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 November 12, 2009. 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 November 26, 2009.
- 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. RIP uses Dijkstra's algorithm to compute the best paths. (1p)
B. TCP provides a stream-oriented transport service. (1p)
C. IGMP provides a multicast routing service. (1p)
D. Error reporting is one of the main responsibilities of ICMP. (1p)
E. DCCP provides an unreliable congestion-controlled transport service. (1p)
F. Diff-serv is a more coarse-grained model of IP QoS compared to Int-serv. (1p)
G. In IPv6, only hosts are allowed to fragment IP datagrams. (1p)
H. An L1 VPN provides a transparent connection service. (1p)
I. RTSP (Real-Time Streaming Protocol) defines a standardized way to encapsulate audio/video data in packets. (1p)
J. A peer-to-peer application based on query flooding relies on a centralized directory for locating content. (1p)

Answer:

A. False
B. True
C. False
D. True
E. True
F. True
G. True
H. True
I. False (it is a protocol for exchanging control information)
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 protocols in the correct TCP/IP protocol layer: PPP, SCTP, IGMP, and FTP. (1p)
B. The network 199.1.1.0/24 is split in half to create two subnets of equal size. Specify (in CIDR notation) the two resulting subnets. (1p)
C. What does UDP use to address a specific process running on a computer? (1p)
D. What is the purpose of a CDN (Content Distribution Network) distribution node? (1p)

E. List which ones of the following multicast routing protocols that use source based trees and which ones that use group shared trees: PIM-SM, MOSPF, DVMRP, CBT. (1p)
F. What is the overall purpose with a playback buffer? (1p)
G. In BitTorrent, how does a peer determine which requests to serve first? (1p)
H. What is the difference between a distance vector and a path vector? (1p)
I. Which are the two categories of ICMP messages? (1p)
J. How does the TCP congestion window increase in size during “slow start” and “congestion avoidance” respectively? (1p)

Answer:

A. PPP: Link, SCTP: Transport, IGMP: Network, FTP: Application
B. 199.1.1.0/25 and 199.1.1.128/25
C. A port number (or protocol port).
D. To replicate and push content to selected CDN servers.
E. Source based trees: MOSPF, DVMRP. Group shared trees: CBT, PIM-SM.
F. To absorb delay jitter in the network for real-time applications.
G. The peer will give priority to neighbors currently supplying data at the highest rate.
H. A distance vector contains the hop count to a destination while a path vector protocol contains the path.
I. Error reporting messages and query messages.
J. The congestion window increases exponentially during slow start and linearly during congestion avoidance.

3) Dynamic Routing (2p) (Word limit: 100)

Explain briefly the difference between the route propagation mechanisms in a link state protocol and a distance vector protocol. Which of the two generally adapts faster to network topology changes?

Answer:

When a router receives an LSP with information about topology change, it can immediately forward that LSP to other neighbors. In distance vector routing, a router that receives a distance vector from a neighbor router will have to re-compute a new distance vector before it can inform its other neighbors.
Link-state protocols generally adapt faster to topology changes.

4) SCTP and DCCP (2p) (Word limit: 80)

In the past ten years, two new transport protocols have been standardized within IETF: SCTP and DCCP. What are the main characteristics of these two protocols that distinguish them from TCP and UDP, respectively?

Answer:

SCTP inherits many of its features from TCP, but introduces multi-streaming to avoid head-of-line blocking in between different transactions, and multi-homing to realize highly available transport connections.
Similar to UDP, DCCP is unreliable and message based. However, unlike UDP, DCCP is congestion aware and provides for a connection to dynamically select a suitable congestion control mechanism.

5) Quality of service in IP networks (2p) (Word limit: 75)

What are the main drawbacks with the integrated service (int-serv) model for IP quality of service?

Answer:

The end-to-end connection set-up and the resource reservations on a per flow basis make int-serv very unpractical (impossible) to scale. There could literally be millions of flows to keep track of, each requiring its own buffer. The required state per flow in each router along the path is very costly for routers.

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

Many peer-to-peer network applications make use of so-called Distributed Hash Tables (DHTs) for their operation. What is the principal idea behind a DHT, and in what way does a DHT differ from an ordinary hash table?

Answer:

The principal idea behind a DHT is the same as for a hash table: to be able to insert, and delete large amounts of information associated with keys. However, the concept of “bucket” is now replaced by a physical node, which could be located anywhere globally (distributed). Keys are hashed, and the hashed keys are mapped to the nodes according to the DHT algorithm; the nodes hold the key and value pairs.

7) VPNs (2p) (Word limit: 50)

Ethernet VPWS (Virtual Private Wire Service) and VPLS (Virtual Private LAN Service) are two different types of Ethernet VPNs. What is the difference between their services?

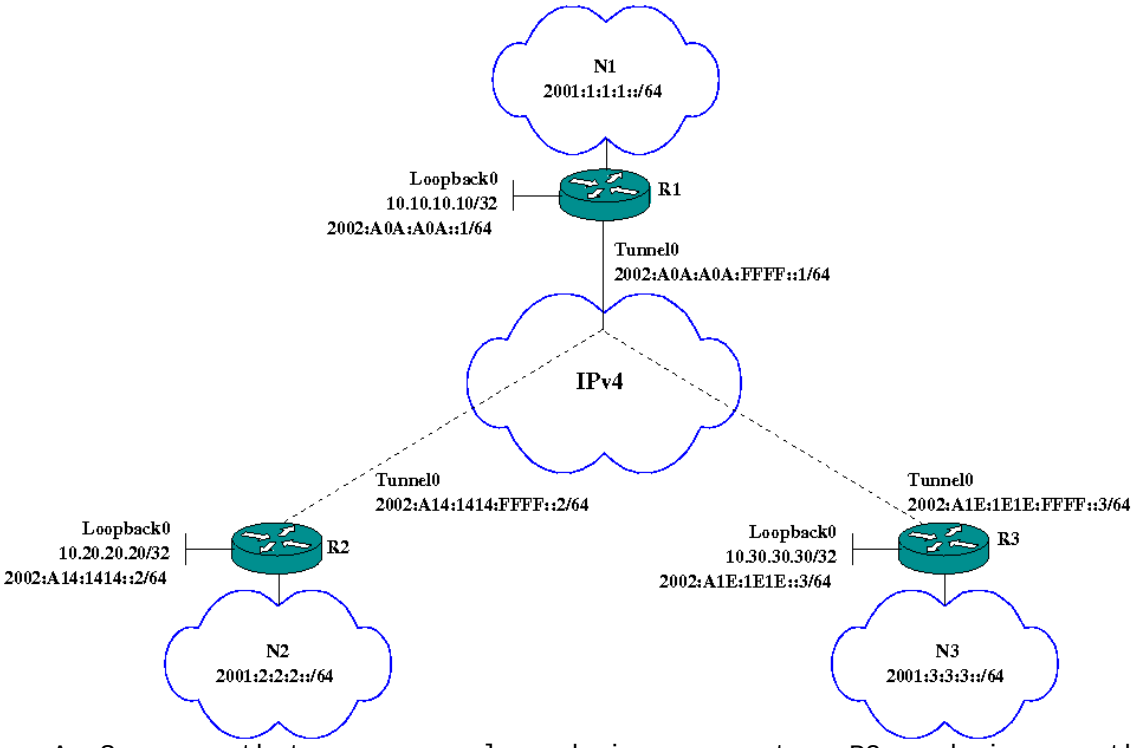
Answer:

Ethernet VPWS: provides a virtual link service where the VPN appears as a point-to-point circuit.
VPLS: provides a virtual switch service where the VPN appears as a (distributed) Ethernet switch, or learning bridge.

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
```

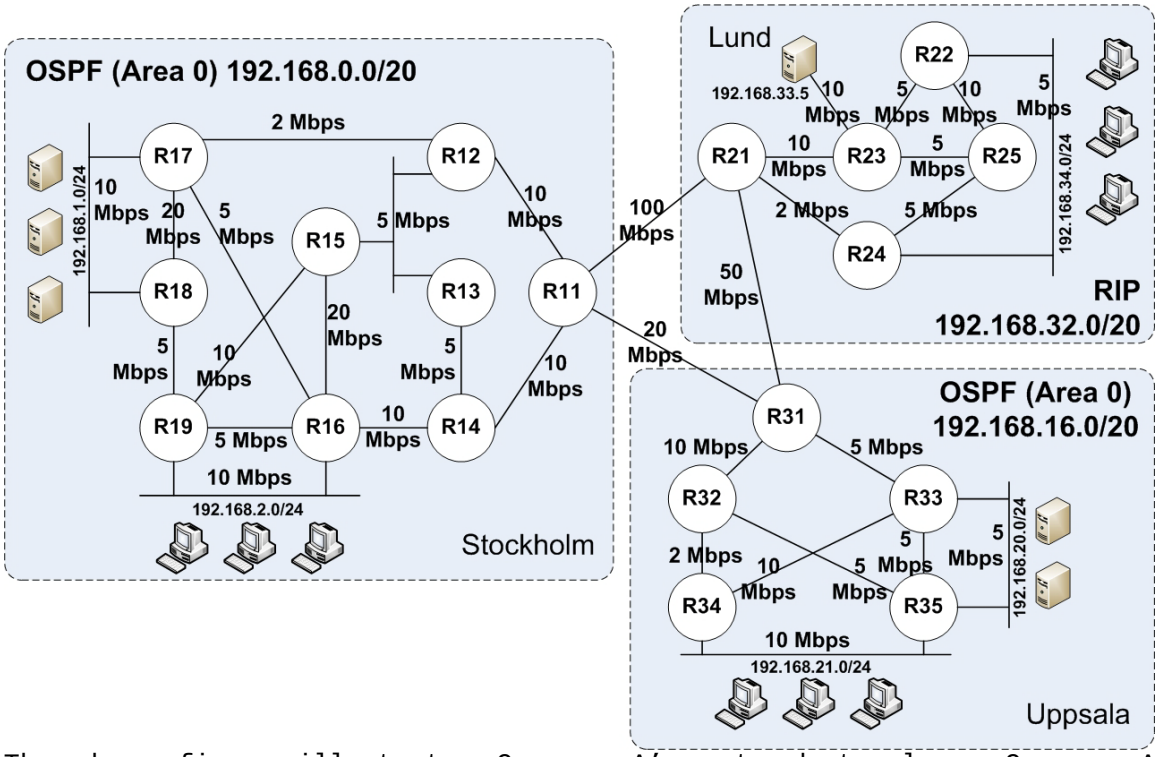
9) TCP and UDP (5p)

A. You are writing an application to send interactive unicast real-time audio over the Internet, such as an IP telephony service. Should you use TCP or UDP as your transport protocol? Briefly motivate you answer. (2p)
B. 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)
C. What is the difference between *offered window* and *usable window* in TCP? (2p)

Answer:

A. The preferred choice is UDP. TCP provides retransmissions and a reliable service. This may give extra delay that is undesirable for such an application.
B. No. TCP is not defined for IP multicast transmissions.
C. The offered window is advertised by the receiver and defines how much data the receiver is ready to accept. The usable window is maintained by the sender and defines the amount of data the sender can transmit immediately.

10) Scenario (10p)



The above figure illustrates Company A's network topology. Company A has three branch offices in different cities each with different networks. First office is located in Stockholm using the 192.168.0.0/20 subnet. 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 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 R11-R21 link, R21-R31 link, and 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 their sole routing protocol within its network. All routers (R31-R35) are running in the backbone area (OSPF area 0). On the other hand, the Lund office uses RIPv2 on all its routers (R21-25).

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

On R11,
All traffic destined to 192.168.16.0/20 forwards to R31
All traffic destined to 192.168.32.0/20 forwards to R21
On R21,
All traffic destined to 192.168.0.0/20 forwards to R31
All traffic destined to 192.168.16.0/20 forwards to R11
On R31,

All traffic destined to 0.0.0.0/0 forwards to R11

In addition to configure static routes, the Stockholm office has been configured to originate default route from R11 to all other routers within the branch office. The Uppsala office has configured R31 to redistribute all static routes into OSPF. The Lund office has configured R21 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, R35 is active router and R33 is passive router. For the user network, R35 is active router and R34 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. R22 is active router and R24 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 Stockholm with IP address 192.168.2.3 is trying to ping a host in Lund with IP address 192.168.34.4. 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

Assume that R15, R16 and R25 have lost electricity and stop running. A host in Stockholm with IP address 192.168.2.3 is trying to ping a host in Lund with IP address 192.168.34.4. 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 Lund with IP address 192.168.34.5 is trying to ping a host in Uppsala with IP address 192.168.21.6. 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 the same scenario as shown in the figure above. 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:

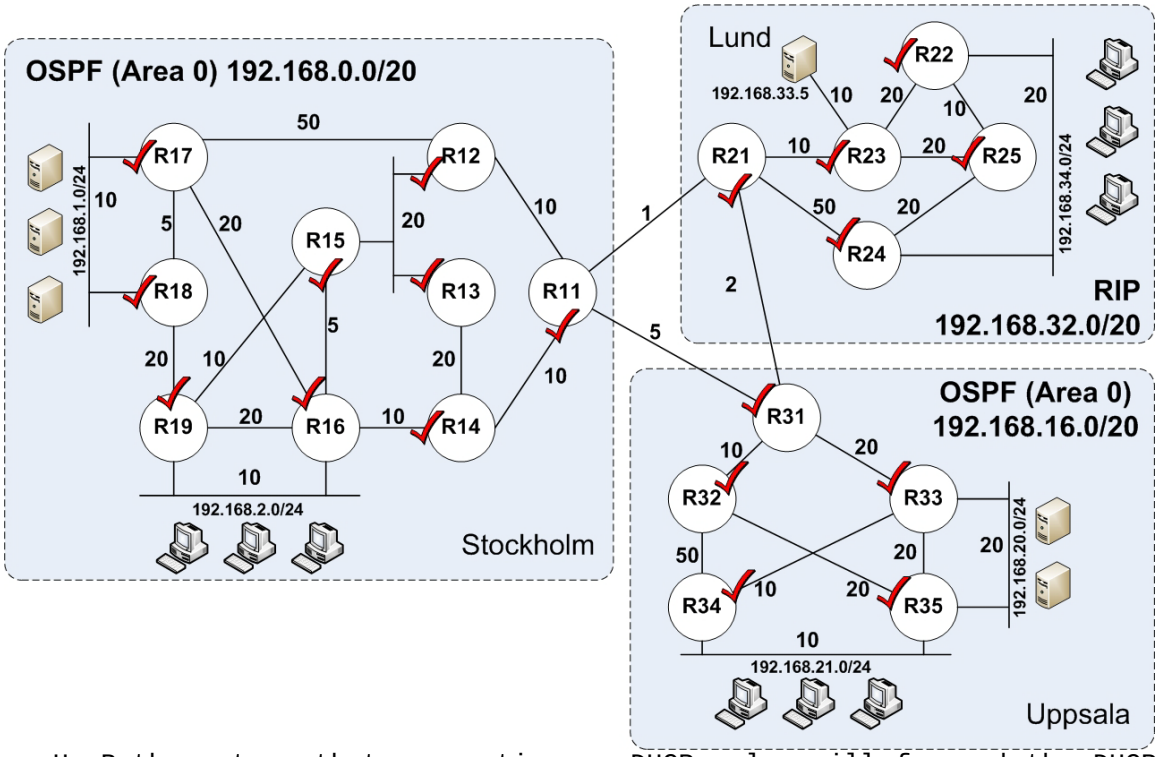
G. Assume that you are using a reverse path forwarding (RPF) scheme for the scenario in the figure to send multicast datagram originating from a streaming server in Stockholm office. Identify the RPF path that will be used for streaming from the streaming server to the different hosts in each office. 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)

Assume that in each office there is one centralized DHCP server.

H. The network administrator has reconfigured R19 and R16 to act as DHCP relay for the client network. When a new client is connected to a network and sends a DHCP discover message on this LAN, which router(s) will take care of this message? (1p)

Answer:

A. 192.168.2.3 -> R19 -> R15 -> R16 -> R14 -> R11 -> R21 -> R24 -> 192.168.34.4
B. 192.168.34.4 -> R22 -> R23 -> R21 -> R31 -> R11 -> R14 -> R16 -> 192.168.2.3
C. 192.168.2.3 -> R19 -> R18 -> R17 -> R12 -> R11 -> R21 -> R24 -> 192.168.34.4
D. 192.168.34.4 -> R22 -> R23 -> R21 -> R31 -> R11 -> R12 -> R17 -> R18 -> R19 -> 192.168.2.3
E. 192.168.34.5 -> R22 -> R23 -> R21 -> R11 -> R31 -> R32 -> R35 -> 192.168.21.6
F. 192.168.21.6 -> R35 -> R32 -> R31 -> R11 -> R21 -> R24 -> 192.168.34.5
G. The RPF paths used for sending the stream are as follow:
    a. 192.168.1.9 -> R18 -> R19 -> 192.168.2.10
    b. 192.168.1.9 -> R17 -> R16 -> R14 -> R11 -> R31 -> R32 -> R35 -> 192.168.21.10
    c. 192.168.1.9 -> R17 -> R16 -> R14 -> R11 -> R31 -> R21 -> R23 -> R22 -> 192.168.34.10



H. Both routers that are acting as DHCP relay will forward the DHCP discover message to the DHCP server.