Ethernet packet) and L = 50 bytes (ATM packet). Considering that packetization delays greater than 20 msec can cause a noticeable and unpleasant echo, what can you observe?

   Hint: Exercises Link layer, first part of problem 27

   (c) (4 p) In the BitTorernt p2p file distribution protocol, the seed breaks the file F that is distributed into blocks and the peers redistribute the blocks to each-other. Without any protection, an attacker can easily send bogus blocks to a small subset of peers, who could spread them further. Thus it is critical to verify the integrity of a block. Assume that when a peer joins a torrent, it initially gets a `.torrent` file associated with the file F, from a fully trusted source. Describe a scheme that allows peers to verify the integrity of blocks.

   Hint: Integrity can be verified with eg hash-based signatures. Exercises security, problem 13

3. Internet Transport Layer Protocols (12 p)

   (a) (4 p) Describe TCP's acknowledgement policy.

   Hint: Ack-numbers index bytes, ack next expected in-order byte; cumulative ack; delay ack's for optimization purposes; slides 9-12 lecture 5.

   (b) (4 p) Suppose that two TCP segments sent by a host A arrive in order at the receiver, host B. The first acknowledgment is lost and the second acknowledgment arrives after the first timeout interval. Draw a timing diagram, showing these segments and all other segments and acknowledgments sent. (Assume there is no additional loss.) For each segment in your figure, provide the sequence number and the number of bytes of data; for each acknowledgment that you add, provide the acknowledgment number.

   Hint: Exercise session about TCP, problem 27

   (c) (4 p) Suppose a hypothetical day when all the network applications on the Internet are streaming applications and run using UDP. (i) Explain and motivate a risk associated with such a scenario. (ii) What could be done to prevent this?

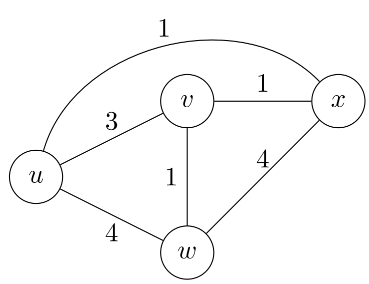
   Hint: (i) Extreme congestion, nobody would care for congestion if TCP is not there. (ii) Enforce a protocol providing TCP-friendly functionality, like QUIC, together with UDP at the application level. Cf slide 42 lecture 11

4. Network Layer (12 p)

   (a) (4 p) What can Software-Defined Networking do that is not possible with the standard, destination-based routing and forwarding in the classic Internet routing? How is the new functionality enabled?

   Hint: Forwarding-decisions can be based on more info than only the destination. In SDN this is configurable; the control plane calculates the configurable forwarding tables and defines the rules for using them at the data plane.

   (b) (8p)



Router	IP address
u	129.16.22.0
v	129.16.22.64
w	129.16.22.42
x	129.16.22.48

   (i) Using the distance vector algorithm, compute the routing table of all nodes in the above network. Write the distance vector of each node obtained after each iteration of the algorithm till it stabilizes. (ii) Simplify the forwarding tables, if possible, by using the longest prefix rule.

   Hint: straightforward application of the algo, lecture 6 and the prefix-based policy, see eg lecture 6, slide 36;

```
nodes = [u,v,w,x]
Iteration 1:
DV(u) = [0,3,4,1]
DV(v) = [3,0,1,1]
DV(w) = [4,1,0,4]
DV(x) = [1,1,4,0]
Iteration 2:
DV(u) = [0,2,4,1]
```

```
DV(v) = [2,0,1,1]
DV(w) = [4,1,0,2]
DV(x) = [1,1,2,0]
Iteration 3:
DV(u) = [0,2,3,1]
DV(v) = [2,0,1,1]
DV(w) = [3,1,0,2]
DV(x) = [1,1,2,0]
Iteration 4 same as Iteration 3, end of algorithm.
Routing tables
u: (u->u,) v->x, w->x, x->x;
simpl: (129.16.22.0/32 -> u;) 129.16.22.0/25 -> x
v: u->x, (v->v,) w->w, x->x;
simpl: (129.16.22.64/32 -> v;) 129.16.22.40/29 -> w, 129.16.22.0/24 -> x
w: u->v, v->v, (w->w,) x->v;
simpl: (129.16.22.42/32 -> w;) 129.16.22.0/25 -> v
x: u->u, v->v, w->v, (x-x);
simpl: (129.16.22.48/32 -> x;) 129.16.22.0/25 -> v, 129.16.22.0/27 -> u
```

5. Error Detection/Correction and Medium Access (12 p)

   (a) (4p) To what family of MAC protocols CDMA belongs to? Mention one other MAC protocol belonging to this group. What are the advantages and disadvantages of this group? **Hint: CDMA belongs to the "channel partitioning" family as TDMA (Tine-Division Multiple Access); Advantages: simple & fair when n senders (n=number of codes in CDMA and number of slots in TDMA); Disadvantages:poor when only one sender & needs synchronization.**

   (b) (8 p) Let's consider an error detection scheme that adds a single parity bit for error detection after every seven bits; the error bit is set to one when the number of ones in the message is odd.
   (i) Is an error detected for bytes 00101010 and 10111011?
   (ii) To improve the error detection, we add a two dimensional parity bit check by transmitting a column-wise parity bit for the 8 *columns* after every 7 bytes (as described in the course, the last bit is then the parity bit of the 7 previous error bits). Is an error detected in the following situations and can it be corrected?

(A)

1	0	0	0	1	1	0	1
0	0	0	0	1	0	1	0
1	1	1	0	1	0	0	0
0	0	1	0	1	0	1	1
1	1	1	0	0	1	1	1
1	0	1	0	1	0	0	0
1	0	0	0	0	0	0	1
1	0	0	0	1	0	1	0

(B)

1	0	0	0	1	1	0	1
0	0	0	0	1	0	1	0
1	1	1	0	1	0	0	0
0	0	0	0	1	0	1	1
1	1	1	0	0	1	1	1
1	0	1	0	1	0	0	0
1	0	0	0	0	0	0	1
1	0	0	0	1	0	1	0

(C)

1	0	0	0	1	1	0	0
0	0	0	0	1	0	1	0
1	1	1	0	1	0	0	0
0	0	1	0	1	0	1	1
1	1	1	0	0	1	1	1
1	0	1	0	1	0	0	0
1	0	0	0	0	0	0	1
1	0	0	0	1	0	1	0

(D)

1	0	0	0	1	1	0	1
0	0	0	0	1	0	1	0
1	1	1	0	1	0	0	0
0	0	1	0	1	0	1	0
1	1	1	0	0	1	1	1
1	0	1	0	1	0	0	0
1	0	0	0	0	0	0	1
1	0	1	0	1	0	1	0

   (iii) The two dimensional parity bit scheme has the property that "any single error in the message can be corrected" and "any two errors in the message can be detected". Explain briefly how those properties are obtained by considering the different possibilities for the location of errors.

Hint: (i) 00101010, 3 ones = error bit should be 1, error detected; 10111011, 5 ones, error bit set to 1, OK no errors detected.

(ii) (A) Undetermined (cannot be corrected); line 6 fail. 2 errors must have occurred: either on line 6 and 8 parity bits (so no error in the message) or in one column of line 6 and its associated parity bit (error in the message detected).

(B) Error detected (cannot be corrected); lines 4 and 6, and column 3 fail.

(C) No error detected; lines 1 and 6 and 8 fail. It is more likely that 3 parity bits are incorrect that 4 errors appeared (2 in the data and 2 in the column parity bits).

(D) Error detected (cannot be corrected); lines 4, 6, 8, and column 3 fail.

(iii) -a single error can be in: (1) in the data part: can be corrected. (2) in the error bits: no need for correction (no error detected).

-two errors can be in: (1) both in the data part: errors are detected but we cannot correct. (2) one in data and one in error bits: an error is detected but we cannot correct it as well. (3) both in error bits: if one is in column vector and one in row vector we have a false positive error, if both in row or column, no error is detected.