

Test 1: NET3012 – IP Architectures & Solutions

Winter 2017

Time: 60 minutes; Test scored out of: 48 Total Marks available: 53
(Allocation of marks is shown beside each question)

Instructions:

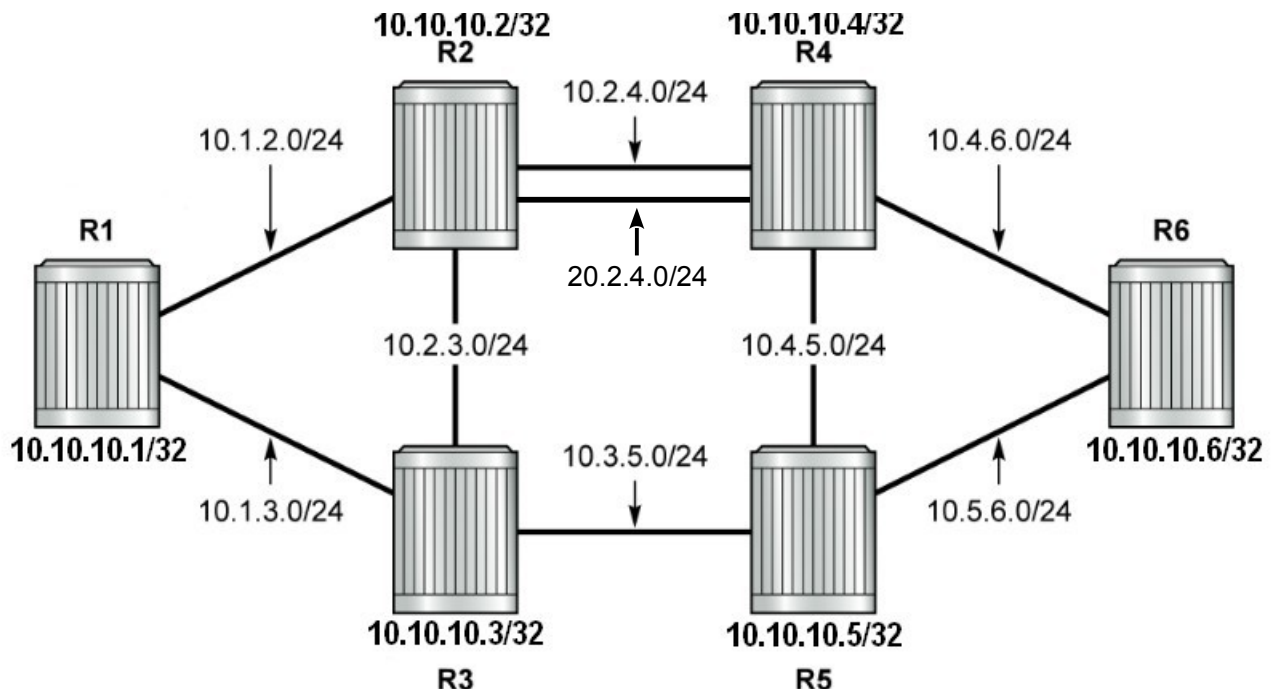
1. **BEFORE** answering any questions, please check that your copy of the test has all pages (as indicated in the footer at the bottom of each page). Please **read all questions** carefully, then answer question 0 first!
2. This is a **closed book** test. No textbooks, notes, electronic devices, or any other aids are permitted.
3. Be sure to carefully examine the reference topology provided below.
4. There's one question where you think you need extra space to answer but you don't.
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? 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 similar to the topology used throughout the MPLS courseware and slide decks.



- [2 marks] Module 1 identified two mechanisms of MPLS that provide High Availability. **Clearly** identify each of the two mechanisms. Hint: this is a repeat from a previous midterm except the wording has been changed slightly. Ref: slide 15.

fast re-route; secondary LSPs

- [2 marks] Module 1 says that MPLS can help solve the problem of hyper-aggregation. From amongst the various forms of MPLS protocols that we've studied, **clearly** identify all that are suitable for reducing or eliminating hyper-aggregation and **why**.

[1 mark] RSVP only

[1 mark] Hyper-aggregation is caused by IGP always choosing the same path and LDP always follows the IGP so no relief from hyper-aggregation.

Note: ECMP won't solve the hyper-aggregation problem since it too always follows the same paths; the problem is only delayed until a higher level of traffic is reached

Note: Saying LDP counts against you since LDP always follows the IGP!

- [2 marks] Draw a **clear** sketch of an MPLS header. Be sure to identify the name and size/length of each field.

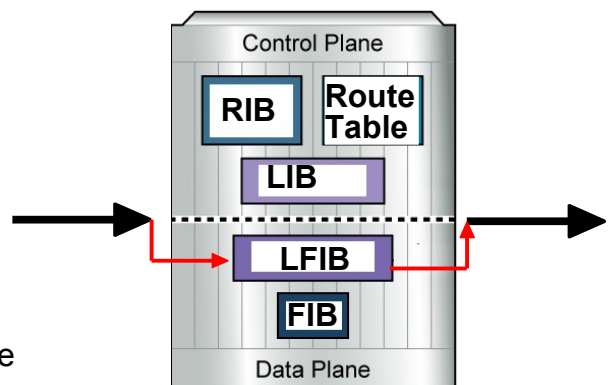
[1 mark for all four fields; 1 mark for all field lengths]



- [1 mark] Explain **clearly** why LDP would be used for implementing a BGP-free core rather than RSVP.

LDP provides a full-mesh of LSPs by default; every RSVP LSP is built individually

- A. [1 mark] In the diagram on the right shows an MPLS router. **Clearly** identify (eg. name) all the most important data tables that are maintained (i.e. via dynamic protocols).



- B. [1 mark] Assume the router is a "P" router. **Clearly** illustrate which tables are involved in forwarding an MPLS packet through the router. (One way to illustrate is to mark-up the diagram similar to the way it was originally marked up in the slide deck!)

a P router = LSR = only LFIB is necessary or used

6. Carefully examine the output of "show router ldp bindings active" below.

```
# show router ldp bindings active
```

Prefix	Op	IngLbl	EgrLbl	EgrIntf/LspId	EgrNextHop
10.10.10.1/32	Push	--	131070	1/1/3	
10.10.10.1/32	Swap	131067	131070	1/1/3	
10.10.10.2/32	Push	--	131071	1/1/4	
10.10.10.2/32	Swap	131071	131071	1/1/4	
10.10.10.3/32	Push	--	131071	1/1/3	
10.10.10.3/32	Swap	131069	131071	1/1/3	
10.10.10.4/32	Push	--	131068	1/1/4	
10.10.10.4/32	Swap	131068	131068	1/1/4	
10.10.10.5/32	Pop	131070	--	--	
10.10.10.6/32	Push	--	131068	1/1/3	
10.10.10.6/32	Swap	131066	131068	1/1/3	

A. [1 mark] On which router was this command executed? **R5**

B. [1 mark] Explain **clearly** why? i.e. Justify your answer.

POP only appears on the router where command is executed.

C. [1 mark] There are **no** repeated numbers showing in the IngLbl column. Explain **clearly** whether this must always be the case or whether there could be repeats.

Assuming the default per-platform label space: this **must** always be the case: each prefix (dest) is a unique FEC so must offer a unique label for each FEC to LDP peers. (If per-interface is explicitly stated, then an answer of repeated labels is acceptable.)

D. [1 mark] In the EgrLbl column there are repeats of pairs of labels with identical values. Explain **clearly** whether this must always be the case or whether there could be *no* repeats.

Labels received from peers have no correlation; there may be repeated pairs or not. (However, there must **never** be a repeated pair to the same egress interface!)

E. [2 marks] The listing has been edited for this test. Were the entries in the EgrLbl column changed in a way that results in two (or more) LSPs that merge together into one (ie. labels having the same value)? Explain **clearly** why or why not.

Whatever editing may have been done did **not** create merged LSPs: since there is never a repeated combination of label + egress interface, next-hop LSRs always receive a unique value of label which lead to a unique destination.

7. [2 marks] **Clearly** explain the **difference** between "per platform" and "per interface" LDP label spaces, and give **examples** of where each is used.

A per platform label space means the same label value is distributed to all peers for a given FEC i.e. there is one, single set of labels for the router's entire set of FECs.

A per interface label space means every interface has its own completely separate set of labels; different peers may be given different labels for the exact same FEC.

Frame mode MPLS uses per-platform; Cell mode MPLS uses per interface.

8. [4 marks] Assume a service provider's network consists of 3 routers organized in a simple chain. **Clearly** explain the effects on the IP TTL field in a customer's packet when traversing an ePipe service operating in:

A. pipe mode None; no change in TTL. An ePipe is a "wire"!

B. uniform mode None; no change in TTL. An ePipe is a "wire"!

C. What exact protocol would be used to signal the service labels for the above ePipe?

T-LDP is used to signal labels for L2 services

D. **Clearly** explain which label(s) would have the S bit set to 1. (A conceptual answer is sufficient for this question.)

The service label at each hop would have the S bit set.

9. [3 marks] This question refers to **LDP** configured in the reference topology (cover page)
A. How many LDP sessions exist between each pair of routers? (Assume all interfaces are suitably and correctly configured for LDP.)

1 (one)

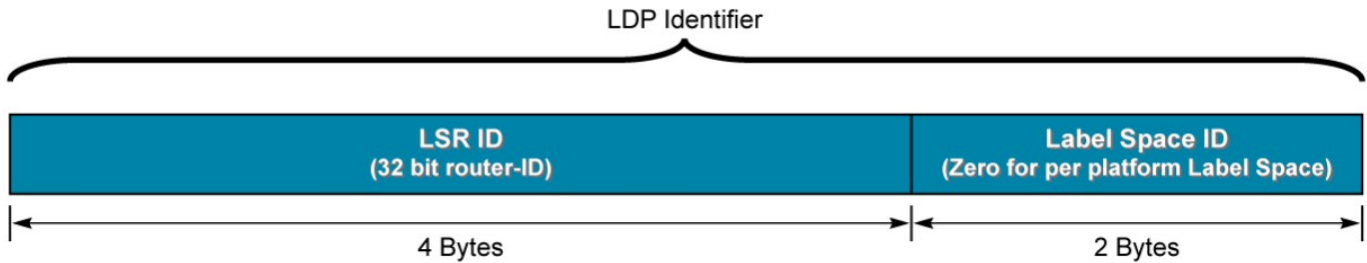
B. Now, go back and re-examine R2 & R4. Does your answer change? **Clearly** explain why or why not; include references to specific fields or parameters in your answer.

[1 mark] Transport Address is used to form adjacencies

[1 mark] It will be identical (system interface address) on both links!

10. [3 marks]

A. Similar to STP bridge ID and port ID, "LDP ID" is a two-part field. Draw a diagram of the complete field, **clearly** identifying the source and length (in bytes) of each part.



[1 mark] source for the values; [1 mark] length of each part; Ref: Mod 3, slide 15

B. Give example values for **both** parts (i.e. for a Nokia 7750 router running SR OS).

[1 mark; all-or-nothing] 10.10.10.1:0 ... see Q12 below!!

11. [5 marks] **Clearly** define the difference between "explicit NULL" and "implicit NULL" labels by describing how each one works. Be sure to include **why** these labels are used!

Each def'n requires: sender; recipient; reason/action/effect

Implicit NULL: sent by PE router, requesting PHP from upstream router;
thereafter, **no** transport labels are used on the customer data to egress

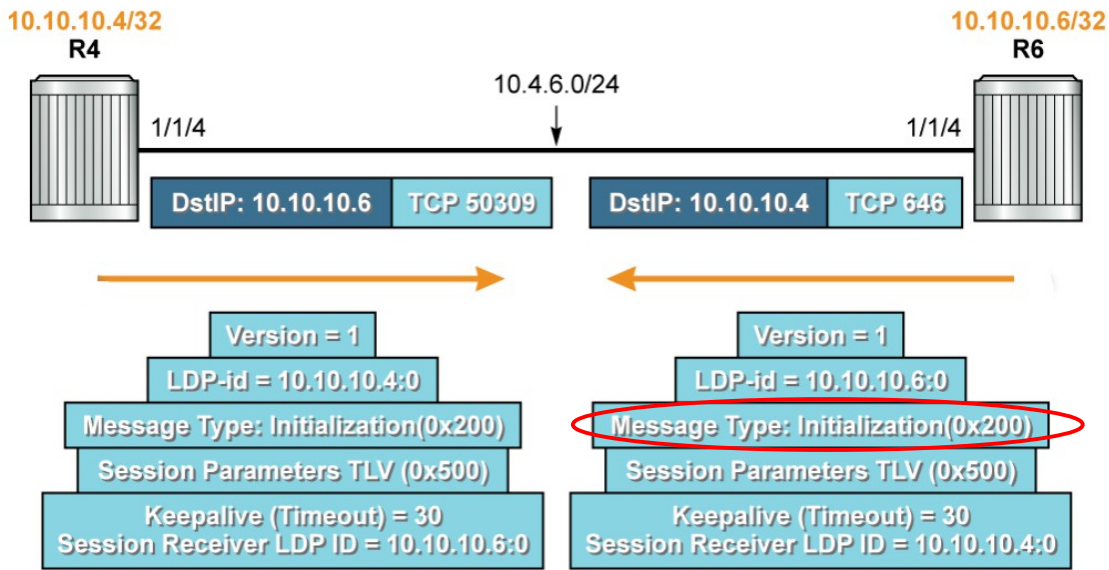
Explicit NULL: sent by PE router, requesting upstream router to use only label value 0,
solely for the purpose of providing QoS via the EXP/Traffic Class bits
contained in the MPLS header

The purpose of both labels is to reduce processing requirements on the PE router,
presumably because it is a smaller, lower-end model of MPLS router (for reasons of
cost and actual power consumption)

B. Give the specific value for each of these labels.

[1 mark; all-or-nothing] Implicit NULL = 3; Explicit NULL = 0 (IPv4) or 2 (IPv6)

12. [6 marks] Carefully examine the diagram below of two routers exchanging messages.



A. Clearly identify what kind of messages these are. LDP session Initialization; see figure!

B1. Which router *initiated* this exchange of messages? R6 initiated the peering

B2. Why (how) was that router chosen to initiate the exchange? Highest Transport Addr

C. What is the L4 transport protocol used for these messages? TCP (see diagram!)

D1. What kind/which messages use the *other* L4 transport protocol? Hello messages

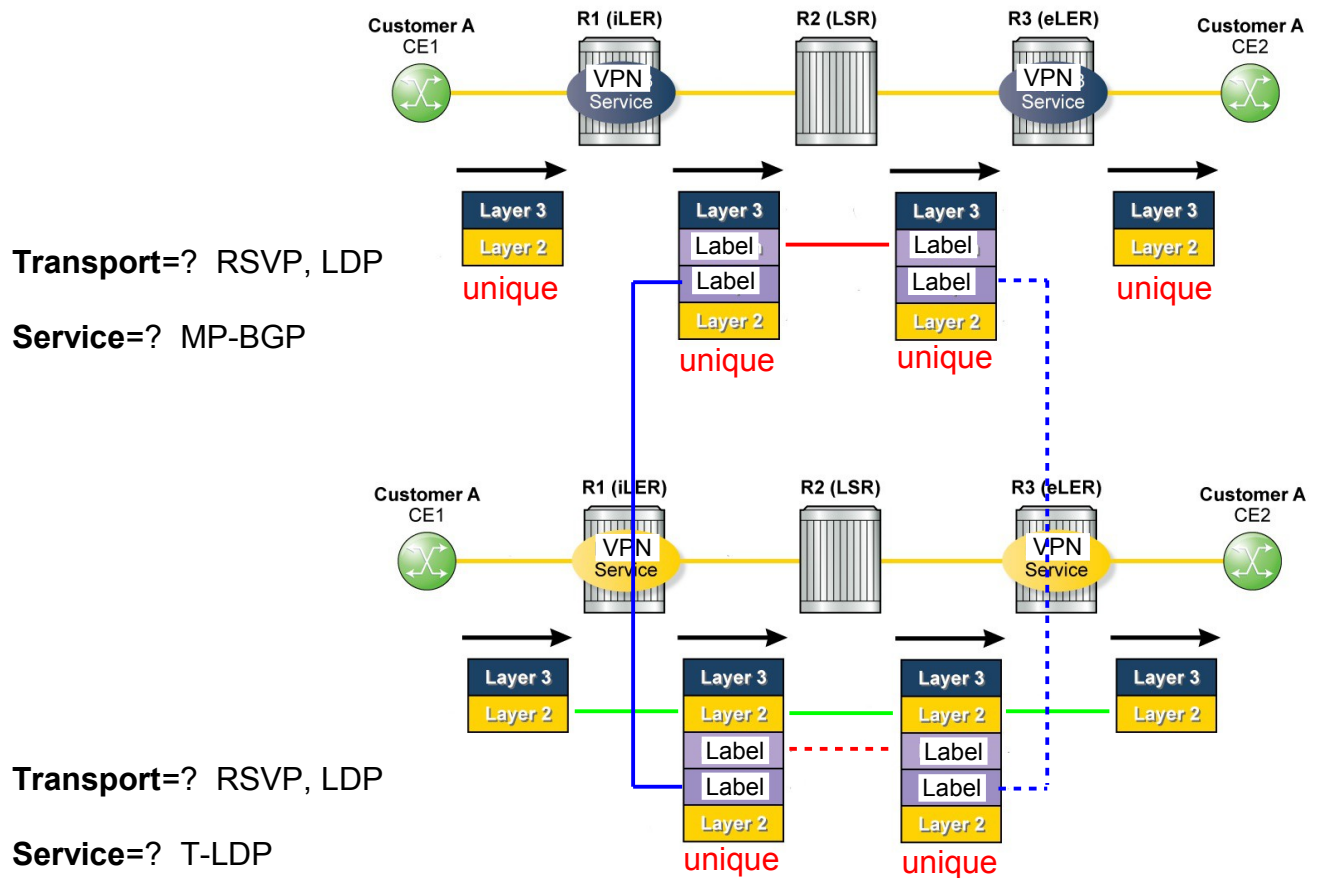
D2. For messages that use the *other* L4 transport protocol, what is the destination port?

Hello messages are sent to port 646 also (via UDP)

13. [2 marks] When testing an LSP, the test request travels via the LSP and the response returns via the IGP. **Clearly** explain why logically this must be the case for how it works.

Since LSPs are *unidirectional*, there may not exist any LSP that can be used for a reply! Furthermore, if an LSP was used for the return, the command would be inadvertently testing a combined pair of LSPs, which *complicates the determination of which LSP* is responsible in the case of a failure.

14. [8 marks] Carefully examine the diagrams below, showing a pair of MPLS services between the same two locations (e.g. Toronto and Vancouver).



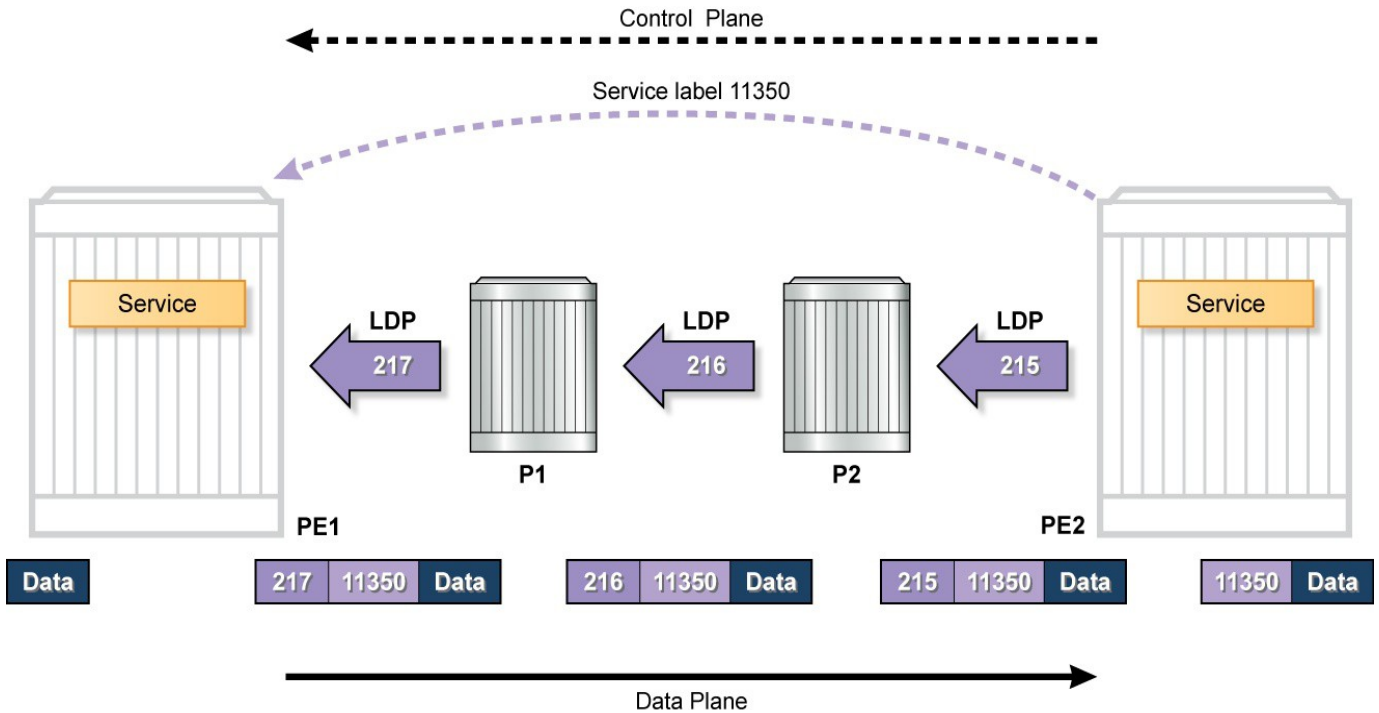
A. Draw lines that connect **labels** with identical values, and write "unique" beside all others
 Think carefully before you start drawing!
 [No ½ marks: 1 mark for both pairs of svc labels; 1 mark for transport labels]

B. Draw lines that connect identical **L2 headers**, and write "unique" beside the others.
 [1 mark] Identical L2 headers marked; [1 mark] **all** others are unique

C. Complete the diagram by filling in **all** possible protocols which could have been used to exchange service and transport labels.
 [1 mark] Transport protocols; [1 mark] service protocols

D. Which service(s) above, if either, would always leave the customer TTL unchanged (regardless of whether pipe or uniform mode was used)?
 [2 marks] Bottom service, which is L2 (VPWS or VPLS)
 For comparison, the top service **always** changes the customer TTL by 2 or more (depending on pipe/uniform mode for the transport)

15. Carefully examine and then complete the diagram below.



- A. [2 marks] **Clearly** label the diagram to indicate the label values for each PDU.
- B. [1 mark; all-or-nothing] Draw two arrows to indicate the direction of the Control Plane flow and the Data Plane flow.
- C. [2 marks; Bonus] Based on your knowledge of label ranges:
 - Is 11350 a valid value for service label? Yes: 2,048-18,431 (statically assigned srvc)
 - Are labels 215-217 valid values for LDP? No: 32,768+ (dynamically assigned)
 - Are labels 215-217 valid values for LSPs? Yes: 32-1,023 (static LSPs)

Extra Work