Computer Networks

23rd of December 2016

Full name and student number:

- This exam consists of 6 questions with subquestions. Every subquestion counts for 10 points.
- Mark every page with name and student number.
- Use of books, additional course material, and calculator is prohibited.
- Do not use pencil or red ink. Give your answers on the exam paper (if needed, you may request additional paper.)
- Answers on the exam sheets. **Please submit everything, including scrap paper. It may help in case of disputes about grades.**

1. **Multiple choice**

   Please answer the following questions. For each question, mark the correct answer. There is exactly one correct answer per question. Each question is worth 10 points. *If needed, you are allowed to add one line of explanation to each answer – but no more.*

   (a) Kilgore Trout sends a request to a server for 1 HTML web page that contains links to 4 images, one of which is stored on a remote server. The browser uses persistent connections and the cache is empty. Kilgore's browser:

   (i) sets up 5 TCP connections over which it sends 5 http requests and receives 5 http responses in total

   (ii) sets up 5 TCP connections over which it sends 1 http request and receives 5 http responses

   (iii) sets up 2 TCP connections over which it sends 5 http requests in total and receives 5 http responses in total

   (iv) sets up 2 TCP connections over which it sends 1 http request each and receives 5 http responses in total.

   (v) sets up 1 TCP connection over which it sends 5 http requests and receives 5 http responses in total.

   (vi) sets up 1 TCP connection over which it sends 1 http request and receives 5 http responses

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   (b) Reference models

   (i) The session layer is only available in the ISO/OSI reference model and is responsible for things like synchronization, compression, and encryption of the session.

   (ii) The session layer is not available in the TCP/IP model that we discussed in Kurose/Ross (and encounter in the actual Internet). Its functionality in the TCP/IP world is found in the transport layer.

   (iii) The session layer is not available in the TCP/IP model that we discussed in Kurose/Ross (and encounter in the actual Internet). Its functionality in the TCP/IP world is found in the application layer.

   (iv) If an application wants reliable transport, it *has* to use TCP instead of UDP. It is not *possible* for the application to implement reliable transport via UDP if the underlying IP network is not reliable.

(c) Packet switching

(i) Compared to packet switching, circuit switching is better if the data is "bursty"

(ii) In a store-and-forward network with 3 hops with link speeds 1 Gbps, 2 Gps, and 100 Mbps, respectively, the total delay for a 100 Mb (100 megabit) packet will at least 1.15 seconds

(iii) A sender sends data at 100 Mbps to a router which transmits the data over another port at 1 Gbps. The sender's traffic will therefore never experience queueing delay.

(iv) The bottleneck is the link with the largest delay

(d) Two hosts simultaneously send data through a link of capacity 1 Mbps. Host A generates data with a rate of 1 Mbps and uses TCP. Host B uses UDP and transmits a 100 bytes packet every 1 ms. Which host will obtain higher throughput?

(i) Host A.

(ii) Host B.

(iii) They obtain roughly the same throughput.

(iv) They experience congestion collapse and negligible throughput.

(e) Link layer

(i) The "End-to-End Principle" applies mainly to layers higher than the link layer

(ii) While rare, modern Ethernet still experiences collisions. For this reason, collision detection is crucial.

(iii) By means of backward learning, switches automatically build a spanning tree.

(iv) When the application uses TCP for reliable data transfer anyway, error detection at the link layer is redundant and just a waste of resources.

(f) Defining efficiency in terms of resource utilisation, CDMA (Code Division Multiple Access) with a chipping sequence length of 16

(i) will be less efficient than FDMA with 16 frequency bands if the number of senders is less than 16

(ii) will be as efficient as FDMA with 16 frequency bands but not as efficient as TDMA with 16 slots

(iii) will be about as efficient as FDMA and TDMA

(g) Manchester encoding is principally designed to:

(i) ensure that a transition occurs in the centre of each bit period.

(ii) have more than one symbol per bit period.

(iii) increase the bandwidth of a signal transmitted on the medium.

(iv) ensure that the line remains unbalanced.

(h) Delay.

  (i) The propagation delay is the time needed to transmit the data from the queue onto the wire
  (ii) A program like `traceroute` allows you to estimate the RTT to each hop along the route to the destination. The one-way latency is always the RTT divided by 2.
  (iii) Queueing delay in routers is mostly due to head-of-line blocking.
  (iv) Latency and bandwidth are separate properties, but they are related. For instance, a high latency may affect the bandwidth you are able to attain in TCP.

(i) Transport layer

  (i) In principle (implementation limits notwithstanding), a single host could sustain over 2^{50} simultaneous TCP connections.
  (ii) GBN (Go-back-N) is less efficient than Selective Repeat and always transmits more ACKs, regardless of the packet loss rate.
  (iii) In selective repeat, the minimum number of sequence numbers we need is: $size\_of\_receiver\_window - 1$
  (iv) The TCP notion of "delayed ack" means that the ack arrives too late to still be of value.

(j) Wifi and mobile.

  (i) Mobile IP employs direct routing to connect to a mobile users.
  (ii) WIMAX uses TDM where every subscriber gets a slot in every round. If the slot is not used, it goes to waste.
  (iii) In cellular networks, the anchor MSC is the first MSC visited during the call
  (iv) Indirect routing requires the home agent to perform network address translation to send an IP packet received from a correspondent to the mobile device.

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2. **Link layer**

  (a) Calculate the CRC bits for the data word `101101010011` with generator `11011`: ____________
  (b) You receive the following code word that is protected using Hamming code with even parity: `011100101110`. Indicate if there was an error, and if so which bit flipped. If you cannot tell, say so explicitly. Assume at most 1 bit flipped.
    (i) There was an error (Y / N / Cannot tell): ____________
    (ii) If yes, the bit that flipped was bit # ____________
  (c) Kilgore says: "All this talk of address shortages, with 6 bytes per addresses we have plenty of address space—in the link layer! Moreover, switches are awesome as they are plug-and-play and self-learning, so we do not need routing algorithms anymore. We could (in principle) just replace all routers with switches. We just plug them all in and they would work. ARP would find mappings of IP addresses to MAC addresses. Everything will work swimmingly." Explain in 1 line why old Kilgore is wrong, focusing on security or scalability.
  Scalability: ____________
  Security: ____________

3. **Network layer**

  (a) A router contains the following forwarding table:

Address range	**Interface**
11001010 00010100 00010*** *********	0
11001010 00010100 0001100* *********	1
11001010 00010100 00011*** *********	3
otherwise	2

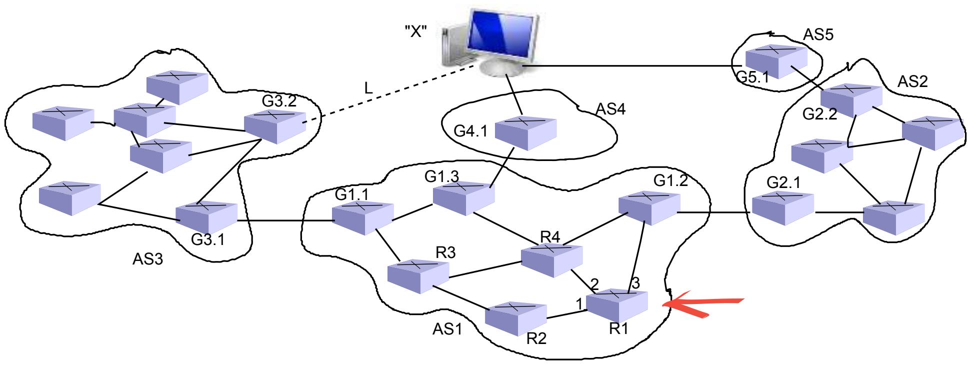

Figure 1: Inter-AS routing

The router receives IP packets with the following destinations: `204.20.16,223`, `202.20.24.24`, `202.20.25.24`, respectively. On which port will be they be transmitted?

Packet 1: ____________, Packet 2: ____________, Packet 3: ____________.

(b) A small network contains the following routers:

```
    (B)---(D)--(E)
    /\    /       \
   /  \ /          \
(A)----(F)          \
      /              \
     /                \
   (H)---(J)---(I)---(G)
```

The network uses distance vector routing (much like RIP). Initially node `(E)` is down. At time t_0, it is turned on. If the nodes exchange routing information every 30 seconds, how long wil it take before the good news has propagated completely? ________________seconds.

(c) See Fig. 1. Suppose link L (between AS3 and network X) does not exist and AS2 announces the reachability of network "X"to AS1. Answer the following subquestions.

Will the transit network AS1 advertise this information to AS3? ________________

If not, what will it do? ________________________________

If yes, what path vector will it advertise? ____________________________

(d) Suppose link L is put in place. What protocol ensures that the routers in AS3 learn about this better route to X? ________________________________

(e) Now suppose link L is in place and BGP has been running sufficiently long for all routing algorithms to have converged. Router R1 receives a datagram for "X" and AS1 uses hot potato routing. On which link (1, 2, or 3) will it transmit the packet? ________________

4. **TCP.**

"Congratulations!". That is the message Vladimir wants to send to his friend Donald after the 8th of December, over a TCP connection. Of course, the time in Moscow is 8 hours ahead of New York and the message takes a bit of time to send, so Vladimir is trying to figure out what time to send the message in order to have it arrive at 0:00h (New York) exactly. In the following subquestions, assume that:

- Vladimir sends only the bytes in the string upto and including te exclamation mark, and nothing more.
- the Ethernet bandwidth is 10 Mbps; and switching/forwarding takes no time;
- receiving a message (of any size) together with all protocol processing takes a constant 0.05 ms, while tranmission takes place at the link rate;
- no connection has been established yet and slow start starts only *after* connection establishment;

- the latency between Moscow and New York is 100 ms;
- the MSS is 1000 bytes (but a segment may contain fewer bytes than that);
- all networks are TCP/IP/Ethernet with header(+trailer) sizes of 18 bytes, 20 bytes and 20 bytes, repectively.

(a) At what time should Vladimir start the transmission for Donald to have received it at 0:00h (New York time) exactly? Be as exact as possible and give your answer in Moscow time (assuming ideal circumstances): __________

A single text message is boring and Vladimir decides to record an elaborate video greeting of 288 Gbit *of data* containing fascinating highlights of Vladimir in a helicopter, on horseback, diving for treasure, etc. Moreover, he makes sure that a TCP connection is pre-established by 0:00h (Moscow time) and then starts transmitting at the maximum rate.

(b) To his surprise, the video is nowhere near completely transmitted at 08:00h (Moscow time). He calls in the Russian Hackers and explains how he did the calculation, saying: "Look, 288 Gb of data at 10 Mbps during eight hours: it should arrive exactly on time!". What will the hackers tell him?

(1) You forgot to account for: __________

(2) And also for: __________

(c) Is it possible in TCP that the value of the threshold *grows* after a packet loss is detected? ___

5. **Application layer**

(a) Sketch (using a drawing), how iterated DNS queries work

(b) (i) What happens if we quickly after another register 2 IP addresses with long TTL for 1 symbolic name? __________

(ii) What happens if a client looks up that name? __________

(iii) What if another client also looks up that name? __________

6. **Wireless/mobile**

Can we use the following two codes ("chipping sequences") for a CDMA protocol to avoid collision between two stations? Why or why not?

- c1 = `(1;-1;-1;-1; 1; 1;-1;-1)`
- c2 = `(-1; 1;-1; 1; 1;-1; 1; 1)`