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 January 31, 2011. 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 14, 2011.
- 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 it may be hard to differ between the two if the hand-writing is indistinct.

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. A distance vector advertisement is sent from a node to all other nodes in the network. (1p)
B. TCP is a byte-stream oriented transport protocol. (1p)
C. PIM-SM and PIM-DM are both based on a source-based tree. (1p)
D. If an IP packet is fragmented, the destination system is the only place where reassembly occurs. (1p)
E. SCTP provides an unreliable congestion-controlled transport service. (1p)
F. Int-serv is generally considered simpler to implement and deploy compared to Diff-serv. (1p)
G. The main purpose with IPv6 was to increase the address space. (1p)
H. VPWS provides a virtual link service. (1p)
I. RTSP (Real-Time Streaming Protocol) provides time stamps and sequence numbers for proper playback of received data.(1p)
J. BitTorrent uses a central tracker to handle peer discovery. (1p)

Answer:

A. False (it is sent only to the node's neighbors)
B. True
C. False
D. True
E. False (SCTP provides a reliable service)
F. False
G. True
H. True
I. False
J. True

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 protocols/mechanisms in the correct TCP/IP protocol layer: ICMP, DCCP, RTSP, and FTP. (1p)
B. FDEC:BA98:0000:3210:000F:0000:0000:FFFF is an IPv6 address. Use the IPv6 abbreviation rules to give the address in its shortest form (as few characters as possible). (1p)
C. When a router needs to send an ICMP error messages, what does it put in the destination address field? (1p)

D. What is the overall philosophy with a CDN (Content Distribution Network? (1p)
E. A multicast router is in promiscuous mode. What does that mean? (1p)
F. What is the purpose with a playback buffer for real-time traffic? (1p)
G. What is the purpose with using “rarest chunk first” in BitTorrent? (1p)
H. An OSPF router has just built an LSA (Link State Advertisement). Where does it send the LSA? (1p)
I. Name the two types of messages that RSVP uses to set up a reservation. (1p)
J. Assuming that no messages are lost, how many TCP messages does it take to set up a TCP connection? (1p)

Answer:

A. ICMP: Network, DCCP: Transport, RTSP: Application, FTP: Application
B. FDEC:BA98:0:3210:F::FFFF
C. The source address of the datagram that caused the error.
D. To bring content closer to the clients.
E. It listens to all multicast addresses.
F. To absorb delay jitter induced by the network.
G. To achieve good replication of data.
H. To all other OSPF routers in its area.
I. PATH message and RESV message.
J. Three.

3) IP routing (2p) (Word limit: 50)

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*	4
N_2	*A*	5
N_3	*B*	6
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	5
N_2	4
N_3	6
N_4	3
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*	6
N_2	*A*	5
N_3	*B*	6
N_4	*A*	4
N_5	*C*	4
N_6	*A*	3
N_7	*C*	2

4) Transport protocols (2p) (Word limit: 50)

In the following table we list four transport protocols and a list of different features. Redraw the table and mark what features each protocol support by filling in yes/no in the empty cells.

Feature	UDP	TCP	SCTP	DCCP
Connection-oriented				
Reliable transport				
Ordered delivery				
Flow control				
Congestion control				

Answer:

Feature	UDP	TCP	SCTP	DCCP
Connection-oriented	No	Yes	Yes	Yes
Reliable transport	No	Yes	Yes	No
Ordered delivery	No	Yes	Yes	No
Flow control	No	Yes	Yes	No
Congestion control	No	Yes	Yes	Yes

5) IP multicast (2p) (Word limit: 75)

IP multicast address to Ethernet multicast address mapping is not unique. What implication does this have on the IP and how is it solved?

Answer:

It means that IP may receive multicast packets for which there is no receiving process. Such packets are filtered out in software by the IP layer (based on IP multicast address).

6) Peer-to-peer networking (2p)(Word limit: 30+30)

A. What is the purpose of using peer-to-peer technology in Skype? (1p)
B. How does Skype handle users that are behind a NAT/firewall?

Answer:

A. In Skype, peer-to-peer technology is used to implement a directory service, i.e., to map users to nodes.
B. Skype uses a third party machine (super peer) to proxy traffic to/from users behind a NAT/firewall.

7) IP QoS (2p) (Word limit: 80)

Briefly describe what each of the following IP QoS terms mean (you should not use more than 20 words per term):

- Classification
- Policing
- Shaping
- Scheduling

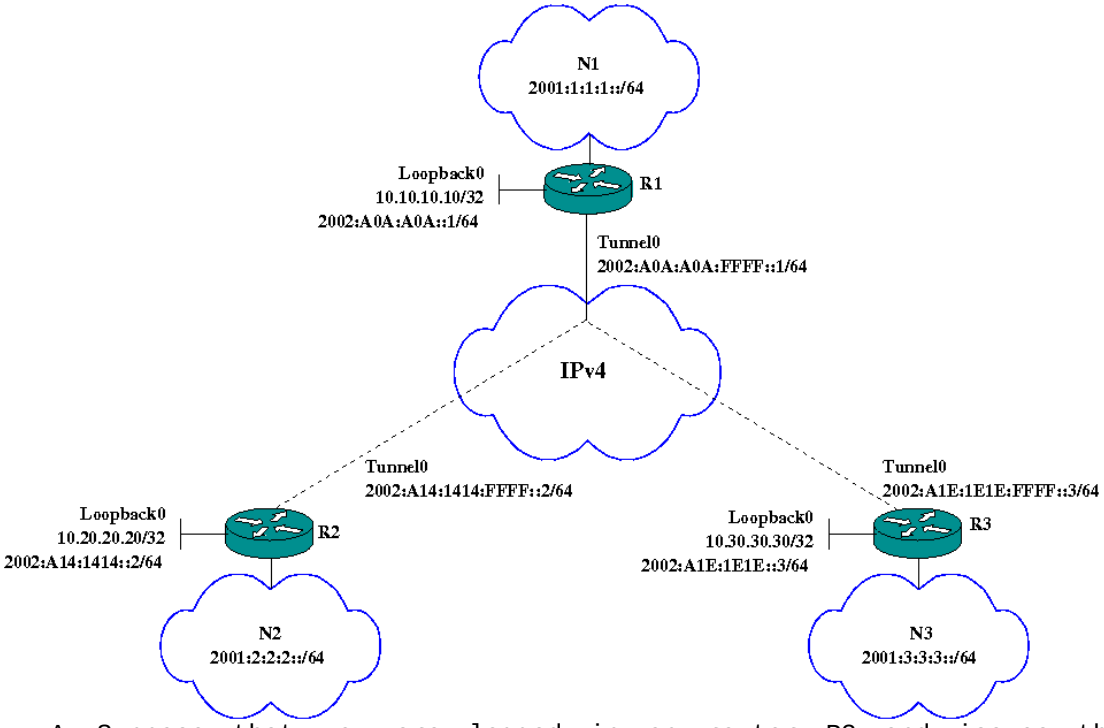
Answer:

Classification
– Identifying the packets belonging to a certain traffic flow
Policing
– Ensure that the flow conforms to a traffic specification
Shaping
– Smoothing out packet bursts (traffic is often bursty)
Scheduling
– Manage packets in queues so that they receive desired service

Exam Part B (20p)

8) IPv6 (5p)

6to4 tunnels are multi-point tunnels. The figure below illustrates how three IPv6 networks are interconnected by a single 6to4 tunnel, Tunnel0. The tunnel interfaces have been given 6to4 IPv6 addresses that match their corresponding loopback IPv4 addresses. All routers have IPv4 connectivity between their loopback addresses. The IPv4 network runs OSPF, and the three routers, R1, R2, and R3 advertise their loopback addresses into the OSPF area. Further, static routes for the tunnel (ipv6 route 2002::/16 Tunnel0) have been added to R1, R2, and R3.



A. Suppose that you are logged in on router R3 and issues the command, ping 2002:A0A:A0A::1. Explain how the corresponding ICMPv6 Echo Request is routed through the IPv4 network. Particularly, explain how the IPv6-to-IPv4 address translation is done. (2p)

B. Does the 6to4 tunnel in itself provide connectivity between the hosts in the networks N1, N2, and N3. That is, are hosts in the respective networks able to ping each other? If not, which static routes (ipv6 route <destination> <next hop>) are needed in the three routers, R1, R2, and R3, to provide host connectivity (3p)

Answer:

A. The router R3 looks up its route table and sees that we have a static route that says that anything that starts with 2002::/16 should be sent out on tunnel, Tunnel0. The Tunnel0 interface has 6to4 tunnel encapsulation turned on, and R3 takes the IPv6 address of the ICMPv6 packet (2002:A0A:A0A::1) and converts it into an IPv4 address, 10.10.10.10. The ICMPv6 packet is then

encapsulated in an IPv4 header and sent along to the 10.10.10.10 interface of router R1.

B. No, the 6to4 tunnel does not in itself provide for connectivity between the hosts in the three networks. You have to provide the following static routes:

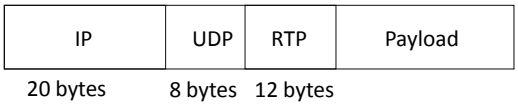
```
R1:
ipv6 route 2001:2:2:2::/64 2002:A14:1414::2
ipv6 route 2001:3:3:3::/64 2002:A1E:1E1E::3
R2:
ipv6 route 2001:1:1:1::/64 2002:A0A:A0A::1
ipv6 route 2001:3:3:3::/64 2002:A1E:1E1E::3
R3:
ipv6 route 2001:1:1:1::/64 2002:A0A:A0A::1
ipv6 route 2001:2:2:2::/64 2002:A14:1414::2
```

9) Multimedia networking (4p)

Assume that speech frames are carried inside RTP (Real-time Transport Protocol). The RTP header is 12 bytes. The packetization time is 20 ms per audio frame and we are using PCM audio with 8 kHz and 8 bits per sample.
Sketch the IP packet, including all protocol level headers and audio data You don’t need to show any header fields, just the name of the protocol headers involved (keep in mind that port level addressing is needed).
How many bytes of audio payload will there be in each IP packet? What is the total overhead, counting IP header and headers above IP?

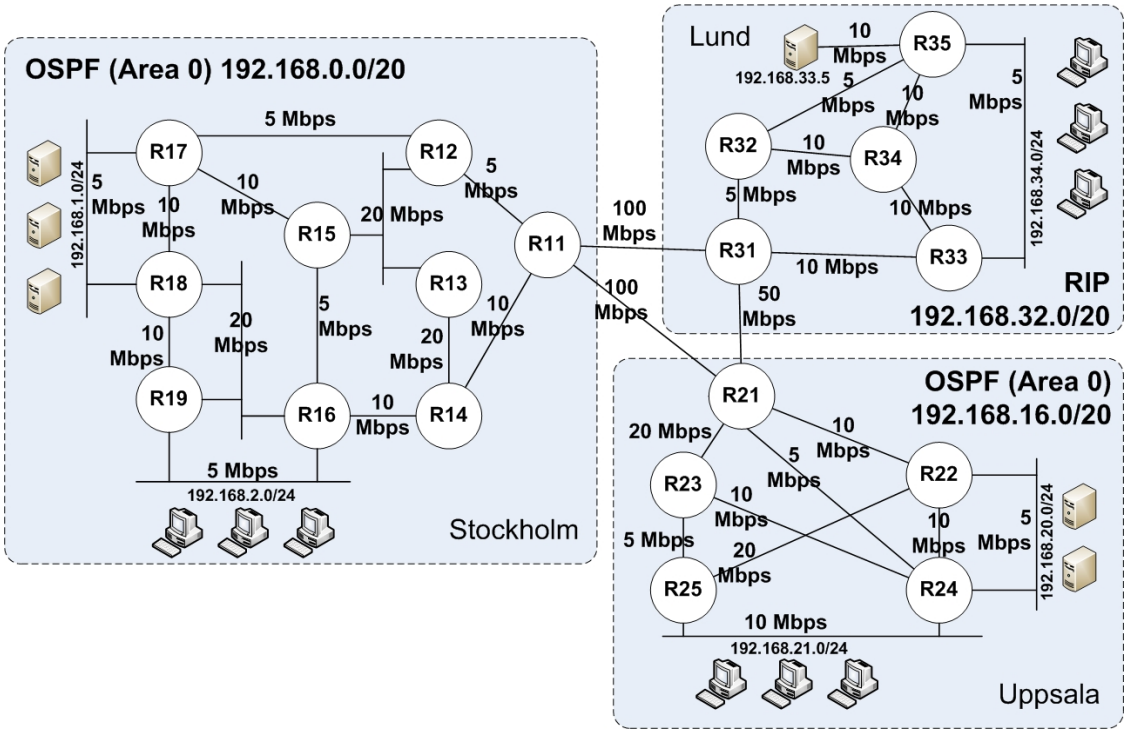
Answer

IP packet with encapsulation:



Using 8 kHz and 8 bits per sample results in 64000 bits/s. If the packetization time is 20 ms, the amount of data will be:
(64000/50)*8 = 160 bytes.
The overhead is (20+8+12)/160 = 40/160 = 25%

10) Scenario (11p)



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.

Each office has designed its own internal network and runs its own routing protocol internally. There is no routing protocol running between the different offices (no routing protocol is used between the R11-R21 link, the R21-R31 link, and the R31-R11 link).

For its internal network, 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). On the other hand, the Lund office uses RIPv2 on all its routers (R31-35).

To communicate between branch offices, the following static routes are configured:

On R11,
All traffic destined to 192.168.16.0/20 forwards to R21
All traffic destined to 192.168.32.0/20 forwards to R31

On R21,
All traffic destined to 192.168.32.0/20 forwards to R31

Set default route for all traffic to forward to R11

On R31,
All traffic destined to 192.168.0.0/20 forwards to R21
Set default route for all traffic to forward to R11

In addition to configure static routes, the Stockholm office has configured R11 to redistribute all static routes into OSPF. The Uppsala office has configured R21 to originate default route to all other routers within the branch office. 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 for each network. For the server network, R17 is active router and R18 is passive router. For the user network, R19 is active router and R16 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 for each network. For the server network, R24 is active router and R22 is passive router. For the user network, R24 is active router and R25 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 for the user network. R35 is active router and R33 is passive router. (Note that only one server is shown in the figure.)

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). 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. In addition, if a router learns a route with equal cost from multiple routers, it will prefer to use the route from the router with lowest number. For example, if R51 learns a route 10.0.0.0/24 from R55 and R60, it will prefer to use the route learned from R55.

A host in Lund with IP address 192.168.34.5 is trying to ping a host in Stockholm with IP address 192.168.2.3. 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

A host in Uppsala with IP address 192.168.21.3 is trying to ping a server in Stockholm with IP address 192.168.1.2. Answer the following questions:

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

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

Assume that R14, R23, R32 have lost electricity and stop running. After the topology has converged, a host in Stockholm with IP address 192.168.2.3 is trying to ping a server in Uppsala with IP address 192.168.20.4. Answer the following questions:

G. What path does an ICMP echo request take? (1p)
H. 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 electricity 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 broadcast 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:

I. Assume that you are using PIM sparse mode to distribute your multicast stream, R15 is selected as a rendezvous point. If the SPT-threshold (Shortest Path Tree) 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. To avoid confusion caused by having two routers on the network (HSRP routers), all traffic must come to the receiver via the receiver's active router. The sender can send via any of the routers as long as it is the best RPF path from the receiver. 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)

J. What is the main benefit of using shared tree over source tree? (1p)
K. 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 -> R21 -> R11 -> R14 -> R16 -> 192.168.2.3
B. 192.168.2.3 -> R19 -> R16 -> R14 -> R11 -> R31 -> R33 -> 192.168.34.5
C. 192.168.21.3 -> R24 -> R23 -> R21 -> R11 -> R14 -> R16 -> R18 -> 192.168.1.2
D. 192.168.1.2 -> R17 -> R15 -> R13 -> R14 -> R11 -> R21 -> R22 -> R25 -> 192.168.21.3
E. 192.168.2.3 -> R19 -> R16 -> R15 -> R12 -> R11 -> R21 -> R22 -> 192.168.20.4
F. 192.168.20.4 -> R24 -> R21 -> R11 -> R12 -> R15 -> R16 -> 192.168.2.3
G. The paths used for sending the stream are as follow:
    a. 192.168.1.9 -> R17 -> R15 -> R13 -> R14 -> R16 -> 192.168.21.10
    b. 192.168.1.9 -> R17 -> R15 -> R13 -> R14 -> R11 -> R21 -> R23 -> 24 192.168.21.10
    c. 192.168.1.9 -> R17 -> R15 -> R13 -> R14 -> R11 -> R21 -> R31 -> R32 –> R35 -> 192.168.34.10

H. It reduces the amount of state information kept by the routers.
I. No. TCP is not defined for IP multicast transmissions.