

# Test 1: NET3012 – IP Architectures & Solutions

Winter 2018

Time: 80 minutes; Test scored out of: 60 Total Marks available: 65  
(Allocation of marks is shown beside each question)

## Instructions:

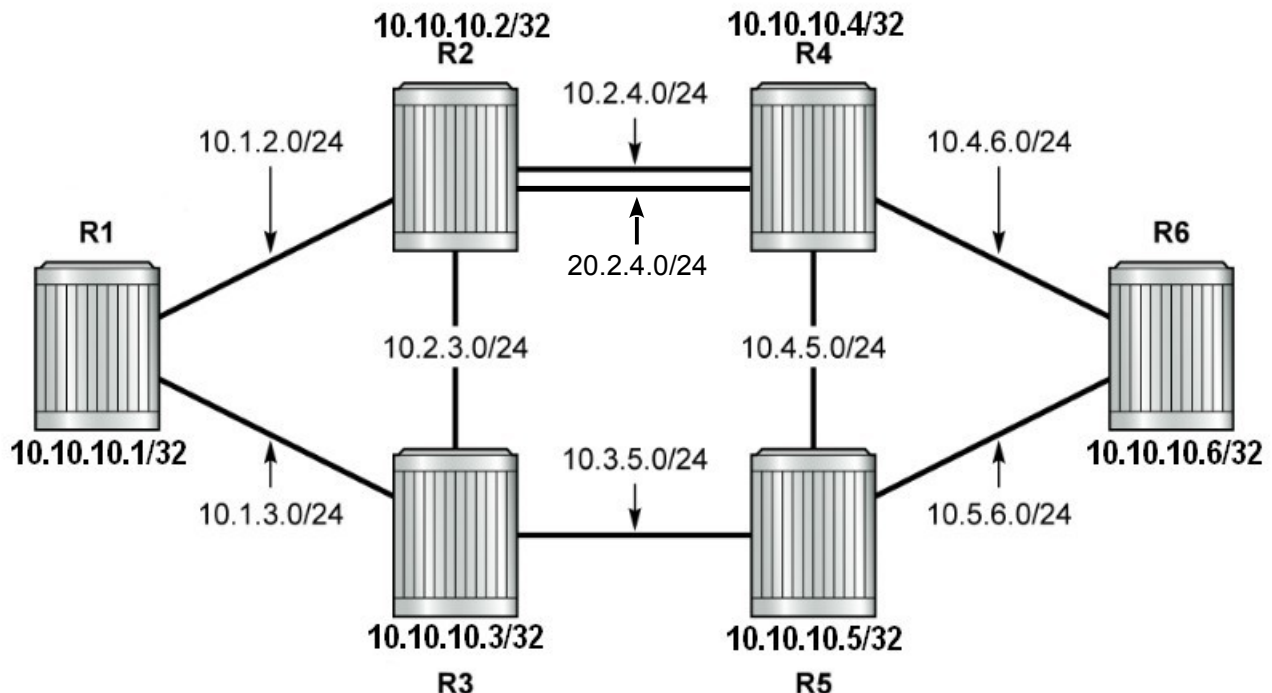
1. **BEFORE** answering any questions, please check that your copy of the test has all pages (as indicated in the footer at the bottom of each page). Please **read all questions** carefully, then answer question 0 first!
2. This is a **closed book** test. No textbooks, notes, electronic devices, or any other aids are permitted.
3. Recall from NET1002 that PDU means Protocol Data Unit.
4. Be sure to carefully examine the reference topology provided below.
5. 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? \_\_\_\_\_

## Reference Topology

Use the topology below for questions which refer to R1-R6 but do **not** have a topology diagram. Note that this is similar to the topology used throughout the MPLS courseware and slide decks.

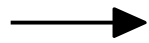
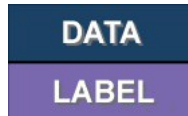


1. A. [6 marks] Imagine three routers which implement a Label Switched Path.

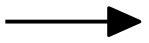
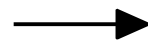
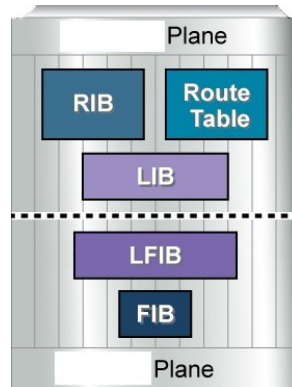
Using the diagrams of the routers provided below:

- clearly identify which *type of PDU* ingresses and which *type of PDU* egresses (i.e. re-draw them at each location where they should be!)
- clearly illustrate the flow of the frame *through* the router (i.e. which tables are used to process the frame), according to the role labeled for each router. (Ref: Mod 1.39-40)

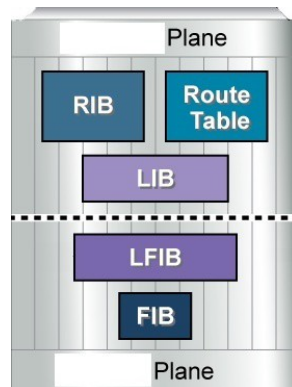
Sample PDU Types



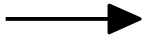
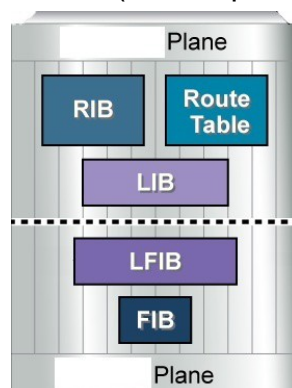
**eLER** (Label op = \_\_\_\_\_)



**iLER** (Label op = \_\_\_\_\_)



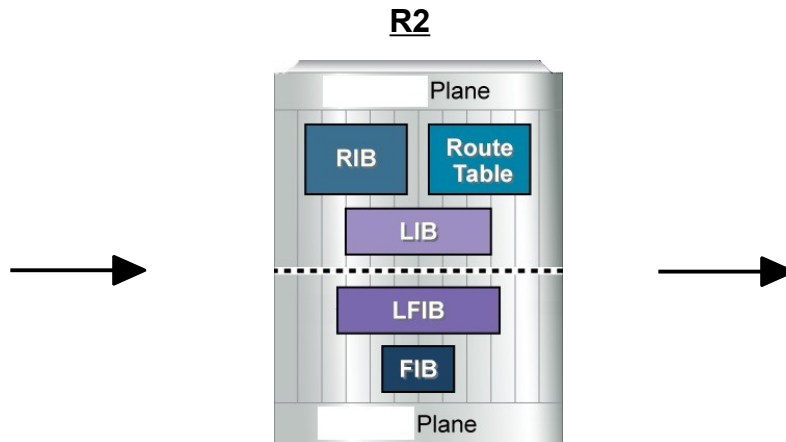
**LSR** (Label op = \_\_\_\_\_)



**B.** [2 marks] Next, clearly label the different **planes** for each of the three types of routers.

**C.** [1 mark] Lastly, clearly label the type of label operation that's occurring at each router.

2. A. [2 marks] Similarly to the previous question, clearly identify the flow of a ***PATH message*** through a MPLS router. Ref: Module 4.18, 20, 21



B. [2 marks] Assuming the ***PATH message*** is sent by R1 to R6:

- draw a simple sketch of the ingress packet and egress packet in the correct locations;
- clearly identify actual values of key fields (and any important options) in the IP header, and any label values (if appropriate).

3. [1 mark] Clearly identify which protocol(s) contribute information that is used to populate the LFIB.

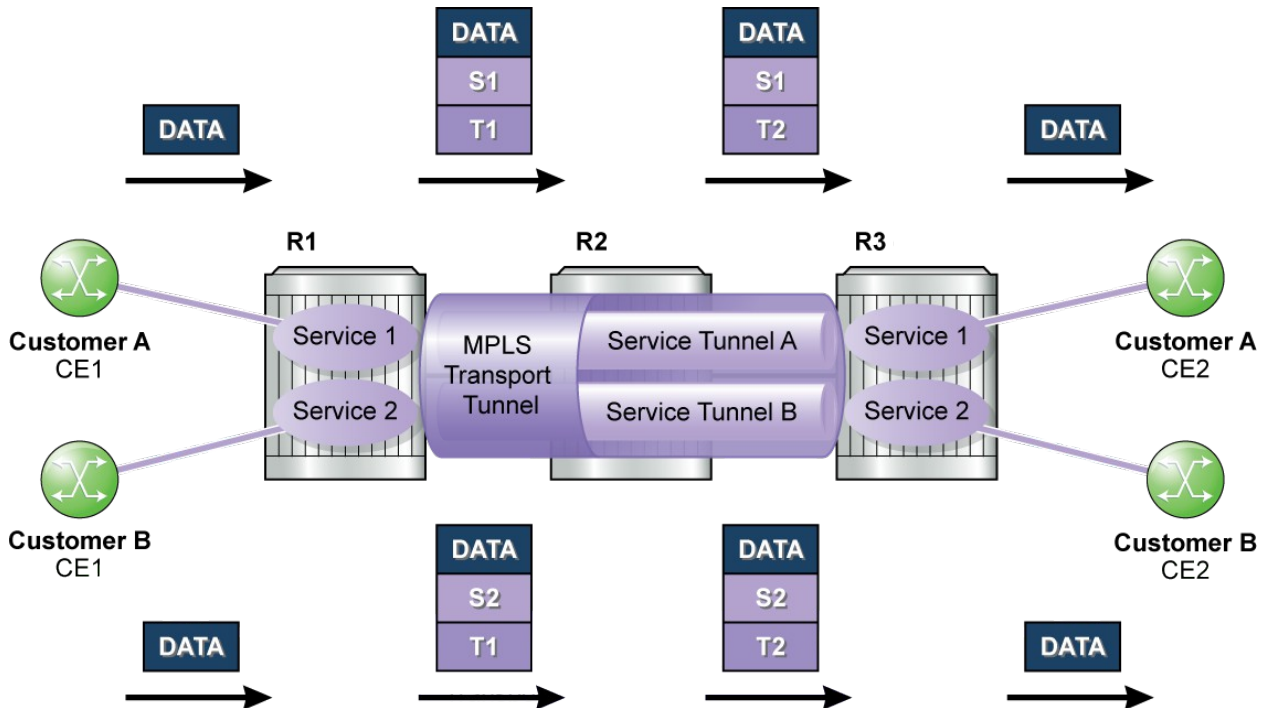
4. A. [1 mark; all-or-nothing] So far in the course, we've treated "FEC" as equivalent to a IPv4 subnet but the definition given in the course materials has three aspects to it. The full, proper definition for a FEC is "a group of frames/packets that are forwarded ..."

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

B. [1 mark] A key distinction between ***pure IP routing*** and ***MPLS label switching*** is **where** [***at which router(s)***] FEC lookup is done. (Ref: Mod 1.30-31)

- For IP routing, where is FEC lookup done? \_\_\_\_\_
- For MPLS label switching, FEC lookup is done \_\_\_\_\_

5. Carefully examine the diagram below of a Service Provider network (adapted from Mod 2.7)



A. [1 mark] Clearly identify the following terms by labeling the diagram appropriately:

- Downstream, Upstream
- Head end, Tail end (assuming RSVP for this one item)

B. [1 mark] Use an "S" to clearly mark all labels with the "S" bit set.

C. [1 mark] What exact protocol(s) could have been used to distribute:

service labels: \_\_\_\_\_ transport labels: \_\_\_\_\_

D. [2 marks] How were the labels distributed? Give full details below. Include all possible routers and protocols, as appropriate.

Label S1: distributed by R\_\_\_ to R\_\_\_ using protocol(s) \_\_\_\_\_

Label S2: distributed by R\_\_\_ to R\_\_\_ using protocol(s) \_\_\_\_\_

Label T1: distributed by R\_\_\_ to R\_\_\_ using protocol(s) \_\_\_\_\_

Label T2: distributed by R\_\_\_ to R\_\_\_ using protocol(s) \_\_\_\_\_

E. [2 marks] Assuming a VPN with Traffic Engineering, list all the labels that were sent:

Downstream on Demand: \_\_\_\_\_ Downstream Unsolicited: \_\_\_\_\_

Ordered Control: \_\_\_\_\_ Independent Control: \_\_\_\_\_

Liberal Retention: \_\_\_\_\_ Conservative Retention: \_\_\_\_\_

F. [1 mark] Assuming a VPN with Traffic Engineering, how many additional "T" labels must exist (if any)? # of extra labels = \_\_\_\_\_

6. [3 marks]

A. Within an LSR in a **L1** MPLS VPN service running over ethernet, what is the minimum and maximum total number of L2 headers that could appear in a PDU?

Minimum: \_\_\_\_\_ Maximum: \_\_\_\_\_

B. Within an LSR in a **L2** MPLS VPN service running over ethernet, what is the minimum and maximum total number of L2 headers that could appear in a PDU?

Minimum: \_\_\_\_\_ Maximum: \_\_\_\_\_

C. Within an LSR in a **L3** MPLS VPN service running over ethernet, what is the minimum and maximum total number of L2 headers that could appear in a PDU?

Minimum: \_\_\_\_\_ Maximum: \_\_\_\_\_

7. [4 marks] Did you completely understand our lab work with LSPs and TTL values? If yes, read these next questions carefully so that you can give the correct answer!

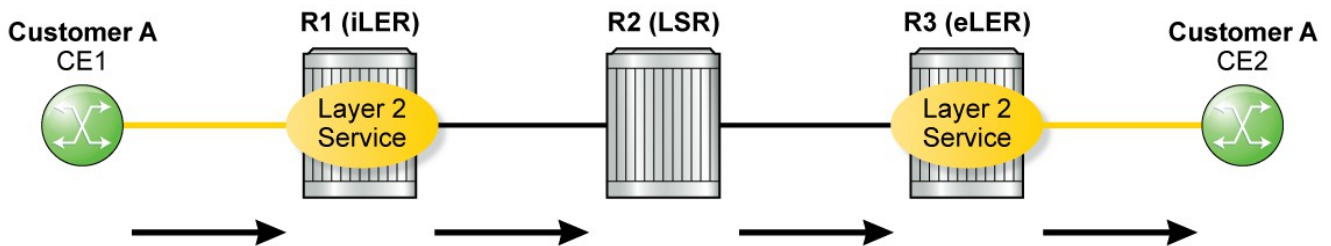
**A.** Clearly explain what property of OAM commands makes it possible for `oam lsp-trace` and `ping` to show a different number of hops?

**B.** Clearly explain what property of LSPs makes it possible to have a different number of hops between a `traceroute` command and a `ping` command?

**C.** Clearly explain what two commands (or parameters) act as on/off switches to influence the number of hops seen by `traceroute` and `ping` commands?

**D.** Clearly explain the difference (or give example usages) between using OAM commands to test an LDP LSP vs a RSVP LSP?

8. A. [4 marks] The course notes give clear, specific diagrams showing how customer data frames are handled by L2 & L3 services in Pipe mode, and L3 services in Uniform mode. They omit any diagram of L2 services operating in uniform mode. Prove your knowledge and understanding of MPLS by completing the diagram below for a L2 service in Uniform mode. Be sure to show all:  L2 headers  L3 headers  Labels  TTL values.



B. [2 marks] Use symbols (e.g. ①, ②, ③, ...) to mark all L2 headers. Use the same symbol if/wherever headers are identical.

9. [1 mark] Consider only routers R2-R5 of the reference topology (cover page). Assume LDP is fully and correctly configured on all four routers. In total, how many RSVP LSPs are needed so there's as many as LDP LSPs?

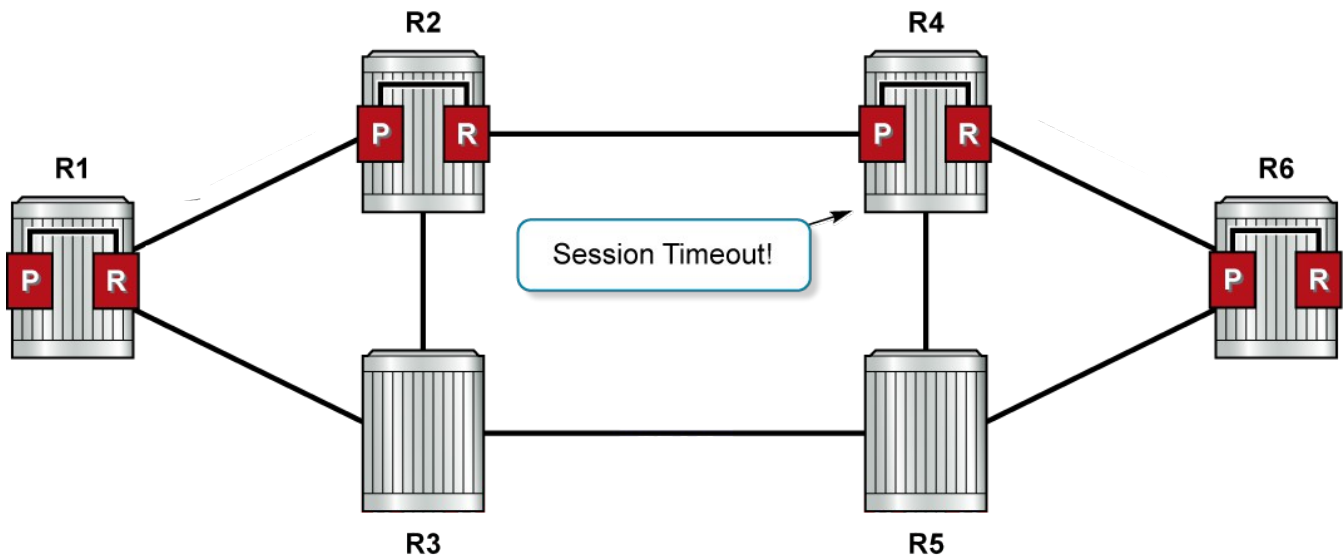
10. A. [1 mark] The Cisco routers in T108 are capable of basic MPLS functionality. Based on your exposure to Cisco routers in NET2001 (and NET3008?) and your existing knowledge of MPLS, are the routers capable of demonstrating cell mode? Why or why not?

B. [1 mark] Based on your response above, what kind of label-space would be used?

11. **A.** [1 mark] 3<sup>rd</sup> year BIT-NET is *filled* with acronyms, in all courses. Python is a well known and well-used programming language for web applications; it's also available on the Nokia SR OS for Triple Play. **Clearly** describe what is "Triple Play" (i.e. in a networking context, not a baseball context).

**B.** [1 mark] You'll also recognize PHP from NET3010 - Web Programming. PHP is also available on the Nokia SR OS. **Clearly** describe the details of Nokia's PHP implementation. (e.g. When is it used? Why? Etc)

12. [3 marks] Pictured below is an LSP from R1 → R6 that had been Up/Up for some time when a timeout occurred at R4. (Ref: 4.39)



**A.** Clearly identify the LSP protocol shown above. \_\_\_\_\_

**B.** How does R4 respond to the session timeout? i.e. By annotating the diagram, clearly identify the type(s) of message(s) it will send out, and in which direction(s).

**C.** By annotating the diagram, **clearly** show two ways that the other routers respond.

13. [3 marks] Timeouts are always undesirable. The protocol above has several optimizations for very busy networks. There's a specific pair of optimizations that work together to provide protection against lost messages [somewhat "similar" to the error protection in TCP but perhaps better?]. (Ref: Module 4.54)

**Clearly** explain the pair. A diagram could be an excellent way of explaining.

14. [1 mark] **Clearly** explain the connection between Special Use labels and PHP.

15. **A.** [1 mark] Explain **clearly** how the SR OS ensures that RSVP (7) and LDP (9) tunnels are used instead of sending data via regular IP routing when IGP shortcuts are enabled?

**B.** [1 mark] Explain **clearly** how an intermediate MPLS router (running in frame mode) knows whether it's receiving a simple, regular IP packet or MPLS data plane traffic? (... So that it knows how to process it properly!)



16. Carefully examine the output of "show router ldp bindings active" below (Ref: NRSII p. 554)

```
*A:R1# show router ldp bindings active
```

Prefix	Op	IngLbl	EgrLbl	EgrIntf/LspId	EgrNextHop
10.10.10.1/32	Pop	131071		--	--
10.10.10.2/32	Push	--		1/1/X	10.1.X.X
10.10.10.2/32	Swap	131070		1/1/X	10.1.X.X
10.10.10.3/32	Push	--		1/1/X	10.1.X.X
10.10.10.3/32	Swap	131069		1/1/X	10.1.X.X
10.10.10.4/32	Push	--		1/1/X	10.1.X.X
10.10.10.4/32	Swap	131068		1/1/X	10.1.X.X
10.10.10.5/32	Push	--		1/1/X	10.1.X.X
10.10.10.5/32	Swap	131067		1/1/X	10.1.X.X
10.10.10.6/32	Push	--		1/1/X	10.1.X.X
10.10.10.6/32	Swap	131066		1/1/X	10.1.X.X

A. [2 marks] If this command was executed on **R4**, how would the table look? Modify the table accordingly.

B. [2 marks] Give examples for all egress labels in the table. Label values *must be plausible*  
 Tip: Are there values which *must* be identical? Are there values which *must* be different?

C. [2 marks] From our lab work, modify the label table to show how it would look on a Nokia router if the prefixes were all /24 subnets (i.e. 10.10.10.1/32 → 10.10.1.0/24, etc)

17. Have you been keeping up with lab work? Route redistribution is done differently under the Nokia SR OS than on Cisco IOS.

A. [1 mark; Bonus] What statements are used to a *define* redistribution policy?

B. [1 mark] What statement(s) *activate* (or put into use) a redistribution policy?

18. [1 mark + 1 bonus mark] Have you been keeping up with the lab work? We've already implemented one or more direct applications for LDP and/or RSVP LSPs. **Clearly** identify as many of these variants or uses as you can for LSPs, based on our lab work.
19. [2 marks] What aspect impressed you the most during William Vail's talk about his work at CENGN? Explain clearly with as much detail as possible.
20. [1 mark; Bonus] During the field trip, what impressed you the most about the technology in use, or in development, at Nokia? Alternatively, you could also discuss any one of the product teams. Explain clearly with as much detail as possible.

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END

## Extra Work

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