Test 1: NET3012 – IP Architectures & Solutions

Winter 2014

Time: 50 minutes; Test scored out of: 40 Total Marks available: 46
(Allocation of marks is shown beside each question)

Instructions:

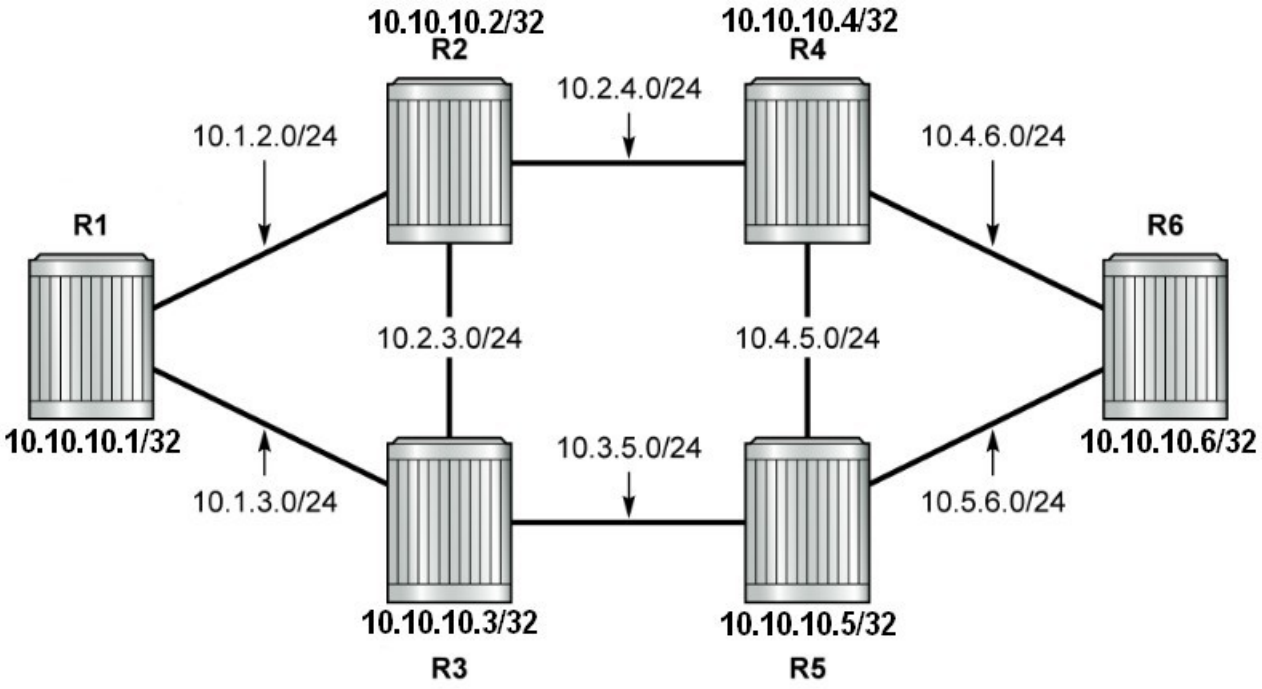
1. BEFORE answering any questions, please check that your copy of the test has all pages (as indicated in the footer at the bottom of each page). Please **read all questions** carefully, then answer question 0 first!
2. This is a **closed book** test. No textbooks, notes, electronic devices, or any other aids are permitted.
3. The lab guide we've been using is dated Nov 24, 2011.
4. If you are uncertain what a question is asking, make reasonable assumptions, write those assumptions down on this test paper, and continue answering the question.

0. What is your:

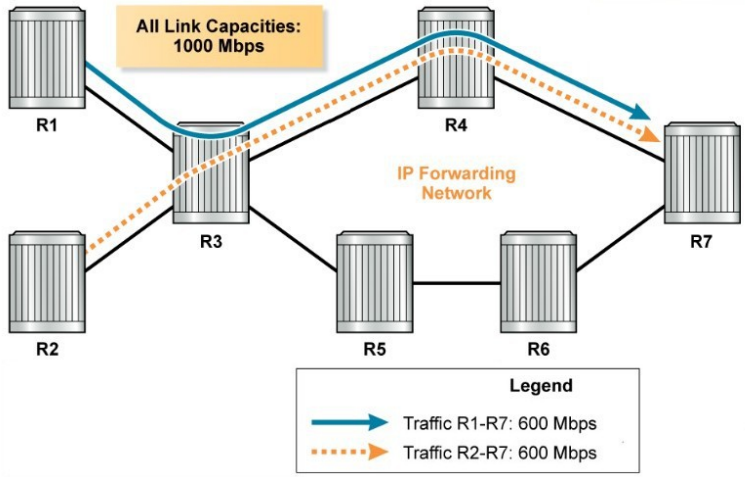
NAME? Answers

Reference Topology

Use the topology below for questions which refer to R1-R6 but do **not** have a topology diagram. Note that this is the standard topology we have been using throughout the course.



1. A. [2 marks] **Clearly** explain the term "hyper-aggregation". Specific details from the diagram on the right (eg. addresses, links, and/or hosts) **must** be included in your explanation.



Links R3-R4 and R4-R7 suffer from hyper-aggregation.

Hyper-aggregation is the tendancy of an IGP to send all traffic over the same links, resulting in some links becoming saturated while others remain under-used.

B. [2 marks] **Clearly** explain: **What** role can Traffic-Engineering play in the above scenario? **Why** (or how) is it able to accomplish what it does?

Traffic-engineering allows path selection based on criteria other than cost, which allows balancing of traffic across multiple links to alleviate potential hyper-aggregation.

2. [3 marks] Name and briefly describe the 3 different VPN services made possible by MPLS.

Layer 1 VPN: aka **VLL** or **VPWS**; a virtual point-to-point connection; simulates a "wire"

Layer 2 VPN: aka **VPLS**; a virtual "switch" with "ports" anywhere within the service provider's network.

Layer 3 VPN: aka **VPRN**; a virtual router with ports anywhere within the service provider's network.

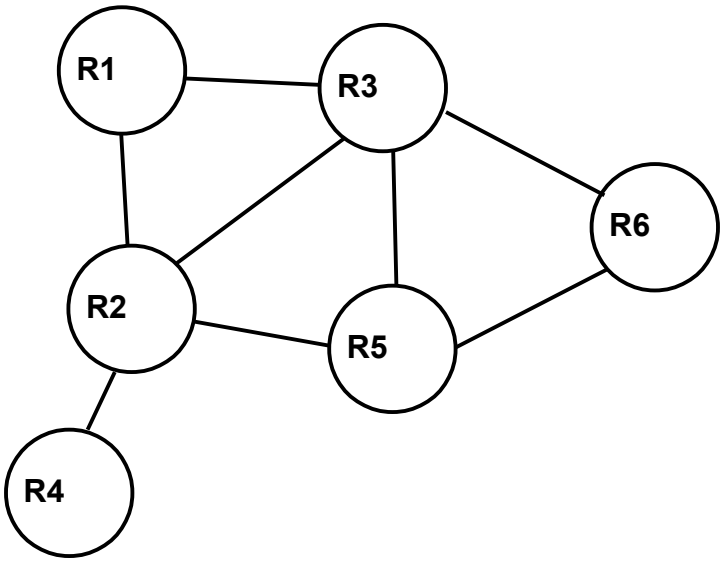
3. [3 marks] **Clearly** define the three MPLS label operations. [Ref: slide 1-40, Q4]

PUSH — An MPLS header is inserted into a frame
SWAP — An existing MPLS header is exchanged for a new MPLS header
POP — An MPLS header is removed from a frame

4. [2 marks] **Clearly** define the terms LFIB and LIB. Include their relevance to the appropriate router plane. (Reminder: there are two planes in a router.)

   LIB: Label Information (data)Base; created in the control plane by protocols such as LDP or RSVP.
   LFIB: Label Forwarding Information (data)Base; downloaded to the data plane; used for forwarding (switching) frames/packets along a Label Switched Path (LSP).

5. Carefully examine the network topology below. There are six routers; the label tables for the first five routers are given on the right.



X: R6-R5-R3-R2-R1; **Y**: R6-R3-R1-R2-R4
Z: R6-R5-R3-R1-R2; **Q**: R6-R3-R1-R2-R5

A. [4 marks] Complete the last column in the table below, showing which router originates each FEC.

R6 Label Table

FEC	OUT Label	Next Hop	Originator?
X	100	R5	
Y	200	R3	
Z	300	R5	
Q	400	R3	

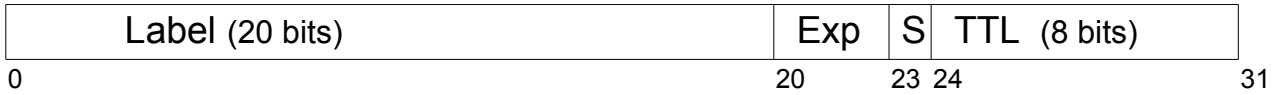
X = R1; Y = R4; Z = R2; Q = R5

B. [2 marks] Pick one of the FECs from R6's table. **Circle** it. Identify all **eLER**, **iLER**, and **LSR** routers relevant to that FEC by writing those terms on the topology diagram above.

iLER at origin; eLER at R6; LSR at other hops

IN label	OUT label	Next Hop
R1		
240	130	R2
110	pop	IP
330	pop	IP
140	160	R2
150	170	R2
R2		
170	pop	IP
210	330	R1
130	150	R4
160	260	R5
R3		
100	110	R1
140	130	R2
220	330	R1
120	210	R2
400	140	R1
130	260	R5
350	150	R1
200	240	R1
R4		
150	pop	IP
R5		
160	130	R2
100	120	R3
300	350	R3
260	pop	IP

6. [4 marks] Pictured below is an MPLS header in an ethernet frame. In the available space, write the name of each of the four fields, then briefly (but **clearly**) describe each one below. [Ref: slide 2-16]



Label (20 bits): assigned by the router to a unique path; used for forwarding traffic
Exp (3 bits): field for marking traffic with QoS bits, to determine treatment of traffic (formerly Experimental field, but now they've decided what to use it for!)
S (1 bit): bottom of Stack flag; identifies the current Label as the last (bottom) label
TTL (8 bits): Time To Live; measured in MPLS hops; same role as TTL in IP header

7. [1 mark] A customer packet passes through 10 LSR routers in the service provider's MPLS VPN network. What happens to the TTL in the customer packet at each of those 10 hops? Assume the service provider's equipment is running in pipe mode. [Ref: slides 2-17,18]

"Nothing" (regardless of L2 or L3 VPN); that's the definition of pipe mode!

8. [2 marks] Give the three label handling characteristics of LDP.
Give the three label handling characteristics of RSVP. [Ref: slide 2-38]

LDP: Downstream unsolicited; Ordered; Liberal retention

RSVP: Downstream on Demand; Ordered; Conservative retention

9. [1 mark] MPLS routers depend on (and **require**) what (kind of) protocol to distribute the **reachability** information that the routers use to generate LFIB entries? [Ref: slide 2-57, Q9]

IGP; it's *always* required to be complete and converged for MPLS to function at all!

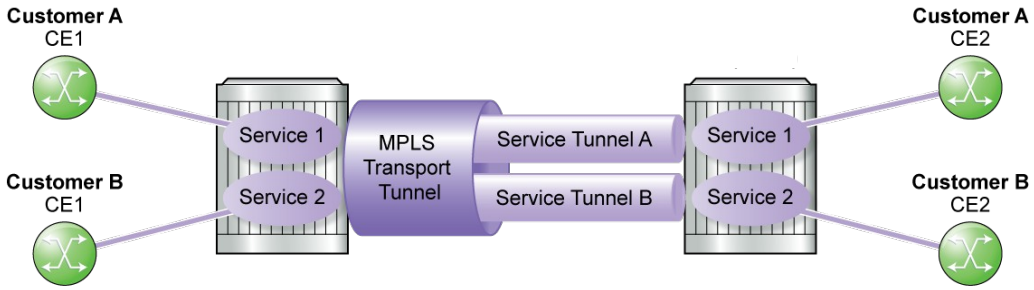
10. **A**. [1 mark] Which label distribution method requires that the iLER request and wait to receive a label from the next-hop before forwarding data downstream? (But see part B!)

Downstream On Demand

B. [1 mark] Which protocol **uses** the above method?

RSVP

11. Carefully examine the diagram below: it shows two customers of a service provider who need full connectivity between their branch offices on opposite sides of the country [Ref 3-6]



A. [1 mark] Link LDP is used for one type of tunnel; T-LDP is used for the other type. **Clearly** identify which type of LDP is used for each type of tunnel.

Transport tunnel: link LDP; Service tunnels: targeted LDP
(This is really a pair of true/false questions.)

B. [2 marks] Think carefully: in the above scenario, what is the total number of LSPs required to implement full connectivity for both clients? **Explain** your answer!

6 LSPs: First, LSPs are always uni-directional (regardless of signaling protocol) so double whatever number of "connections" you determine.
Service tunnels are unique to a FEC, so there need to be **2** (T-LDP) service connections
Transport tunnels can be multiplexed by the service label so only **1** transport connection

12. A. [1 mark] **Identify** which Layer 4 transport protocol is used to establish LDP adjacencies, and to establish LDP sessions.

UDP: used to send LDP Hello messages, to establish an adjacency
TCP: used to establish LDP session between routers

B. [1 mark] **Identify** any changes between link and targeted LDP.

No change to the L4 protocol (the only difference is the L3 IP address: link LDP uses multicast address 224.0.0.2 whereas T-LDP uses the unicast address of the target)

13. The figure below shows the output from "show router ldp bindings" from router R1 in the reference topology (shown on the cover page). Examine it carefully and then answer the questions below about the rows that have been highlighted with bold font.

```
A:R1# show router ldp bindings
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
================================================================================
Prefix              Peer            IngLbl    EgrLbl EgrIntf/    EgrNextHop
--------------------------------------------------------------------------------
10.10.10.1/32       10.10.10.2      131070U     --     --          --
10.10.10.1/32       10.10.10.3      131070U     --     --          --
10.10.10.2/32       10.10.10.2        --      131071 1/1/4       10.1.2.2
10.10.10.2/32       10.10.10.3      131071U   131066   --          --
10.10.10.3/32       10.10.10.2      131069U   131066   --          --
10.10.10.3/32       10.10.10.3        --      131071 1/1/3       10.1.3.3
10.10.10.4/32       10.10.10.2      131068N   131070 1/1/4       10.1.2.2
10.10.10.4/32       10.10.10.3      131068U   131069   --          --
10.10.10.5/32       10.10.10.2      131067U   131069   --          --
10.10.10.5/32       10.10.10.3      131067N   131068 1/1/3       10.1.3.3
10.10.10.6/32       10.10.10.2      131066N   131068 1/1/4       10.1.2.2
10.10.10.6/32       10.10.10.3      131066U   131067   --          --
--------------------------------------------------------------------------------
```

A. [1 mark] **Clearly** explain why there are no egress details for the first two rows (in bold).

The first two lines identify R1 as the **eLER** for reaching *itself*, so no additional forwarding is required, so no egress is necessary.

B. [2 marks] For the first two rows (in bold), the ingress label is identical. Will that always be the case? **Clearly** explain why or why not.

Yes, because with per-platform label space always uses the *same* label for a given FEC (or destination). In this case, the destination is the system interface of R1.

C. [2 marks] For the last two rows in bold, the egress label is identical. Will that always be the case? **Clearly** explain why or why not.

No, it's purely coincidence in this case. For the upper line, R3 happened do use that particular label value to reach R5. For the lower line, R2 happened to use the same label value to reach R6.

D. [1 mark] For the middle row that's bolded, the ingress label is marked with "**N**". **Clearly** explain the significance and reason for that marking.

That label was handed out by R1 to R2 in order to reach R4. Under the current state of the IGP, R2 lies in the direct path to R4 so R2 should not be sending traffic to R4 via R1. Based on that criteria, the label is currently "Not used".

14. [2 marks] **Clearly** explain the use of a PSB and RSB in the creation of an RSVP LSP.

    A PSB (Path State Block) is created upon receipt of a (new) PATH message.
    The PSB stores details of the PATH request, and enables a match to a RSB (later).
    A RSB (Reservation State Block) is created upon receipt of a (new) RESV message.
    The RSB contains information such as the label, and has enough information to uniquely match a PSB.

15. [1 mark] By default, how does RSVP ensure that sessions don't time out?

    By default, every single RSVP session is refreshed by repeating the entire sequence of PATH + RESV messages traversing across the entire network from head to tail end.

16. Some students are experimenting with RSVP. They ensure that both MPLS and RSVP are enabled and running on suitable interfaces, and then type exactly the lines below:

```
path "empty_list"
exit
lsp "to_R6"
  to 10.10.10.6
  primary "empty_list"
  exit
exit
```

    A. [1 mark] What command could be used to test whether the LSP is fully operational?

    Either: **`oam lsp-ping to_R6`** or **`oam lsp-trace to_R6`**

    B. [2 marks] Unfortunately the LSP isn't working! What's missing? (Either explain, or better yet, fix it!)

    Both the **`path empty_list`** and the **`lsp to_R6`** are missing a **`no shutdown`**
    (Add one immediately after the "path" command, and after the second-last line.)

17. [1 mark; Bonus] What's the date on the front cover of the MPLS lab guide?

    Nov 24, 2011 … See the instructions on the front page!

Extra Work