Fundamentals of Communication Networks

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1. **Exercise (5 pts)**:
A host receives 300 packets (100 TCP segments and 200 UDP datagrams). The cumulative density functions (CDF) of the size of the two types of packets are reported in Figure 1.

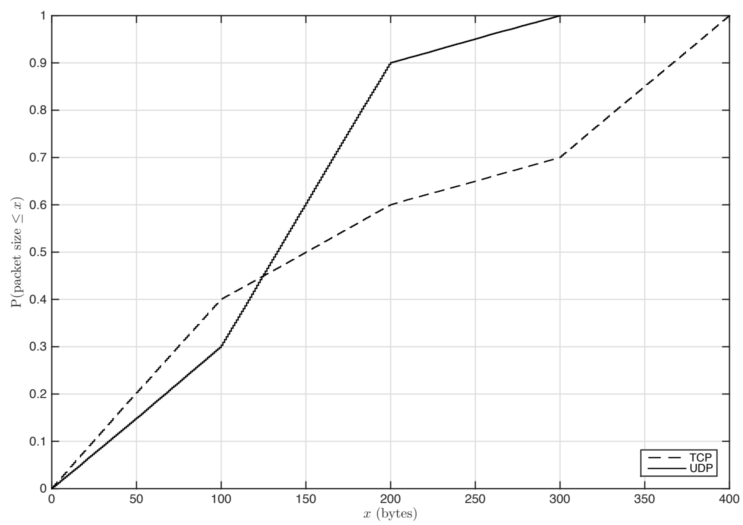

Figure 1: CDF of TCP and UDP packet sizes

(a) Compute the joint probability distribution function indicated in Table 1.

Table 1: Joint PDF

	size $\leq$ 100	100 $<$ size $\leq$ 200	200 $<$ size $\leq$ 300	300 $<$ size $\leq$ 400
TCP				
UDP				

(b) Compute the probability that a packet greater than 200 bytes is a TCP segment

Solution

(a) The probability that a packet is a UDP datagram is $P(\text{UDP}) = 2/3$ and $P(\text{TCP}) = 1/3$ for TCP segments. Since the CDF are given separately for each type of packet we can easily compute $P(\text{size} < x|\text{UDP})$ and $P(\text{size} < x|\text{TCP})$ from the figure. Recalling that $P(A|B) = P(A, B)/P(B)$ we can compute the joint probability as $P(\text{size} < x, \text{UDP}) = P(\text{size} < x|\text{UDP}) \times P(\text{UDP})$, and the same applies for TCP. Therefore we have:
$P(\text{size} \leq 100, \text{UDP}) = 2/3 \times 0.3 = 0.2$
$P(100 \leq \text{size} \leq 200, \text{UDP}) = 2/3 \times (0.9 - 0.3) = 0.4$
$P(200 \leq \text{size} \leq 300, \text{UDP}) = 2/3 \times (1 - 0.9) = 0.066$
$P(300 \leq \text{size} \leq 400, \text{UDP}) = 2/3 \times (1 - 1) = 0$

$P(\text{size} \leq 100, \text{TCP}) = 1/3 \times 0.4 = 0.133$
$P(100 \leq \text{size} \leq 200, \text{TCP}) = 1/3 \times (0.6 - 0.4) = 0.066$
$P(200 \leq \text{size} \leq 300, \text{TCP}) = 1/3 \times (0.7 - 0.6) = 0.033$
$P(300 \leq \text{size} \leq 400, \text{TCP}) = 1/3 \times (1 - 0.7) = 0.1$

(b) $P(\text{TCP}|\text{size} > 200) = P(\text{TCP}, \text{size} > 200)/P(\text{size} > 200)$. We have that $P(\text{size} > 200) = 0.066 + 0 + 0.033 + 0.1 = 0.2$ and $P(\text{TCP}, \text{size} > 200) = 0.033 + 0.1 = 0.133$. Therefore $P(\text{TCP}|\text{size} > 200) = 0.133/0.2 = 0.665$.

2. **Exercise (9 pts)**

A small enterprise purchases the IP address 15.128.224.0/20. Define an addressing plan (clearly indicating network address, network mask and broadcast address) to serve the following requirements:

- 1 subnet, 1000 host
- 3 subnets, 500 hosts each
- 4 subnets, 230 hosts each
- 1 subnets, 100 hosts

How many host addresses are available after this assignment? How many point to point links can be accommodated?

Solution 1000 hosts need 10 bits. Therefore we can use 2 more bits for the network part and create 4 subnets:
sn1: 15.128.224.0/22 - netmask: 255.255.252.0 - broadcast: 15.128.227.255
sn2: 15.128.228.0/22 - to be divided
sn3: 15.128.232.0/22 - to be divided
sn4: 15.128.236.0/22 - to be divided

500 hosts need 9 bits. We can take sn2 and sn3 and use 1 additional bit for the network part to create four new subnets.
sn5: 15.128.228.0/23 - netmask: 255.255.254.0 - broadcast: 15.128.229.255
sn6: 15.128.230.0/23 - netmask: 255.255.254.0 - broadcast: 15.128.231.255
sn7: 15.128.232.0/23 - netmask: 255.255.254.0 - broadcast: 15.128.233.255
sn8: 15.128.234.0/23 - to be divided

230 hosts need 8 bits. We can take sn4 and use 2 additional bits for the network part (in alternative one can use 1 additional bit from sn8 for 2 of the 4 subnetworks)
sn9: 15.128.236.0/24 - netmask: 255.255.255.0 - broadcast: 15.128.236.255
sn10: 15.128.237.0/24 - netmask: 255.255.255.0 - broadcast: 15.128.237.255
sn11: 15.128.238.0/24 - netmask: 255.255.255.0 - broadcast: 15.128.238.255
sn12: 15.128.239.0/24 - netmask: 255.255.255.0 - broadcast: 15.128.239.255

For the 100-hosts subnet we 7 bits for the host part. Therefore, we can use sn8 and create 4 subnetworks
sn13: 15.128.234.0/25 - netmask: 255.255.255.224 - broadcast: 15.128.234.127
sn14: 15.128.234.128/25 - to be divided
sn15: 15.128.235.0/25 - to be divided
sn16: 15.128.235.128/25 - to be divided

Therefore, 3 subnets of 128 hosts are left, for a total of 384 host addresses. Since each p2p link requires 4 host addresses (network, broadcast and the 2 endpoints), the number of p2p links that can be accomodated is 96.

3. **Exercise (6 pts)**

Hosts A and B are interconnected through a router R. The link A-R has a capacity of 1Mbps and the link R-B of 5 Mbps. The propagation delay of both links is equal to 5 ms. Host A needs to transfer a 15 kB file to host B.

(a) Compute the time needed to transfer the file from A to B using TCP (including the connection setup time). Assume MSS = 600 byte, SYN and ACK packets = 20 byte, RCVWND = 2400 byte, SSTHRESH = 3000 byte. Indicate the value of the transmission window as time goes by.

Table 2: Routing table

Network	Netmask	Next Hop
131.168.44.0	255.255.252.0	131.168.72.3
131.175.0.0	255.255.0.0	131.168.72.3
131.175.18.0	255.255.255.0	131.79.1.3
0.0.0.0	0.0.0.0	131.79.1.3

(b) Repeat the computation assuming that a simple Stop-and-Wait protocol is used in place of TCP. Assume 600 bytes packets, 20 bytes ACKs and timeout = 25 ms (ignore all headers).

Solution

(a) $RTT = 4.8 + 5 + 0.96 + 5 + 0.032 + 5 + 0.16 + 5 = 25.952$ ms
$T_{\text{setup}} = 2 \times (0.16 + 5 + 0.032 + 5) = 20.384$ ms
For continuous transmission we need $W \geq RTT/T \geq 5.4 \geq 6$ MSS. Since RCVWND is only 4 MSS, transmission is never continuous. The number of MSS to transmit is 25, therefore the total time is $T_{tot} = T_{\text{setup}} + 8RTT + T = 232.8$ ms. The value of the transmission window at each RTT is: 1 - 2 - 4 - 4 - 4 - 4 - 4 - 2.

(b) In case of stop-and-wait the total time is $25 \times RTT = 648$ ms

4. **Exercise (6 pts)**

A router has two interfaces with the following configuration:

- eth0: 131.79.1.1/23
- eth1: 131.168.72.1/21

The routing table of the router is the following:
Indicate how the packets with the following destination are handled by the router:

1. 131.79.0.12 coming from eth1
2. 131.79.1.255 coming from eth0
3. 131.168.47.12 coming from eth0
4. 131.0.0.6 coming from eth1
5. 131.175.19.12 coming from eth1

Solution

1. direct forwarding to eth0
2. packet dropped (broadcast of eth0 coming from eth0)
3. indirect forwarding to line 1
4. indirect forwarding to line 4 (default)
5. indirect forwarding to line 2

5. **Question (4 pts)**

(a) Compute the efficiency of a stop-and-wait protocol implemented over a 2Km medium characterised by a capacity of 10 Mbps and a propagation delay of 2ms/Km. Assume that packets are 1500 bit long, ACKs are negligible and the stop-and-wait timeout is 20ms.

(b) Repeat the computation assuming a go-back-n protocol with window size equal to 4.

(c) What is the optimal go-back-n window?

Solution

(a) Efficiency is the ratio between the transmission time and the RTT. Therefore we have

$$\nu = T/(T + 2\tau) = 0.15/8.15 = 1.8 \tag{1}$$

(b) In case of go-back-N 4 packets are transmitted in one RTT:

$$\nu = 4T/(T + 2\tau) = 0.15/8.15 = 7.3 \tag{2}$$

(c) The optimal window is the one that allows continuous transmission:

$$W \geq RTT/T = 55 packets. \tag{3}$$

6. **Questions (4 pts - each answer can be either TRUE or FALSE)**
   In case the answer is FALSE, briefly explain why.

   - [T] [F] The Spanning Tree Protocol is implemented through the exchange of BPDU packets.
     TRUE.
   - [T] [F] Two different VLANS connected through a switch can communicate with each other.
     FALSE. Communication among VLANs is allowed only through routers.
   - [T] [F] RIP response messages are transmitted periodically and contain distance vectors.
     TRUE.
   - [T] [F] HTTP persistent mode is less efficient than non-persistent mode. FALSE. Since only one connection is established for all the objects to be retrieved, persistent mode is generally faster.