EE122: Communication Networks **SP'10**

Midterm 2 — April 9

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SOLUTIONS

Problem 1. *(***Multiple Choice 10%***)* *(choose the correct answer(s), if any)*

- *Inter-domain routing in the internet uses a*
  - – *link state protocol;*
  - X *path vector protocol;*
  - – *distance vector protocol.*
- *A* network address translation *device enables to*
  - – *find the name of a device with a given network address;*
  - – *translate the network address of a device into the name of the device;*
  - – *translate the network address of a device into the MAC address of the device;*
  - X *reuse the same IP addresses.*
- *Goals of the* transmission control protocol *(TCP) include to*
  - – *determine which users can connect to a server;*
  - – *regulate the access to a common radio channel;*
  - X *multiplex multiple connections inside a given host;*
  - – *implement forward error coding to reduce the impact of packet losses;*
  - X *regulate the transmissions of packets to limit router congestion.*

Problem 2. *(***Best Choice 10%***) (For each statement, indicate the best choice)*

- *OFDMA-based PHY in WiMAX and LTE allows scheduled multiple access*
    1. *Only in time dimension;*
    2. *Only in frequency dimension;*
    3. *Both in time and frequency dimensions;* X
    4. *None of the above.*

- *In WiMAX, the QoS class intended for a silence-suppressed voice connection is*
    1. *UGS;*
    2. *rtPS;*
    3. *ertPS;* X
    4. *nrtPS;*
    5. *BE.*

- *A WiMAX scheduler is responsible for scheduling*
    1. *Bandwidth Request opportunities;*
    2. *Uplink data transmission grants;*
    3. *Downlink data transmission;*
    4. *Opportunities for HARQ Ack/Nack;*
    5. *All of the above.* X

- *ARP allows a host to discover*
    1. *Own DHCP based IP address;*
    2. *Destination IP address;*
    3. *MAC address of the final destination;*
    4. *MAC address of the receiver on its own LAN;* X
    5. *None of the above.*

- *When transmitting a packet externally, a NAT device uses its own IP address and a new port number that is uniquely mapped to*
    1. *Destination IP address and destination port number;*
    2. *Destination IP address and source port number;*
    3. *Source IP address and source port number;* X
    4. *Source IP address and destination port number;*
    5. *None of the above.*

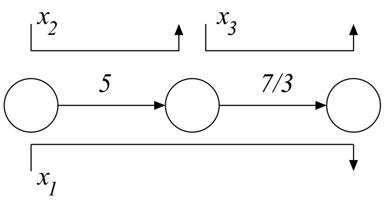
- *Receiver Advertised Window is used by TCP to enforce*
    1. *Congestion control;*
    2. *Flow control;* X
    3. *Error control;*
    4. *All of the above;*
    5. *None of the above.*

Problem 3. *(20%) Consider the network shown in the figure below. Three flows of packets with rates x_1, x_2, x_3 share two links with rates 5 and 7/3.*

a) What is the max-min rate allocation?

b) What is the max-sum rate allocation?

c) Show that the rate allocation that maximizes $\sum_{i=1}^{3} \log(x_i)$ is such that $x_1 = 1$.



a) The max-min rates are the largest rates that maximize the minimum rate. They are $(x_1, x_2, x_3) = (7/6, 23/6, 7/6)$.

b) The max-sum rates are the rates whose sum is maximized. They are $(x_1, x_2, x_3) = (0, 5, 7/3)$.

c) We have to solve the following problem:

$$\text{Maximize } \sum_{i=1}^{3} \log(x_i)$$
$$\text{subject to } x_1 + x_2 \leq 5, x_1 + x_3 \leq 7/3.$$

The solution is such that $x_2 = 5 - x_1$ and $x_3 = 7/3 - x_1$, so that the function to maximize is

$$\log(x_1) + \log(5 - x_1) + \log(7/3 - x_1).$$

Taking the derivative with respect to x_1, we see that the solution is such that

$$\frac{1}{x_1} - \frac{1}{5 - x_1} - \frac{1}{7/3 - x_1} = 0.$$

We verify that $x_1 = 1$ solves this equation since $1 - 1/4 - 3/4 = 0$.

Another approach is to consider the Lagrangian

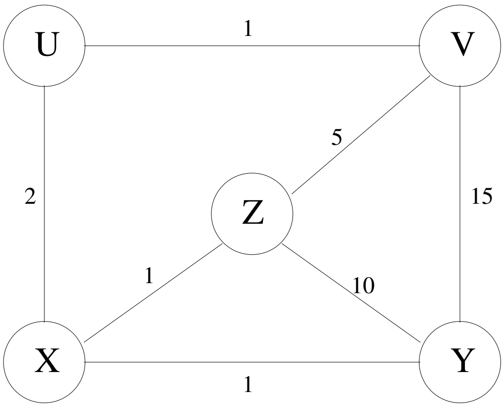
$$L(x, \lambda) = \sum_{i=1}^{3} \log(x_i) - \lambda_1(x_1 + x_2 - 5) - \lambda_2(x_1 + x_3 - 7/3).$$

The solution x maximizes L and λ minimizes L, so that

$$\frac{1}{x_1} = \lambda_1 + \lambda_2, \frac{1}{x_2} = \lambda_1, \frac{1}{x_3} = \lambda_2 \text{ and } x_1 + x_2 = 5, x_1 + x_3 = 7/3.$$

Choosing $x_1 = 1, x_2 = 4, x_3 = 4/3$ yields $\lambda_1 = 1/4, \lambda_2 = 3/4$, which satisfy these identities.

Problem 4. *(30%) Consider the network shown below, and assume that each node initially knows the costs to each of its neighbors (and for part (b), the complete network topology).*

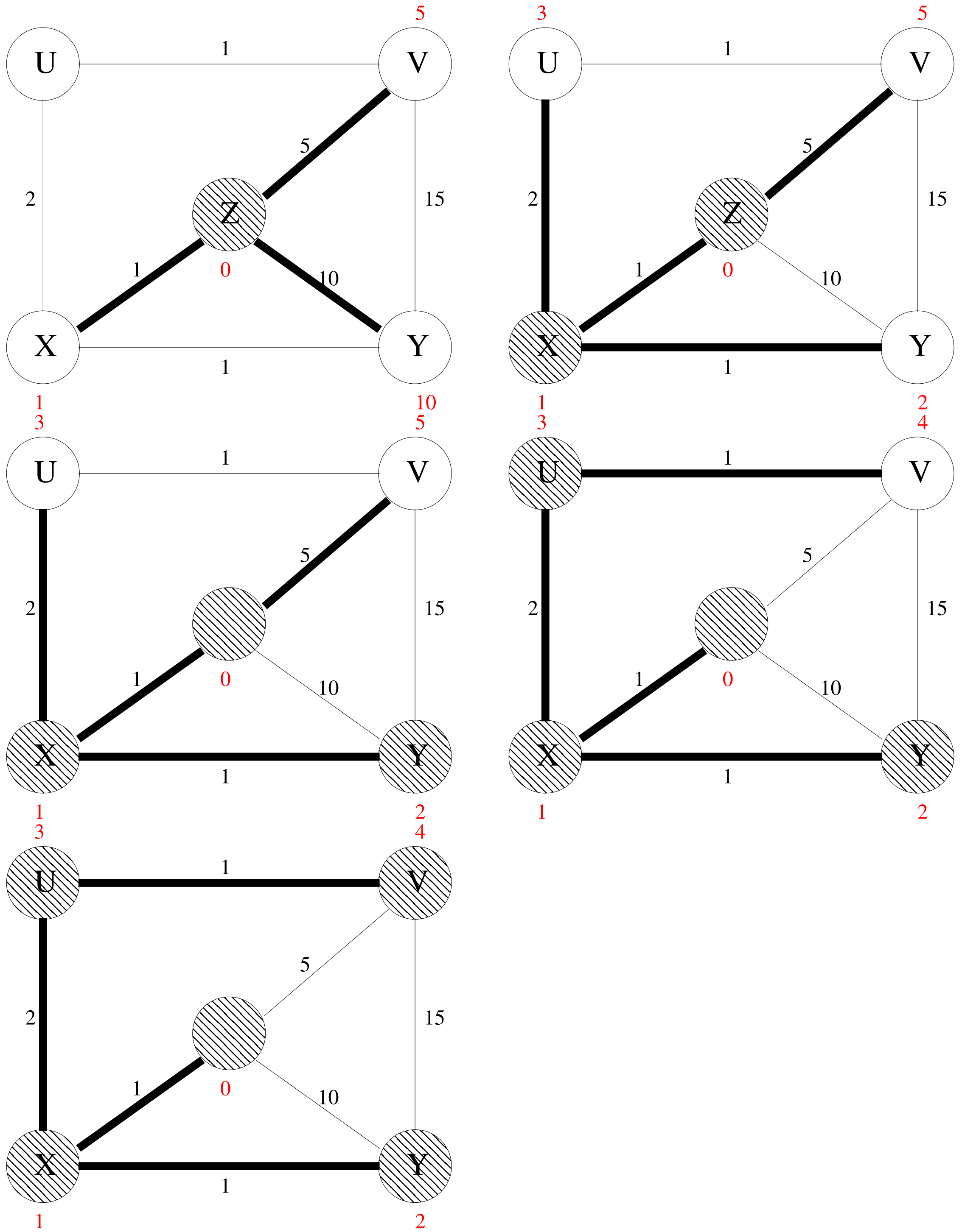


a *Consider the distance vector algorithm and fill in the distance table entries at node z below.*

The distance table in z is:

Cost To					
		u	v	x	y
Via	v	6	5	8	9
	x	3	4	1	2
	y	13	14	11	10

b *Find the shortest path from z to all other node using Dijkstra's algorithm. For each step of the algorithm, label dist(n) next to node n, where dist(n) is the distance from z to n at that instant and mark/darken the link(s) that are part of the shortest path.*



U
V
Z
X
Y
1
2
5
15
1
10
1
5
0
1
10
3
5
U
V
Z
X
Y
1
2
5
15
1
10
1
0
1
2
3
5
U
V
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5
15
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10
1
0
1
2
3
4
U
V
X
Y
1
2
5
15
1
10
1
0
1
2

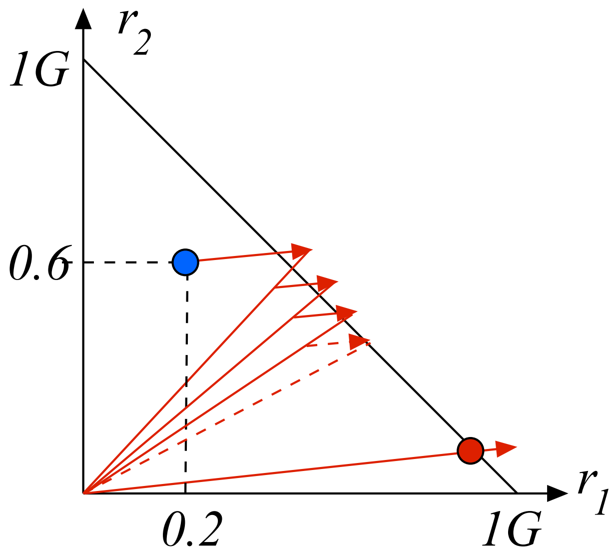
Problem 5. *Consider two connections that share a bottleneck link that has rate 1Gbps using AIMD. Connection 1 has a RTT equal to 50ms and connection 2 has a RTT equal to 200ms. AIMD works as follows. As long as the source gets ACKs, it increases its window size at the rate of 1KByte per RTT. When the source misses ACKs, it drops its window size by a factor slightly larger than 1.*

a) Assume that during 1 second, the two sources get ACKs. By how much does each source increase its window during that time?

b) During the same time, by how much does each source increase its connection rate?

c) On the diagram below, show a typical evolution of the rates $r_1(t)$ and $r_2(t)$ of the two connections, in Mbps. Assume that $r_1(0) = 0.2Gbps$ and $r_2(0) = 0.6Gbps$.

d) What are the limiting rates?



a) Source 1 increases its window by 20Kbytes = 160 Kbits and source 2 by 5Kbytes = 40 Kbits.

b) Source 1 increases r_1 by 160Kbits/50ms = 3.2Mbps and source 2 increases r_2 by 40Kbits/200ms = 0.2Mbps.

c) See Figure.

d) In the limit, the rates r_1 and r_2 are such that $r_1/r_2 = 3.2/0.2 = 16$. Indeed, eventually, the rates are along the line from the origin whose slope corresponds to the increase rates. Since $r_1 + r_2 = 1$Gbps, we see that

$$r_1 \approx \frac{16}{17}Gbps \text{ and } r_2 \approx \frac{1}{17}Gbps.$$