Computer Networks WS20/21

Exercise 5

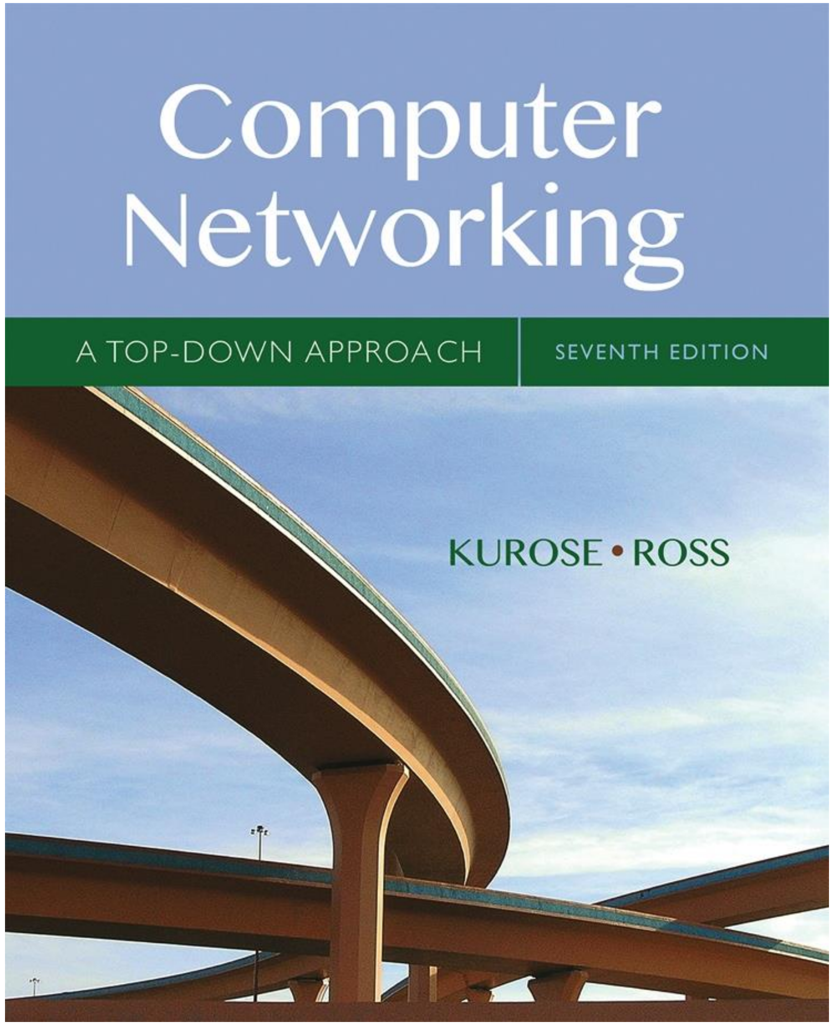
Recommendation

Try to borrow (or buy) this book:

Computer Networking: A Top Down Approach

7th edition. Jim Kurose, Keith Ross, Pearson, 2019.

It is very good to understand!



Q1

- What are the two key functions of the network layer, that each router performs? Please explain the difference between them.

Key Functionalities of a Router

- Network Layer Functions:
    - Forwarding
    - Routing
- Forwarding: move packets from router's input to an appropriate router output
- Routing: determine route taken by packets from source to destination

Q2

- Assume you have a 3,000 byte long datagram which needs to be fragmented for a 1,396 bytes MTU.

  Please fill the following table:

IP Datagram Fragmentation

- 3000 byte datagram, 1396 byte MTU.
- IPv4 header has 20 byte: datagram has 2980 byte in data field, 1376 byte of these can be send at a time (each smaller datagram also needs 20 byte header)
- The 2980 byte datagram is fragmented into two smaller datagrams of 1376 byte and one of 228 byte, each adding 20 byte as header

Datagram No.	Length	Frag. Flag	Offset = (MTU-Header data) / 8
1	1396 (= 1376+20)	1	0
2	1396 (= 1376+20)	1	172 (= 1376 / 8)
3	248 (= 228+20)	0	344 (= 2 * 1376 / 8)

Q3

- A provider has been assigned the network 128.30.0.0/23 and wants to divide it among three customers. Customer A needs to accommodate up to 220 hosts, customer B needs to accommodate up to 110 hosts and customer C needs to accommodate up to 80 hosts. Please fill the following table with the details of the subnetworks that the provider can create to fit its customers' needs.

Subnet calculations

- Subnet calculations are used to break a given network into smaller pieces
- Subnet mask:
  - A 32-bit number that masks an IP address, and divides the IP address into network address and host addresses.
- Decimal: /23
  - In binary notation, the first 23 bits are 1 (network address), the rest 0 (for host addresses)
  - Binary: 11111111.11111111.11111110.00000000
  - Dot-decimal: 255.255.224.0

Subnet calculations

- Network ID is the first IP address in the range. (hosts bits are all 0s)
- Network Broadcast is the last IP address in the range. (hosts bits are all 1s)
- Hosts range = IP addresses range – 2 (Network ID,Broadcast)

Subnet calculations

- Given network: 128.30.0.0/23
- Wanted: Three sub networks
- First step: Find new subnet mask
  - To address three sub networks we need at least two more bits for the subnet mask (2^2 = 4).
  - The new subnet mask is 23+2 = 25
  - That would leave 7 bits for the host ranges (7 bits = 126 possible hosts)
  - Customer A needs to accommodate 220 hosts => needs 8 bit for host range (8 bits = 254 possible host addresses) => subnet mask 25 is not possible for A => A gets subnet mask 24
  - For Customers B and C 7 bits are enough to accommodate all their hosts => get subnet mask 25 (remaining range of mask 24 can later be used by another customer that needs more than 126 hosts)
- Second step: Find new network addresses (see next slide) by replacing the corresponding bits in network ID
- Third step: Calculate data for new networks

Subnet calculations

Customer A:

New netmask: 24 (= 255.255.255.0)

11111111.11111111.11111111.00000000

=> New network A: 128.30.0.0/24

10000000.00011110.00000000.00000000

Customers B & C:

New netmask: 25 (= 255.255.255.128)

11111111.11111111.11111111.10000000

=> New network B: 128.30.1.0/25

10000000.00011110.00000001.00000000

=> New network C: 128.30.1.128/25

10000000.00011110.00000001.10000000

Network ID bits replacing with subnet bits to create new network IDs

Subnet calculation

A provider has been assigned the network 128.30.0.0/23 and wants to divide it among three customers. Customer A needs to accommodate up to 220 hosts, customer B needs to accommodate up to 110 hosts and customer C needs to accommodate up to 80 hosts. Please fill the following table with the details of the subnetworks that the provider can create to fit its customers' needs.

Subnet No.	Network Address	Netmask	Host Range	No. of Hosts
1 Cust. A	128.30.0.0/24	255.255.255.0	128.30.0.1 – 128.30.0.254	254
2 Cust B	128.30.1.0/25	255.255.255.128	128.30.1.1 – 128.30.1.126	126
3 Cust C	128.30.1.128/25	255.255.255.128	128.30.1.129 – 128.30.1.254	126

Q4

- What problem is tackled by Network Address Translation (NAT)? Please briefly describe what NAT does.

Network Address Translation (NAT)

- IPv4: Address shortage
- NAT: One network (of an arbitrary number of hosts) has only one IP address (NAT enabled router) that is accessible from the internet
- The remaining hosts are addressed internally
- Use port numbers to decide which host the datagram is destined to, mapping inside NAT table
- NAT is often considered a „dirty fix“ to the address shortage issue (→ IPv6)

Q5

- What are the main differences between IPv4 and IPv6?
- What are two approaches towards the transition between IPv4 and IPv6?

IPv4 vs IPv6 - Differences

- Number of bits & address space:
  - IPv4: 32 bit address (2^32 = 4.294.967.296 possible addresses)
  - IPv6: 128 bit address (2^128 = 3,40282 e+38 possible addresses)
- IPv6: Fixed header length, additional information needs to be stored in additional headers
- IPv6: No packet fragmentation supported, fragmentation is moved to the sending host
- IPv6: No header checksum, error detection on layer 4 & 2
- ...

IPv4 to IPv6 - Migration

- There is no „flag day“ on which IPv4 routers are replaced by IPv6 routers.
  - Not all routers can be upgraded simultaneously
  - A slow process of transition
  - How to achieve this transition, i.e., a mixed, concurrent operation of IPv4 and IPv6 routers?

IPv4 and IPv6 together

- Two different possibilities
  - Tunneling: IPv6 datagram is carried as payload in IPv4 datagram between IPv4 routers; IPv6 routers then decapsulate IPv6 datagram.
  - Dual Stack: Routers can do both, IPv4 and IPv6; direct connection between same protocol clients (IPv4 → IPv4, IPv6 → IPv6)

Q6

- Compare Link State routing algorithms to Distance Vector algorithms in terms of scalability and robustness.

- Scalability
  - LS uses broadcasts to disseminate complete knowledge about all links to entire network
  - DV only sends (local) information to neighboring nodes. Convergence time and DV size still increase with network size
- Robustness
  - LS: every router does its own calculations
  - DV: if DV calculated wrongly by a node, the result will be used by neighboring nodes and they further propagate the error

Q7

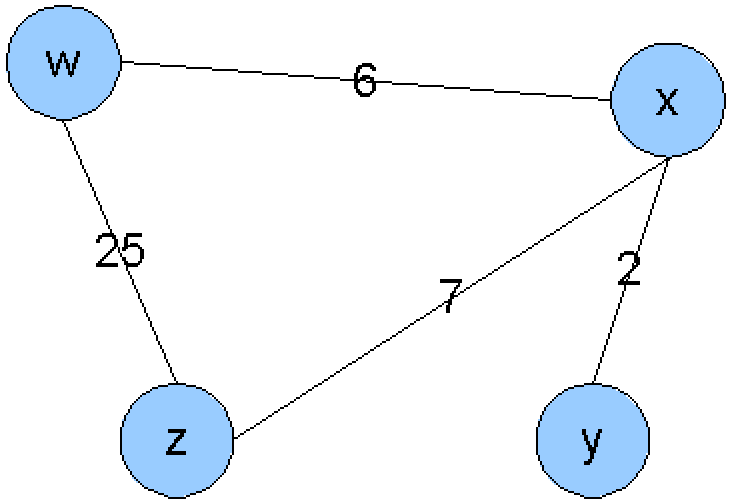
- Q: What is the difference between Intra-AS and Inter-AS routing? Why are different routing protocols needed for each? Name one example for each category. (Actually this question should have belonged to the next exercise. Sorry!)

Intra- vs. inter-AS routing

- Different policies
  - Inter-AS: control over how (foreign) traffic is routed via the own network(policy)
  - Intra-AS: control over how traffic is routed within the own network(performance)
- Scale
  - Hierarchical routing saves table size, reduced update traffic
- Performance
  - Intra-AS: can focus on performance
  - Inter-AS: policy may dominate over performance
- Examples:
  - Inter-AS: BGP
  - Intra-AS: OSPF

Q8. Distance Vector algorithm

- Given the following network, use the Distance Vector algorithm to find the least cost paths for all nodes. Fill the provided tables and indicate with arrows between the tables when a node sends a distance vector to another node.



Distance Vector algorithm

1. Each node sends its own costs to its neighboring nodes
2. When node has calculated better costs for itself to other nodes: node sends its updated own costs to its neighboring nodes

Node w

from \ cost to	w	x	y	z
w	0	6	∞	25
x	∞	∞	∞	∞
y	∞	∞	∞	∞
z	∞	∞	∞	∞

Node x

from \ cost to	w	x	y	z
w	∞	∞	∞	∞
x	6	0	2	7
y	∞	∞	∞	∞
z	∞	∞	∞	∞

Node y

from \ cost to	w	x	y	z
w	∞	∞	∞	∞
x	∞	∞	∞	∞
y	∞	2	0	∞
z	∞	∞	∞	∞

Node z

from \ cost to	w	x	y	z
w	∞	∞	∞	∞
x	∞	∞	∞	∞
y	∞	∞	∞	∞
z	25	7	∞	0

Node w

from \ cost to	w	x	y	z
w	0	6	8	13
x	6	0	2	7
y	∞	∞	∞	∞
z	25	7	∞	0

Node x

from \ cost to	w	x	y	z
w	0	6	∞	25
x	6	0	2	7
y	∞	2	0	∞
z	25	7	∞	0

Node y

from \ cost to	w	x	y	z
w	∞	∞	∞	∞
x	6	0	2	7
y	8	2	0	9
z	∞	∞	∞	∞

Node z

from \ cost to	w	x	y	z
w	0	6	∞	25
x	6	0	2	7
y	∞	∞	∞	∞
z	13	7	9	0

Node w

from \ cost to	w	x	y	z
w	0	6	8	13
x	6	0	2	7
y	∞	∞	∞	∞
z	13	7	9	0

Node x

from \ cost to	w	x	y	z
w	0	6	8	13
x	6	0	2	7
y	8	2	0	9
z	13	7	9	0

Node y

from \ cost to	w	x	y	z
w	∞	∞	∞	∞
x	6	0	2	7
y	8	2	0	9
z	∞	∞	∞	∞

Node z

from \ cost to	w	x	y	z
w	0	6	8	13
x	6	0	2	7
y	∞	∞	∞	∞
z	13	7	9	0

w -> x -> y: 6 + 2 = 8 < ∞

w -> x -> z: 6 + 7 = 13 < 25

y -> x -> w: 2 + 6 = 8 < ∞

y -> x -> z: 2 + 7 = 9 < ∞

z -> x -> w: 7 + 6 = 13 < 25

z -> x -> y: 7 + 2 = 9 < ∞