Fundamentals of Communication Networks

Prof. Alessandro Redondi

September, 23 2016

1. **Exercise (6 pts)**:

   Consider the TCP three-way handshake between two hosts A and B, where host A starts the connection. Compute the probability that the three-way handshake fails when:

   (a) The link connecting A and B is symmetric and characterized by a packet error rate (PER) of 10^{-1} in both directions

   (b) The link connecting A and B is asymmetric and characterized by a $\mathrm{PER_{AB}}$ of 10^{-1} from A to B and a $\mathrm{PER_{BA}}$ of 5×10^{-2} from B to A

   (c) The link connecting A and B is symmetric and characterized by a bit error rate (BER) of 2×10^{-5} in both directions. Assume that all frames transmitted during the three way handshake have the same size $L = 1000$ bits, and that a frame is lost if at least 1 bit is lost.

   Solution

   The three-way handshake requires to exchange a SYN packet from A to B, an ACK packet from B to A and a third SYN-ACK packet from A to B to start the connection. Let $P(E)$ be the probability of an error during the handshake.

   (a) In case the link is symmetric, we have:

   $$P(E) = 0.1 + 0.9 \cdot 0.1 + 0.9 \cdot 0.9 \cdot 0.1 = 0.271 \quad (1)$$

   or, similarly:

   $$P(E) = 1 - 0.9^3 = 0.271 \quad (2)$$

   (b) In case the link is asymmetric we have:

   $$P(E) = 0.1 + 0.9 \cdot 0.05 + 0.9 \cdot 0.95 \cdot 0.1 = 0.2305 \quad (3)$$

   or, similarly:

   $$P(E) = 1 - (0.9 \cdot 0.99 \cdot 0.9) = 0.2305 \quad (4)$$

   (c) Finally, given a BER of 2×10^{-5} on both links we have:

   $$PER = 1 - (1 - 2 \times 10^-5)^1000 = 0.0198 \quad (5)$$

   and thus,

   $$P(E) = 1 - (1 - 0.0198)^3 = 0.058 \quad (6)$$

2. **Exercise (8 pts)**

   An ISP owns the following IP address space 165.124.76.0/23 Define an addressing plan to serve the following subnetworks:

   - NET 1: 110 hosts
   - NET 2,3,4 and 5: 60 hosts
   - NET 6,7,8 and 9: 28 hosts

   For each subnet indicate network address, broadcast address, netmask and maximum number of hosts.

   Solution

   - NET1: 165.124.76.0/25, BC: 165.124.76.127, NM: 255.255.255.128, 126 hosts
   - NET2: 165.124.76.128/26, BC: 156.124.76.191 NM: 255.255.255.192, 62 hosts

- NET3: 165.124.76.192/26, BC: 165.124.76.255, NM: 255.255.255.192, 62 hosts
- NET4: 165.124.77.0/26, BC:165.124.77.63, NM: 255.255.255.192, 62 hosts
- NET5: 165.124.77.64/26, BC: 29.88.195.127, NM: 255.255.255.192, 62 hosts
- NET6: 165.124.77.128/27, BC: 165.124.77.159, NM: 255.255.255.224, 30 hosts
- NET7: 165.124.77.160/27, BC: 165.124.77.191, NM: 255.255.255.224, 30 hosts
- NET8: 165.124.77.192/27, BC: 165.124.77.223, NM: 255.255.255.224, 30 hosts
- NET9: 165.124.77.224/27, BC: 165.124.77.255, NM: 255.255.255.224, 30 hosts

3. **Exercise (8 pts)** In the network below, host A establishes a TCP connection with host B. Assuming
   - Header and ACK lengths negligible
   - Bidirectional links
   - MSS = 1000 [byte]
   - RCWND = 8000 [byte]
   - SSTHRESH = 4000 [byte]

   Compute the time needed to transfer a file of 100 kB from A to B (from TCP connection setup to reception of the last ACK packet) assuming $C_1 = 1$ Mbps, $C_2 = 10$ Mbps, $\tau_1 = 5$ ms, $\tau_2 = 3$ ms.

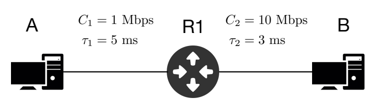

Figure 1: Network topology

Solution
We have $T_1 = 8$ ms, $T_2 = 0.8$ ms, $RTT = T_1 + T_2 + 2(\tau_1 + \tau_2) = 24.8$ ms. Setup time is:

$$T_s = 2(\tau_1 + \tau_2) = 16\text{ms}. \quad (7)$$

Transmission becomes continues for:

$$W \geq RTT/T_1 = 3 \quad (8)$$

Therefore the total transmission time for 100 MSS is:

$$T_s + 2RTT + 96T_1 + 1RTT = 858.4\text{ms} \quad (9)$$

4. **Exercise (8 pts)** A router has the following interface configuration and routing table:
Eth0: 180.12.144.254/26
Eth1: 180.12.144.25/26
Eth2: 180.12.144.180/26

Table 1: Routing Table

Network	Mask	Next Hop
180.12.144.64	255.255.255.192	180.12.144.253
180.12.144.0	255.255.254.0	180.12.144.40
180.12.145.0	255.255.255.192	180.12.144.130
180.12.145.64	255.255.255.192	180.12.144.200
0.0.0.0	0.0.0.0	180.12.144.150

Indicate how packets with the following destinations are handled by the router.
(a) 180.12.144.95
(b) 180.12.144.222
(c) 180.12.145.121

(d) 180.12.145.203

(e) 180.12.144.190

(f) 180.12.146.34

Solution

(a) Indirect forwarding to entry 1, next hop 180.12.144.253

(b) Direct forwarding to Eth0

(c) Indirect forwarding to entry 4, next hop 180.12.144.200

(d) Indirect forwarding to entry 2, next hop 180.12.144.40

(e) Direct forwarding to Eth2

(f) Indirect forwarding to default route.

5. **Questions (4 pts - each answer can be either TRUE or FALSE)**

In case the answer is FALSE, briefly explain why.

- [T] [F] In RIP, each router transmits its distance vectors to all routers in the network.
  FALSE. In a distance vector protocol the DV is sent to directly connected routers only.
- [T] [F] In an IP network, two packets with the same source and destination addresses will always take the same route.
  FALSE. The packets may take different routes due to the network conditions and routing protocol used.
- [T] [F] Flow control in TCP is performed thanks to the RCWND.
  TRUE.
- [T] [F] The codes c1 = {1,-1,-1,1} and c2 = {-1,-1,1,1} are orthogonal.
  TRUE.