Information

- This exam is for course codes IK2215, IK2204, and 2G1701
- The duration of the exam is 4 hours (14.00-18.00).
- 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 November 16, 2015. Requests for grading re-evaluations should be made according to the routines specified by KTH School of Information and Communication Technology.
- 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. When OSPF is configured into several OSPF areas, a node sends LSAs (link state advertisements) to all other nodes in all OSPF areas. (1p)
B. UDP provides a connectionless best-effort delivery service. (1p)
C. A BGP router assigns an AS path to a prefix when adveritising it to its neighbors, (1p)
D. MSDP can be used to interconnect multiple IPv4 PIM-SM domains. (1p)
E. According to GeSI (Global e-Sustainability Initiative), the greenhouse gas (GHG) emissions from ICT is only about 10% of the the GHG emissions from the aviation industry. (1p)
F. One objective with int-serv (Integrated Services) is to provide end-to-end performance guarantees for individual application flows. (1p)
G. In IPv6 the hop-by-hop header checksum from IPv4 has been removed. (1p)
H. In IP multicast the sender needs to keep track of the individual receivers to make sure they all can be reached. (1p)
I. RTP (Real-time Transport Protocol) provides a mechanism to guarantee delay-bounds between two hosts. (1p)
J. In Gnutella, an infrastructure node called tracker was introduced to keep track of the peers in an overlay network. (1p)

Answer:

A. False (LSAs are sends to all nodes within the area)
B. True
C. True
D. True
E. False (they are about at the same level)
F. True
G. True
H. False
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: HTTP, IGMP, UDP, and ICMPv6. (1p)

B. Assume you aggregate the prefixes 189.1.2.0/26, 189.1.2.64/26, 189.1.2.128/26, and 189.1.2.192/26 to one single subnet. Specify (in CIDR notation) the resulting aggregated prefix. (1p)
C. At a given time, a TCP sender has a congestion window of 2048 bytes and a receiver-advertised window of 1024 bytes. What is the maximum number of bytes that the sender can transmit before waiting for an ACK? (1p)
D. Mention one (technical) drawback with a centralized directory architecture for peer-to-peer networking. (1p)
E. Multicast routing protocols can be divided into two groups: those using a source-based tree and those using a group-shared tree. Which one of these groups is most likely to result in suboptimal path lengths? (1p)
F. Setting the playback point in a playback buffer is basically a tradeoff between two parameters. Which ones? (1p)
G. Is the EEE (Energy-Efficient Ethernet) standard based on rate switching (switch to lower tranimssion rate when possible) or low-power idle (sleep between packets when possible)? (1p)
H. Router A is running RIP and sends out a distance vector. Which routers are the ultimate receivers of this distance vector? (1p)
I. Where can fragmentation occur in an IPv6 network? Only in the sending host? Only in a router? In either the sending host or a router? (1p)
J. What does BGP use to detect and prevent loops? (1p)

Answer:

A. HTTP: Application layer, IGMP: Network layer, UDP: Transport layer, ICMPv6: Network layer.
B. 189.1.2.0/24.
C. 1024 bytes.
D. It is a single point of failure and a performance bottleneck.
E. Group-shared tree protocols.
F. It is a tradeoff between packet loss and latency.
G. EEE uses low-power idle.
H. Router A’s neighbors.
I. Only in the sending host.
J. It uses the AS path.

3) Transport layer (2p) (Word limit: 100)

Briefly describe the overall difference between TCP flow control and TCP congestion control.

Answer:

TCP flow control (sliding windows) is a way for the receiver to throttle the sender so that the receiver doesn’t get overwhelmed with data. The purpose with TCP congestion control is to make the sender adapt to the network conditions (so that routers don’t get overloaded).

4) Multicast (2p) (Word limit: 80)

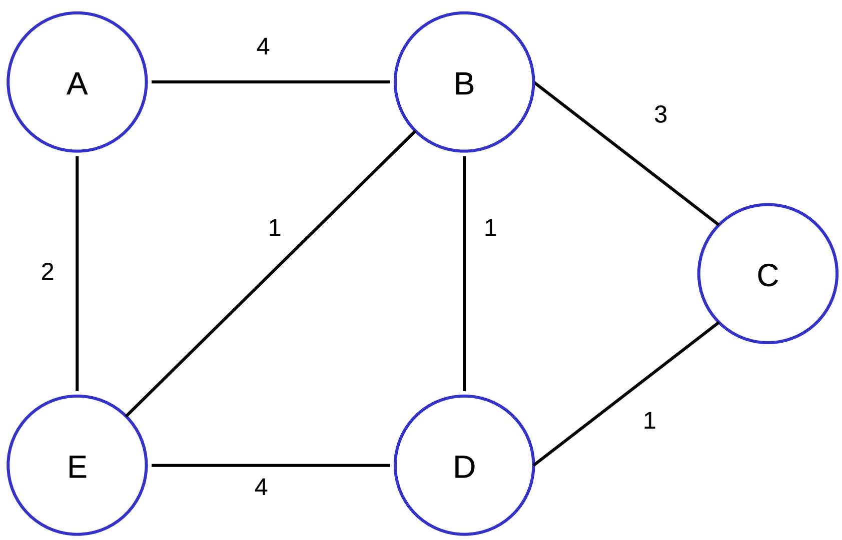
Assume that you use anycast RP (Rendez-vous point) with two RPs with PIM sparse mode within your network. What problem could arise in this situation? How can you solve this problem?

Answer:

A multicast source may register with one RP and receivers may join to a different RP. In this situation, a method is needed for the RPs to exchange information about active sources. You can run MSDP between the RPs to share information about active sources.

5) Link state routing (2p) (Word limit: 50)

Consider the network in the figure below. Use the shortest path first principle according to Dijkstra's algorithm to compute the best route from A to all other nodes in the network. Your solution should show the steps taken in the execution of the algorithm, including cost and path to the destination.



Answer:

M	D_b (path)	D_c (path)	D_d (path)	D_e (path)
{a}	4 (a-b)	∞ (--)	∞ (--)	2 (a-e)
{a, e}	3 (a-e-b)	∞ (--)	6 (a-e-d)	2 (a-e)
{a, e, b}	3 (a-e-b)	6 (a-e-b-c)	4 (a-e-b-d)	2 (a-e)
{a, e, b, d}	3 (a-e-b)	5 (a-e-b-d-c)	4 (a-e-b-d)	2 (a-e)
{a, e, b, d, c}	3 (a-e-b)	5 (a-e-b-d-c)	4 (a-e-b-d)	2 (a-e)

6) Multimedia networking (2p) (Word limit: 60)

a) A programmer is about to implement an application for streaming of stored multimedia content. She selects TCP as the transport protocol. Explain why that might be a good choice. (1p)

b) Her application includes both a web client and a media player. What is the purpose with each of these parts? (1p)

Answer:

a) Firewalls often block UDP traffic. TCP will ensure that the complete file is downloaded without errors and it can then be cached locally at the receiver.

b) The web client is used to request information and the media player is for display and control of the audio/video.

7) Peer-to-peer networking (2p) (Word limit: 100)

What does the “rarest chunks first” mechanism in Bittorrent mean and what is the overall purpose with this mechanism?

Answer:

When a peer is about to request chunks of a file from other peer, the requesting peer needs to decide which chunks of the file to request first. “Rarest chunks first” means that the requesting peer should start with these. The overall purpose is to replicate these chunks to increase the availability of them. That is good for all participating peers.

Exam Part B (20p)

8) Multimedia networking (5p)

A video source is generating video frames of size 10,000 bytes at a constant rate of 25 frames per second. The frames are transmitted over a network with 1 Gb/s Ethernet links, and arrive at the receiver with a maximum jitter (delay variation) of 200 milliseconds.

A. What is the minimum size of the playback buffer in order to ensure smooth playback of the video stream at the receiver? (2p)
B. The video frames are encapsulated in RTP and then transmitted over UDP. What is the reason for using RTP on top of UDP? What does it provide, that UDP does not? (1P)
C. Consider the statement “A TCP connection has large variations in delay because of its error control, flow control and congestion control mechanisms. Therefore, it cannot be used for multimedia communication.” Do you agree with the conclusion? Explain you answer. (2p)

Answer:

A. The buffer needs to be large enough to compensate for the worst-case delay, which is 200 milliseconds, corresponding to 5 frames or 50,000 bytes.
B. RTP has support for timestamps (which can be used to synchronize playout) and sequence numbers (to detect packet loss or reordering).
C. No. In practice, it is not correct to say that TCP has unpredictable delay. Variations in delay might be larger for TCP than UDP, so it requires a larger playout buffer, but there are many applications that can tolerate longer variations, streaming video for instance.

9) Transport protocol (5p)

Suppose that a file transfer is taking place between two hosts, A and B, when a timeout occurs. At the time of the timeout, the congestion window (cwnd) was 16 segments, and ssthresh (slow start threshold) is then set to half the congestion window. The receiver window (rwnd) at B is 32 segments.

A. How many transmission rounds does it take until the cwnd reaches the ssthresh? (1p)
B. How many transmission rounds does it take until the cwnd reaches 12 segments? (2p)
C. How many segments have been successfully received by B at the time the cwnd reaches the ssthresh? (2p)

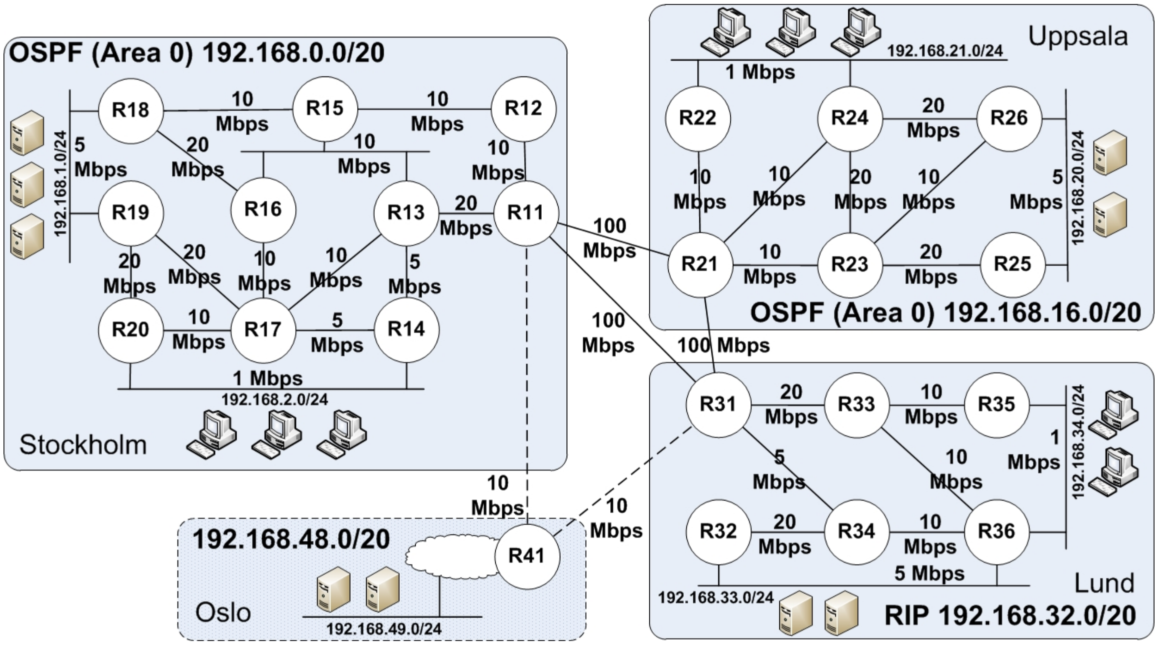
Answer:

A. 3 transmission rounds (After r rounds cwnd has increased to 2^r, consequently after three rounds cwnd has reached the value $2^3 = 8$ segments).
B. 7 transmission rounds (From 1a, we know that congestion avoidance is reached after 3 transmission rounds. Since the cwnd is 8

segments when congestion avoidance is reached, four more transmission rounds are needed).

C. 7 segments (From 1a, we know that the cwnd reaches ssthresh after 3 transmission rounds during which 1 + 2 + 4 = 7 segments have been transmitted by A and acknowledged by B).

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-R20) 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-R26). All routers are running in the backbone area (OSPF area 0). The Lund office uses RIPv2 on all its routers (R31-36). These routing protocols are not running on the links between the offices (no OSPF or RIP on the R11-R21 link, the R21-R31 link, or the 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 R31, there are two static routes:
  First: traffic to 192.168.16.0/20 forwards to R21
  Second: forward all traffic (0.0.0.0/0) to R11

BGP is used between Stockholm's R11 and Uppsala's R21 (over R11-R21 link). Both routers run iBGP peering with private AS 65001 and have "no auto-summary" and "no synchronization" commands configured. They also have the following route advertisements:

R11 advertises a default route (0.0.0.0/0) to all BGP peers. R11 has also a filter to NOT advertised all other routes its peer(s).
R21 advertises only an aggregate address 192.168.16.0/20 to all BGP peerings. All other routes are suppressed and NOT advertised via BGP.

In addition, the Stockholm office has configured R11 to always originate default route in OSPF. The Uppsala office has configured R21 to redistribute all BGP routes into OSPF. The Lund office has configured to redistribute static routes into RIP on R31.

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-tolerant default gateway for each network. For the server network, R18 is active router and R19 is passive router. For the user network, R20 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-tolerant default gateway for each network. For the server network, R26 is active router and R25 is passive router. For the user network, R24 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-tolerant default gateway for each network. For the server network, R32 is active router and R36 is passive router. For the user network, R36 is active router and R35 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 originated routes, the cost will be set to 10. 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, eBGP, 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.

Assume that the topology has converged. Answer the following questions:

A. What path does a packet traverse when a host in Stockholm with IP address 192.168.2.3 sends an ICMP echo request to a server in Uppsala with IP address 192.168.20.3? (1p)
B. What path does a packet traverse when a host in Uppsala with IP address 192.168.21.4 sends an ICMP echo request to a server in Lund with IP address 192.168.33.4? (1p)
C. What path does a packet traverse when a host Lund with IP address 192.168.34.5 sends an ICMP echo request to a server in Stockholm with IP address 192.168.1.5? (1p)

IMPORTANT: if the ICMP echo request cannot reach the destination then identify what happens to the request.

Example answer
10.0.0.1 -> RTX -> RTY -> RTZ -> 10.0.0.2
10.0.0.1 -> RTQ -> RTR -> RTS -> RTS drops the packet
10.0.0.1 -> RTM -> RTN -> RTO <-> RTN (Loop between RTO and RTN!)

Assume that the physical link between Uppsala and Lund (on R21-R31 link) was taken down and the border routers lose all routing information on this link (static routes on this link are removed from the routing tables). Assume that the topology has converged. Answer the following questions:

D. What path does a packet traverse when a server in Uppsala with IP address 192.168.20.3 sends an ICMP echo request to a host in Lund with IP address 192.168.34.3? (1p)
E. What path does a packet traverse when a server in Lund with IP address 192.168.33.4 sends an ICMP echo request to a host in Uppsala with IP address 192.168.21.4? (1p)

IMPORTANT: if the ICMP echo request cannot reach the destination then identify what happens to the request.
Example answer
10.0.0.1 -> RTX -> RTY -> RTZ -> 10.0.0.2
10.0.0.1 -> RTQ -> RTR -> RTS -> RTS drops the packet
10.0.0.1 -> RTM -> RTN -> RTO <-> RTN (Loop between RTO and RTN!)

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. PIM sparse mode is used for this purpose and R16 is selected as a rendezvous point (RP).

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 (R19-192.168.1.0/24 link, R14-192.168.2.0/24 link, R25-192.168.20.0/24 link, R22-192.168.21.0/24 link, R36-192.168.33.0/24 link, and R35-192.168.34.0/24 link).

Assuming that the SPT-threshold is set to inifinity (the threshold is never exceeded). Answer the following questions:

F. Which path is used for streaming from the streaming server to a host with IP 192.168.2.10 in Stockholm office? (1p)
G. Which path is used for streaming from the streaming server to a host with IP 192.168.34.10 in Lund office? (1p)

Company A has bought company B in Oslo and decided to connect company B office to Company A’s network with two physical links; one from Oslo to Stockholm (R41-R11 link) and another from Oslo to Lund (R41-R31 link). To keep the internal routing policy of Company B intact, the network administrator decided to use BGP as the routing protocol on these links. Company B is assigned a private AS 65002 and runs two eBGP peering sessions with AS 65001; one with R11 in Stockholm and another with R31 in Lund. R41 is configured with “no auto-summary” and “no synchronization”. It is also configured to advertise only an aggregate address 192.168.48.0/20 to all BGP peerings with “summary-only” (all other routes are suppressed and NOT advertised). In addition, R41 redistribute all BGP routes into its internal network.

Assuming that the existing BGP configurations on R11 and R21 as described earlier are still in place. Then, R11 adds the following configurations:

- iBGP peering configuration with R31
- eBGP peering with R41
- “next-hop-self” command for all iBGP peering

Now, R31 also run BGP protocol with the following configurations:

- “no auto-summary” and “no synchronization”
- iBGP peering configuration with R11
- eBGP peering with R41
- “next-hop-self” command for all iBGP peering

Assume that the topology has converged. Answer the following questions:

H. What path does a packet traverse when a host in Lund with IP address 192.168.34.3 sends an ICMP echo request to a server in Oslo with IP address 192.168.49.3? (1p)
I. What path does a packet traverse when a host in Uppsala with IP address 192.168.21.4 sends an ICMP echo request to a server in Oslo with IP address 192.168.49.4? (1p)
J. What path does a packet traverse when a server in Oslo with IP address 192.168.49.5 sends an ICMP echo request to a server in Lund with IP address 192.168.33.5? (1p]

Answer:

A. 192.168.2.3 -> R20 -> R17 -> R13 -> R11 -> R21 -> R23 -> R25 -> 192.168.20.3
B. 192.168.21.4 -> R24 -> R21 -> R11 -> R31 -> R33 -> R36 -> 192.168.33.4
C. 192.168.34.5 -> R36 -> R33 -> R31 -> R11 -> R13 -> R16 -> R18 -> 192.168.1.5
D. 192.168.20.3 -> R26 -> R24 -> R21 -> R11 -> R31 -> R33 -> R35 -> 192.168.34.3
E. 192.168.33.4 -> R32 -> R34 -> R31 -> R11 -> R21 -> R22 -> 192.168.21.4
F. 192.168.1.9 -> R18 –>R16 -> R17 -> R20 -> 192.168.2.10
G. 192.168.1.9 -> R18 –>R16 -> R13 -> R11 -> R31 -> R33 -> R36 -> 192.168.34.10
H. 192.168.34.3 -> R36 -> R33 -> R31 -> R41 -> 192.168.49.3
I. 192.168.21.4 -> R24 -> R21 -> R11 -> R41 -> 192.168.49.4
J. 192.168.49.5 -> R41 -> R11 -> R31 -> R33 -> R36 -> 192.168.33.5
   If you somehow assume that the link to HSRP passive routers are not removed, you should have this written as an assumption in your answer explicitly. In this case the answer for H and I is still the same but the answer for J is
   192.168.49.5 -> R41 -> R11 -> R31 -> R33 -> R35 -> 192.168.33.5