Information

- This exam is for course codes IK2215, IK2204, and 2G1701
- The duration of the exam is 4 hours (9.00-13.00).
- Answers should be well structured and readable.
- Write your name and personal-id/date-of-birth on each page.
- No help material is allowed.
- Answers will be posted on the course web within 2 weeks after the exam.
- Results will be published in Daisy no later than February 1, 2013. Graded exams can be found as PDF files in Daisy. Complaints about the grading should be done in writing, and sent to IK2215@ict.kth.se, no later than February 15, 2013.
- The exam consists of 2 parts; Part A and Part B. Part A is a set of questions with short answers. **Respect the word limits!** Answers longer than the word limit will be truncated, meaning that we will disregard from the part of your answer that exceeds the word limit during the exam marking. Part B is a smaller set of questions that require more elaborative answers. To pass the exam you need to attain a certain number of points (preliminary 75%) on Part A. Higher grades (A-C or 4-5) will be based on the total score (Part A + Part B). **Part B will not be graded for those who do not pass Part A.**
- Preliminary grading is as follows:

Points	**Grade (A-F)**
23-30 points on Part A and 45-50 points in total	A
23-30 points on Part A and 40-44 points in total	B
23-30 points on Part A and 35-39 points in total	C
23-30 points on Part A and 23-34 points in total	D
21-22 points on Part A and passed complementary assignment	E
21-22 points on Part A (complementary assignment offered)	Fx
0-20 points on Part A	F (Fail)

Points	**Grade (U-5)**
23-30 points on Part A and 42-50 points in total	5
23-30 points on Part A and 37-41 points in total	4
23-30 points on Part A and 23-36 points in total	3
21-22 points on Part A (complementary assignment offered)	U
0-20 points on Part A	U (Fail)

Good Luck!

Exam Part A (30p) (Note the word limits)

1) Various true/false statements (10p)

Mark the following statements as **true** or **false**. Don't write "t" or "f", since indistinct hand-writing makes it hard to differ between the two.
Note:

- you will get 1p for each correct answer
- you will get -1p for each wrong answer
- you will get 0p for each "no answer"
- you will **not** get less than 0p in total on this question

A. In RIP, each node calculates the shortest past based on first hand information about the network topology. (1p)
B. UDP provides an optional checksum for bit error detection. (1p)
C. BGP is path vector routing protocol. (1p)
D. TCP provides a guaranteed bit rate between sender and receiver. (1p)
E. ICMP error messages are sent back to the original source of the IP datagram that caused the error. (1p)
F. The overall purpose with the diff-serv model (Differentiated Services) is to allocate network resources for individual application flows. (1p)
G. IPv6 uses a fixed size header format and extension headers are used instead of IP options in IPv4. (1p)
H. The mapping between IP multicast addresses and Ethernet multicast addresses is not unique—in fact several IP multicast addresses can be mapped to the same Ethernet multicast address. (1p)
I. The purpose RTP (Real-time Transport Protocol) is to guarantee a low delay between sending and receiving host(s). (1p)
J. BitTorrent uses a central directory to locate files. (1p)

Answer:

A. False
B. True
C. True
D. False
E. True
F. False
G. True
H. True
I. False
J. False

2) Various questions with short answers (10p)

Answer the following questions with short answers.
Note:

- You will get 1p for each entirely correct answer
- Word limit per question: 30 words

A. Place the following four protocols at the correct layer in the TCP/IP protocol stack: IGMP, HTTP, SCTP, and ICMP. (1p)
B. The prefixes 199.1.1.0/25 and 199.1.1.128/25 are aggregated. Specify (in CIDR notation) the resulting aggregated prefix. (1p)
C. What is "sliding windows" used for in TCP? (1p)

D. What mechanism do CDNs typically use to allow users to find the most suitable server? (1p)
E. An IP multicast packet arrives to a router and the router does reverse path forwarding. What address does the router then use for lookup in the forwarding table? (1p)
F. What is the overall purpose of RSTP (Real-Time Streaming Protocol)? (1p)
G. What is DHT (Distributed Hash Table) used for in BitTorrent? (1p)
H. What is flooding used for in OSPF? (1p)
I. What is a “token bucket” in the context of IP QoS? (1p)
J. What is the difference between E-BGP and I-BGP? (1p)

Answer:

A. IGMP: Network layer, HTTP: Application layer, SCTP: Transport layer, ICMP: Network layer.
B. 199.1.1.0/24
C. Flow control.
D. DNS redirection.
E. The source address of the multicast packet.
F. To exchange playback control information (play, stop, rewind etc).
G. Peer discovery.
H. To distribute LSAs (Link State Advertisements) to all routers in the network (area).
I. A way to represent the bandwidth characteristics of a variable data rate.
J. E-BGP coordinates between BGP peers in two different autonomous systems. I-BGP coordinates between BGP peer within an autonomous system.

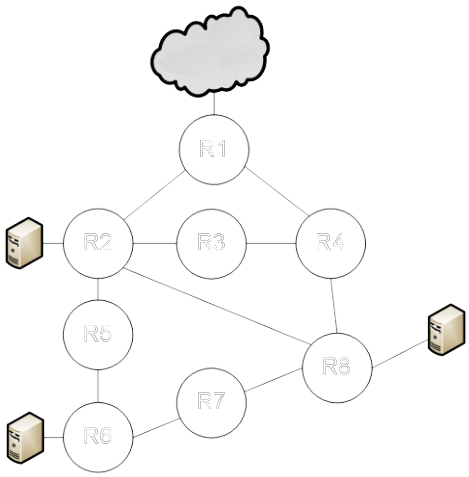
3) Transport layer (2p) (Word limit: 50)

One of the underpinning principles behind TCP congestion control is the so-called “self-clocking” principle. Briefly explain the meaning of this principle.

Answer:

The answer should include the key observation that in equilibrium, the acknowledgements return to the sender at about the rate that packets can be sent over the slowest link in the path.

4) Multicast Routing (2p) (Word limit: 50)



In the topology above, host A is multicasting a video stream to two receivers: host B and host C. Assume that the cost is 1 for each of all the links. R1 is the rendezvous point of this multicast domain. Identify the path for the 1st and 2nd multicast packets from node A to each receiver when the routers are using PIM sparse-mode and the threshold to switch to source-based tree is 0. Name the approach used in the multicast routing tree (source-based tree or group-shared tree) for each path.

Example answer:

1st packet (x-based tree)

Host A -> Rx -> Ry -> Host B
Host A -> Rx -> Ry -> Host C

2nd packet (x-based tree)

Host A -> Rx -> Ry -> Host B
Host A -> Rx -> Ry -> Host C

Answer:

1st packet: (group-shared tree)
Host A -> R2 -> R1 -> R4 -> R8 -> Host B
Host A -> R2 -> R1 -> R2 -> R5 -> R6 -> Host C
2nd packet: (source-based tree)
Host A -> R2 -> R8 -> Host B
Host A -> R2 -> R5 -> R6 -> Host C

5) Distance vector routing (2p) (Word limit: 100)

Consider a router *D* in a network where distance vector routing is used. *D* has the following routing table:

Network	Next router	Distance
N_1	*A*	2
N_2	*B*	4
N_3	*B*	5

N_4	*A*	6
N_5	*C*	4
N_7	*C*	2

D receives a routing message from router A, with the following information:

Network	Distance
N_1	3
N_2	5
N_3	1
N_4	5
N_5	4
N_6	2

Show the routing table in *D*, after *D* has processed the routing message.

Answer:

Network	Next router	Distance
N_1	*A*	4
N_2	*B*	4
N_3	*A*	2
N_4	*A*	6
N_5	*C*	4
N_6	*A*	3
N_7	*C*	2

6) Peer-to-peer networking (2p) (Word limit: 50)

In deciding what chunks to request when using BitTorrent for file distribution, a method called rarest chunks first is used. Explain two advantages with the rarest chunk first technique.

Answer:

The two main advantages are:
1) To get good replication of data in the swarm
2) Increase the chance to get chunks that others want—good for “tit-for-tat”

7) IPv6 (2p) (Word limit: 110)

In IPv6, IP fragmentation is done differently than in IPv4. Explain the changes that have been made in this regard. Your answer should cover where fragmentation can be performed, where reassembly is performed, and what support that might be needed to do fragmentation differently in IPv6 compared to IPv4.

Answer:

In IPv4, fragementation can be done both by the sender and by the routers along the path between sender and receiver (hop-by-hop

fragmentation). In In IPv6, IP fragmentation can only be done by the sending host and path MTU discovery can be used by the sender to determine the smallest MTU between sender and receiver. In both IPv4 and IPv6, reassembly is done by the receiver.

Exam Part B (20p)

8) Stateless address autoconfiguration in IPv6 (5p)

Briefly explain the process (including the messages involved) of how an IPv6 host obtains its IPv6 address using stateless address autoconfiguration.

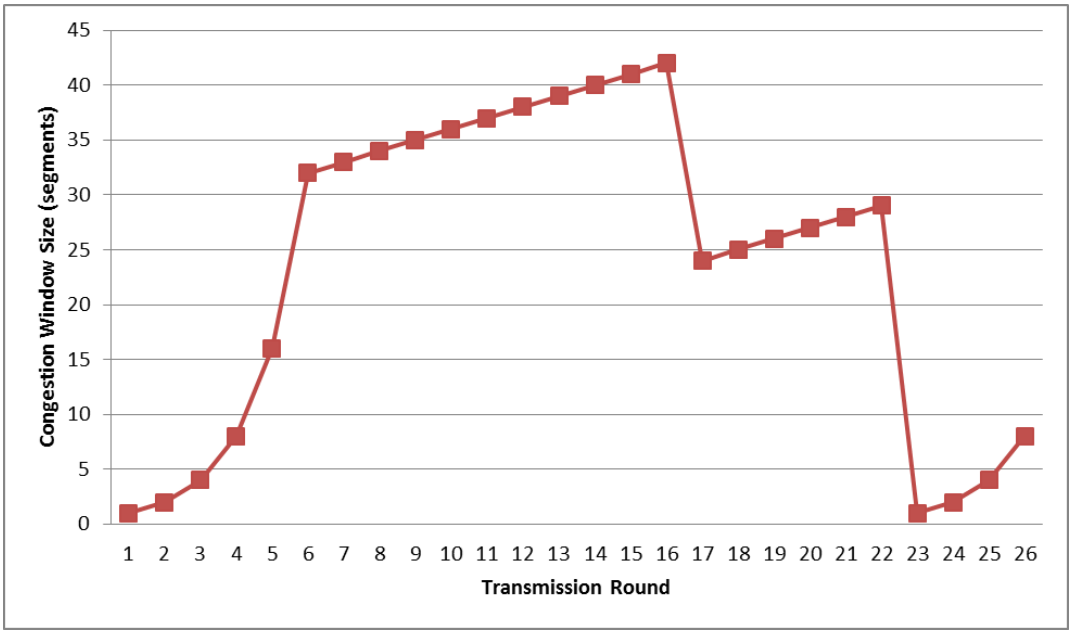
Answer:

First the host creates an IPv6 with the link local prefix and its own MAC address. Then:

1. A Multicast listener report. The host starts to listen on the multicast address associated with the link local address it intends to use.
2. A Neighbor Solicitation request sent to that multicast address. (If another host has already been configured with the same link local address that host would also listen to this multicast address and send a Neighbor solicitation reply back to the same multicast address.)
3. A Router Solicitation request. It looks for a router on the link to advertise a link prefix (in order to form a global IPv6 address).
4. The router replies to the router solicitation. (Thereby the client can form a global IPv6 address)
5. The host sends another DAD message to the associated multicast address. But this time it sends ICMPv6 with the global address as target address.

9) Transport protocol (5p)

Consider the figure below. The figure shows the evolution of the congestion window of TCP Reno, i.e., TCP with both fast retransmit and recovery.

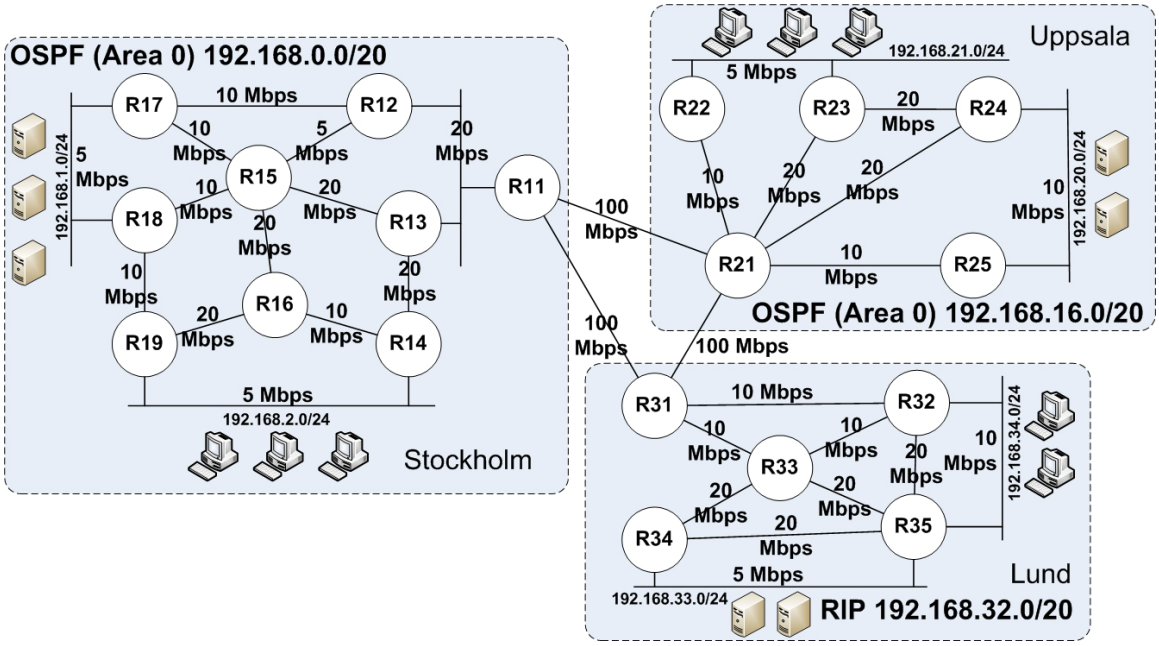


A. Identify the intervals when TCP Reno is in slow start and congestion avoidance, respectively. (1p)
B. During the 16th transmission round, TCP Reno experiences a packet loss. How does it detect the packet loss: through timeout or the reception of three duplicate acknowledgements? (1p)
C. What is the initial size of the slow-start threshold, i.e., the size of the slow-start threshold at the beginning of the first transmission round? (1p)
D. What is the size of the slow-start threshold at the beginning of the 17th transmission round? (2p)

Answer:

A. Slow start: [1,6] and [23,26], congestion avoidance: [6,16] and [17,22].
B. TCP Reno detects the packet loss through the reception of three duplicate acknowledgements.
C. The initial slow-start threshold is 32 segments, since slow-start ends at round 5, i.e., when the congestion window is 2^5 or 32 segments.
D. The slow-start threshold is set to half the value of the congestion window at the time the packet loss is detected, i.e., 42 segments / 2 = 21 segments.

10) Large-scale network scenario (10p)



The above figure illustrates Company A's network topology. Company A has three branch offices in different cities, each with different networks. The first office is located in Stockholm using the 192.168.0.0/20 subnet. The second office is located in Uppsala using the 192.168.16.0/20 subnet. The last office is located in Lund using the 192.168.32.0/20 subnet. All routers are interconnected with different link bandwidths as shown in the figure. All routers are Cisco routers with default parameters set.

Each office has designed its own internal network and runs its own routing protocol internally. The Stockholm office uses OSPF as its sole routing protocol within its network. All routers (R11-R19) are running in the backbone area (OSPF area 0). Similar to the Stockholm office, the Uppsala office uses OSPF as its sole routing protocol within its network (on routers R21-R25). All routers are running in the backbone area (OSPF area 0). The Lund office uses RIPv2 on all its routers (R31-35). These routing protocols are not running on the links between the offices! (no OSPF or RIP on R11-R21 link, R21-R31 link, and R31-R11 link). However, different routing schemes are used for communication between branch offices.

Static routes are configured on the following routers as follows:
On R11, traffic to 192.168.32.0/20 forwards to R31.
On R21, there are two static routes
1) all traffic destined to 192.168.32.0/20 forwarded to R31
2) Set default route (0.0.0.0/0) to forward to R11
On R31, set default route to forward to R11.

In addition, BGP is used between R11 and R21 (over R11-R21 link). Both routers run BGP with private AS 65001 and the following route advertisements:

On R11, advertise only one single aggregate address 192.168.0.0/20 (no other route is advertised via BGP)
On R21, redistribute ospf routes into BGP

In addition, the Stockholm office has configured R11 to always originate default route in OSPF. The Uppsala office is configured to redistribute static routes into OSPF on R21 (IMPORTANT! BGP routes on R21 are NOT redistributed into OSPF in Uppsala. Similarly, the static routes on R21 are NOT redistributed into BGP either). The Lund office has configured R31 to redistribute all static routes into RIP.

The Stockholm office has one server network (192.168.1.0/24) and one user network (192.168.2.0/24). HSRP (Hot Standby Router Protocol) is used to provide fault-tolerance default gateway for each network. For the server network, R18 is active router and R17 is passive router. For the user network, R19 is active router and R14 is passive router.

The Uppsala office has one server network (192.168.20.0/24) and one user network (192.168.21.0/24). HSRP is used to provide fault-tolerance default gateway for each network. For the server network, R25 is active router and R24 is passive router. For the user network, R23 is active router and R22 is passive router.

The Lund office has one server network (192.168.33.0/24) and one user network (192.168.34.0/24). HSRP is used to provide fault-tolerance default gateway for the server network. For the server network, R35 is active router and R34 is passive router. For the user network, R35 is active router and R32 is passive router.

Assume that default cost models are used for OSPF, RIP, as well as for static routes (a static route has a fixed cost of 1, OSPF cost formula is *cost = <100,000,000 bps>/<bandwidth in bps>*). When a route is redistributed from one protocol to the other, the original cost of the route will be inherited to the new protocol and accumulated with the new cost before the route is forwarded to other routers. For BGP routes, the cost will be set to 100 when redistribute to other protocols. In addition, if a router learns the same route from different routing protocols, it will prefer the route from the routing protocol in the following order: static, OSPF, RIP, and iBGP. If a router learns a route with equal cost from the same routing protocol through multiple routers, it will prefer to use the route from the router with the lowest number. For example, if R51 learns an OSPF route 10.0.0.0/24 from R55 and R60, it will prefer to use the OSPF route learned from R55.

A host in Lund with IP address 192.168.34.5 is trying to ping a server in Stockholm with IP address 192.168.1.2. Answer the following questions:

A. What path does an ICMP echo request take? (1p)
B. What path does an ICMP echo reply take? (1p)

Example answer
10.0.0.1 -> RTX -> RTY -> RTZ -> 10.0.0.2

A host in Stockholm with IP address 192.168.2.3 is trying to ping a server in Uppsala with IP address 192.168.20.2. Answer the following questions:

C. What path does an ICMP echo request take? (1p)
D. What path does an ICMP echo reply take? (1p)

Example answer
10.0.0.1 -> RTX -> RTY -> RTZ -> 10.0.0.2

Assume that the link between Uppsala and Lund (R21-R31 link) was cut resulting in lost connectivity at the physical layer (interfaces on both sides of the link are down). After the topology has converged, a host in Uppsala with IP address 192.168.21.5 is trying to ping a server in Lund with IP address 192.168.33.2. Answer the following questions:

E. What path does an ICMP echo request take? (1p)
F. What path does an ICMP echo reply? (1p)

Example answer
10.0.0.1 -> RTX -> RTY -> RTZ -> 10.0.0.2

Assume that the R21-R31 link is back to normal and the original topology in the figure has converged. A network administrator would like to run a multicast routing protocol in order to distribute recorded multimedia, stored on a streaming server (IP 192.168.1.9/24) in the Stockholm office, to all users in all branch offices.
Answer the following questions:

G. Assume that you are using PIM sparse mode to distribute your multicast stream, and that R15 is selected as a rendezvous point (RP). If the SPT-threshold is set very high and never exceeded, identify which path that will be used for streaming from the streaming server to the different hosts in each office according to a-b below.
   To avoid confusion caused by having two routers on the network (HSRP routers), assume that the links between the passive routers and the server and client networks in each office are removed from the topology (R17-192.168.1.0/24 link, R14-192.168.2.0/24 link, R24-192.168.20.0/24 link, R22-192.168.21.0/24 link, R34-192.168.33.0/24 link, and R32-192.168.34.0/24 link).
   The hosts in each office are as follows:
   a. 192.168.2.10 in Stockholm office (1p)
   b. 192.168.21.10 in Uppsala office (1p)
   c. 192.168.34.10 in Lund office (1p)

H. You are writing an application to send video files over IP multicast. Is it possible to use TCP as your transport protocol? Briefly motivate your answer? (1p)

Answer:

A. 192.168.34.5 -> R35 -> R32 -> R31 -> R11 -> R12 -> R17 -> 192.168.1.2
B. 192.168.1.2 -> R18 -> R15 -> R13 -> R11 -> R31 -> R32 -> 192.168.34.5
C. 192.168.2.3 -> R19 -> R16 -> R15 -> R13 -> R11 -> R21 -> R24 -> 192.168.20.2
D. 192.168.20.2 -> R25 -> R21 -> R11 -> R13 -> R14 -> 192.168.2.3

E. 192.168.21.5 -> R23 -> R21 -> R11 -> R31 -> R32 -> R35 -> 192.168.33.2
F. 192.168.33.2 -> R35 -> R32 -> R31 -> R11 -> R21 -> R23 -> 192.168.21.5
G. The paths used for sending the stream are as follow:
    a. 192.168.1.9 -> R18 -> R15 –> R16 -> R19 -> 192.168.2.10
    b. 192.168.1.9 -> R18 -> R15 –>R13 -> R11 -> R21 -> R23 -> 192.168.21.10
    c. 192.168.1.9 -> R18 -> R15 –>R13 -> R11 -> R31 -> R32 -> R35 -> 192.168.34.10
H. No. TCP is not defined for IP multicast transmissions.