Test 1: NET3012 – IP Architectures & Solutions

Winter 2016

Time: 60 minutes; Test scored out of: 48 Total Marks available: 52
(Allocation of marks is shown beside each question)

Instructions:

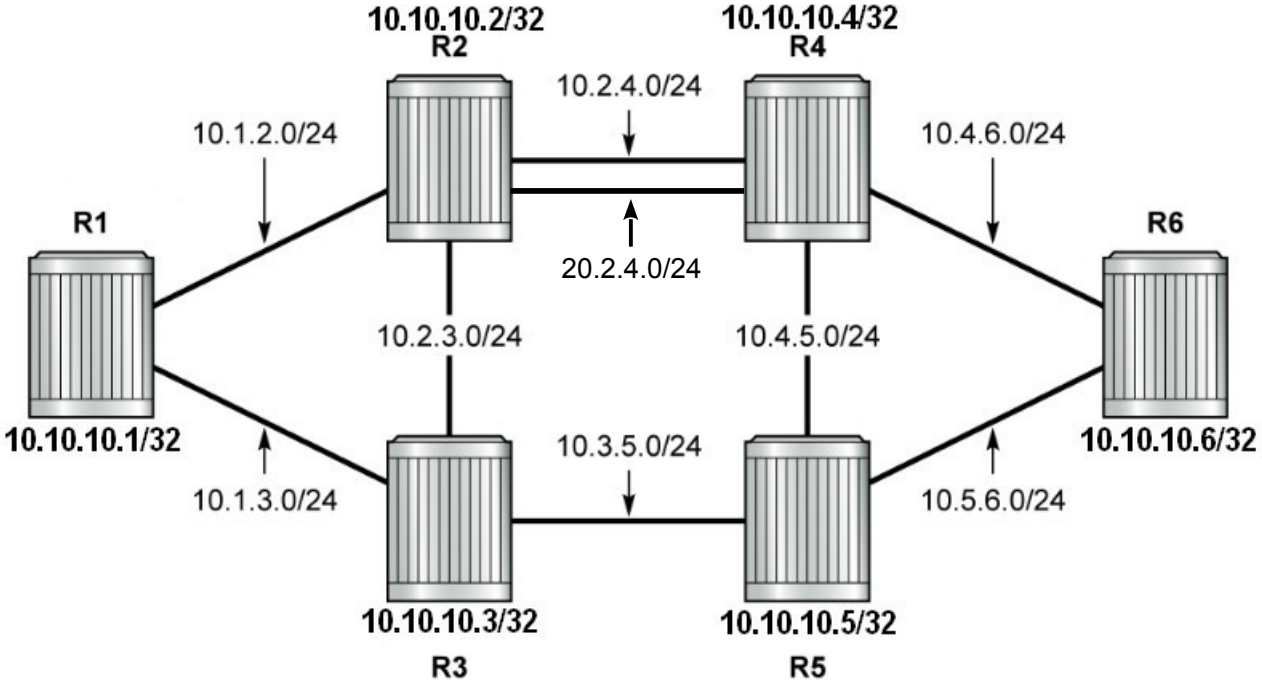
1. BEFORE answering any questions, please check that your copy of the test has all pages (as indicated in the footer at the bottom of each page). Please **read all questions** carefully, then answer question 0 first!
2. This is a **closed book** test. No textbooks, notes, electronic devices, or any other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



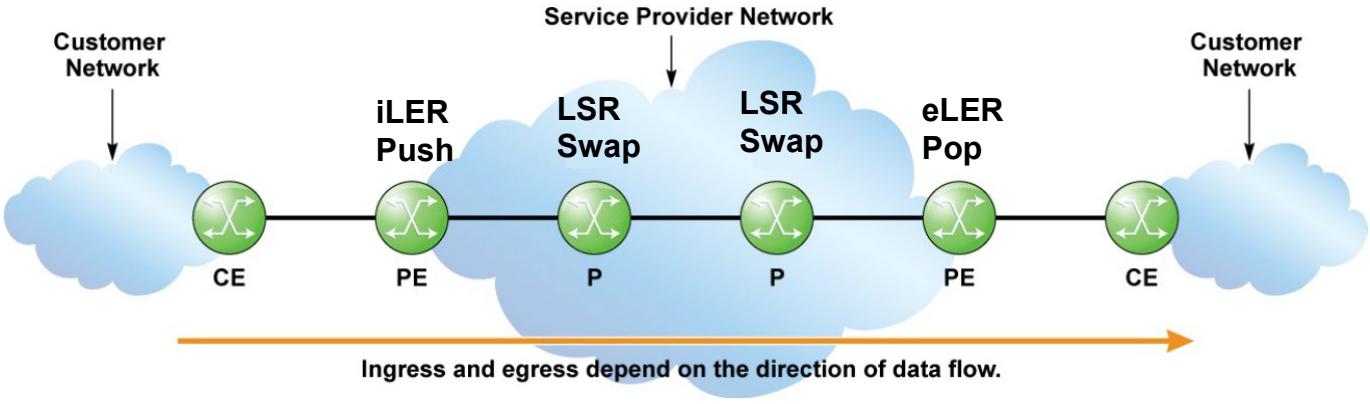
1. [2 marks] Module 1 identified two mechanisms of MPLS that provide "traffic protection" (ie. recovers and reconverges very fast, faster than the IGP). **Clearly** identify each of the two mechanisms. Hint: one of them is also covered in Module 4 and provides 7x protection.

   fast re-route; secondary LSPs

2. [2 marks] In MPLS, there are two methods of protecting against LSP loops. One method is intended to prevent loops from being created in the first place; the other method is intended to control any loops that get created by accident. **Clearly** identify both methods.

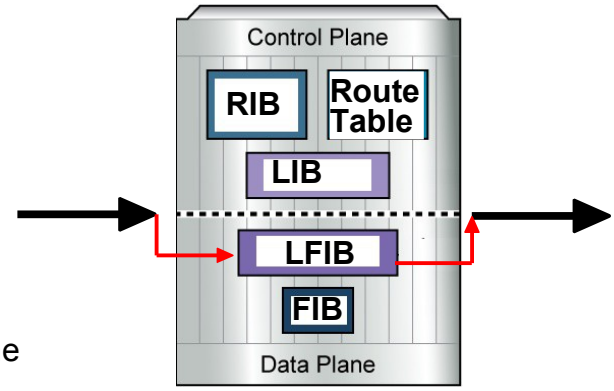
   ordered control mode for label distribution; TTL field in MPLS header

3. [2 marks] Mark-up the diagram below, to **clearly** (and legibly!):
   A. identify the *three* types of MPLS routers, and
   B. identify all label operations that occur at each MPLS router



4. A. [2 marks] 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

5. A. [2 marks] **Clearly** identify (ie. give the name and value of) at least two "Special Use" labels, from the MPLS label range of 0-15. Ref: slide 2-42

   Explicit NULL (for IPv4): 0
   Router Alert: 1
   Explicit NULL (for IPv6): 2
   Implicit NULL: 3

   B. [1 mark; Bonus] Do the same for yet another Special Use label.

   (Any label not already used in part A)

6. [1 mark] What is the range of values for labels that are dynamically assigned by MPLS protocols? If that question is too hard, can you provide one actual value of a dynamically assigned label? (Ref: slide 2-11; lab work)

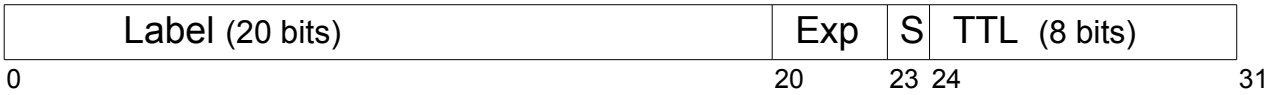
   32,768 – 131,071

7. [1 mark] Draw a **clear** (and legible!) sketch of an Ethernet II frame that clearly identifies where the MPLS headers are placed. (Ref: slide 2-5; also Nokia presentation slide 24)

   immediately after frame header (i.e. after dst + src MAC addresses and ethertype field)

8. [2 marks] Draw a **clear** sketch of an MPLS header. Be sure to identify the name and size/length of each field.

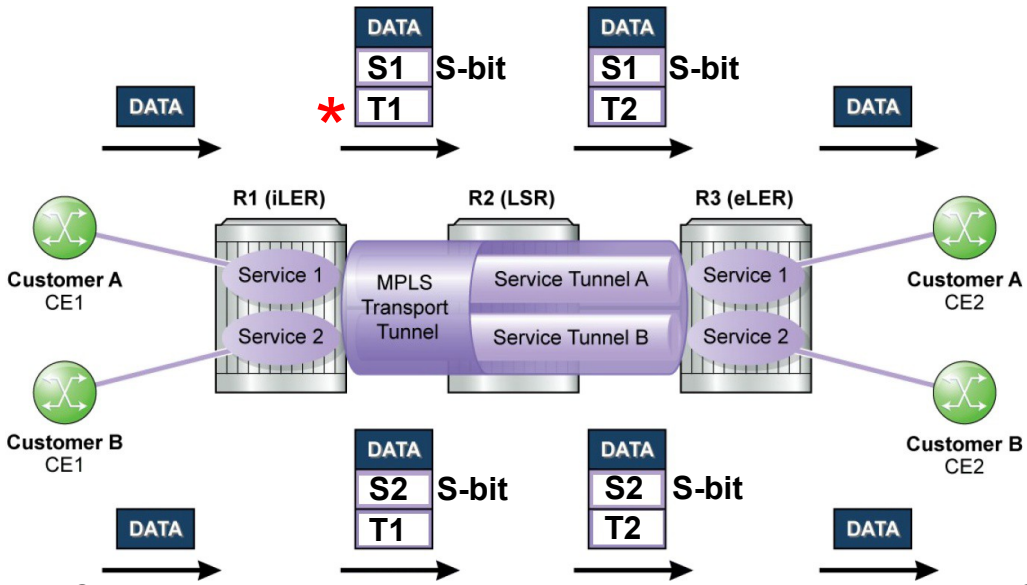
   [1 mark for all four fields; 1 mark for all field lengths]



9. [2 marks] Two potential benefits of MPLS are avoiding hyper-aggregation and offering a BGP-free core. Comment on the suitability of LDP for achieving each of these benefits.

   Hyper-aggregation: little (if any?) benefit because LDP always follows the IGP.
   BGP-free: LDP is great because it provides the *full-mesh* connectivity needed for iBGP.

10. **A**. [2 marks] In the diagram below (ref: slide 2-7), pick label values simply to illustrate the key concepts of values at each stage of the LSP. Carefully consider what labels will be identical and what labels will be different! (For part A, assume LDP is used throughout.)



B. [1 mark] **Clearly** mark-up the diagram to show which label(s) has/have the "S" bit set.

C. [1 mark; all-or-nothing] Give at least two *names* for the label marked with an asterisk (*).

Top, outer, or transport

D. [1 mark] Part A stated "assume LDP is used throughout." Could that assumption be valid in real-life? **Clearly** explain why or why not. (Ref: slide 3-6 and others)

Yes, certainly: Link LDP can be used for Transport tunnels; T-LDP is used for services

11. [3 marks] Name and give a **clear** 1-line **description** of three optimizations for RSVP session refresh.
See slide deck for descriptions and explanations of 4 (or 5, depending on how counted)
Hello Protocol, refresh randomization, Msg ID + ACK, Summary Refresh
Explanation must make it clear that you know what you are talking about!

12. A. [1 mark] What is the minimum and maximum number of "LSP-paths" that may be associated with a single RSVP-based LSP that is up/up?

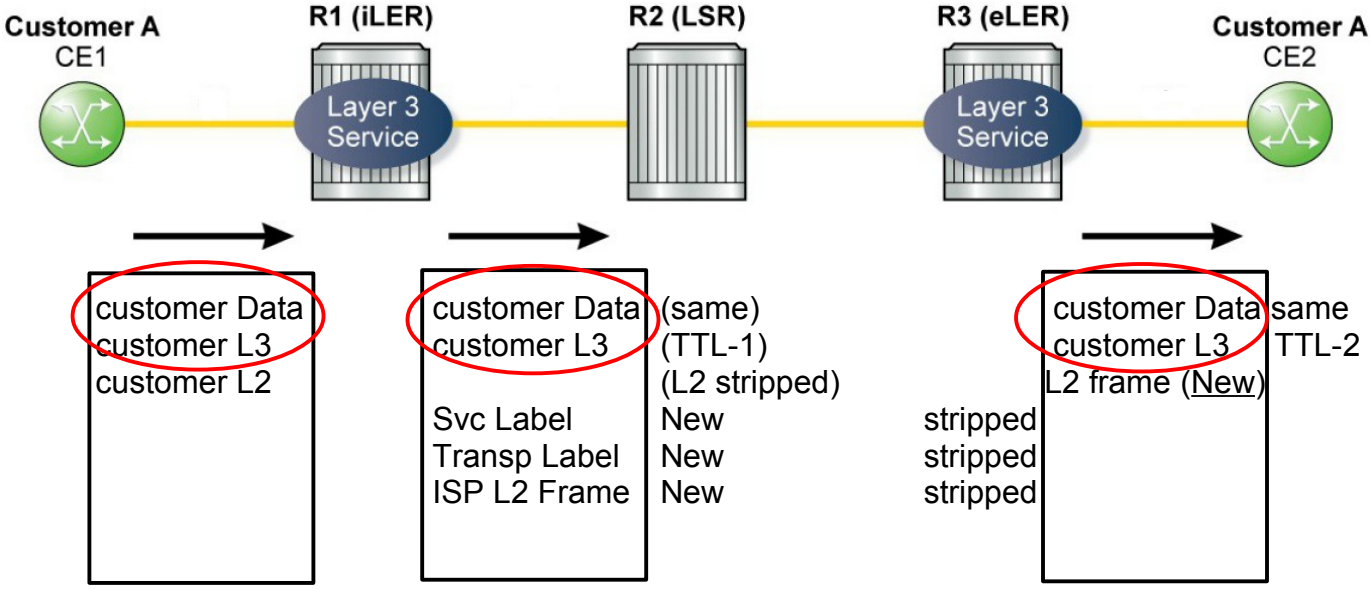
1 path minimum (lab work!), 8 paths maximum

B. [1 mark] What additional constraints exist on the number of LSP-paths?

At most 1 primary; 7 secondaries with 1 primary or 8 secondaries with *no* primary

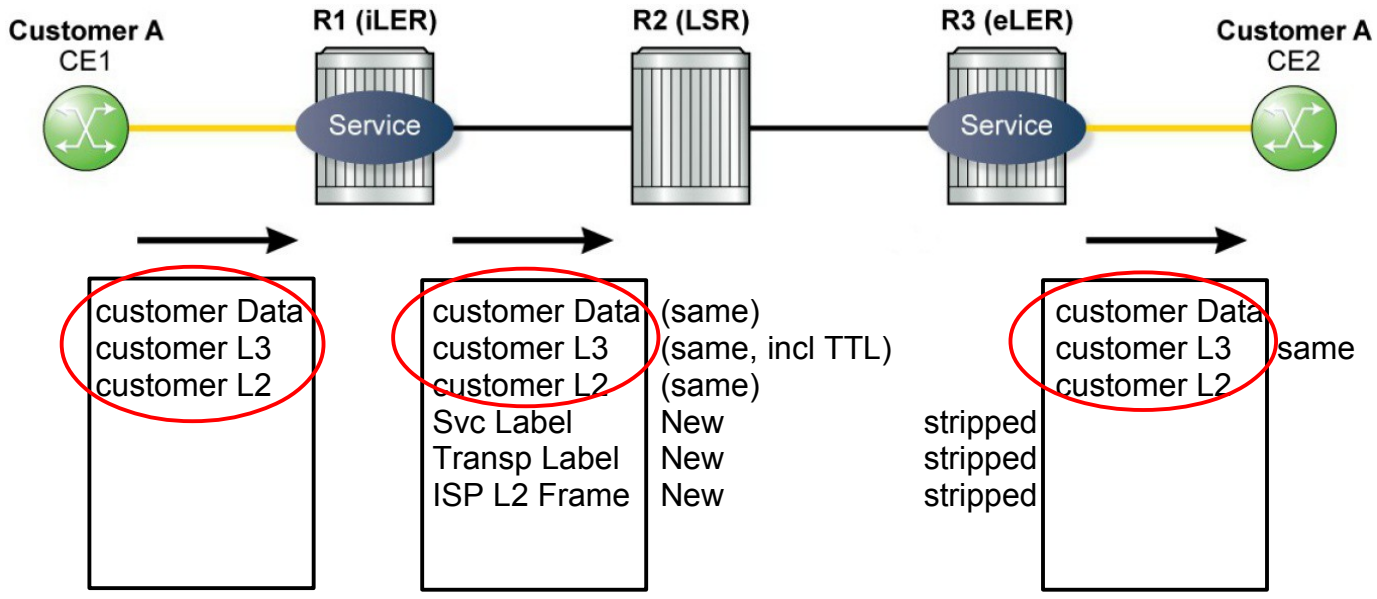
13. A. [3 marks] Complete the diagram below by clearly (and legibly!) illustrating the exact contents of a frame traversing a **MPLS L3 VPN**. **Clearly** identify what sections of the frame are changed and what sections remain constant.

    B. [1 mark] Circle the portion of each frame that represents the payload of Customer Data.



14. A. [3 marks] Complete the diagram below by clearly (and legibly!) illustrating the exact contents of a frame traversing a **MPLS VPLS**. **Clearly** identify what sections of the frame are changed and what sections remain constant.

    B. [1 mark] Circle the portion of each frame that represents the payload of Customer Data.



15. [2 Marks] Choose the *one* diagram above that is *closest* to the operation of a VPWS.
    A. Which one is it?

    VPLS

    B. **Clearly** explain any differences in the *frame handling* for a VPWS and the chosen option.

    None! There are no differences since they are both "frame" (or L2) services.

16. [2 marks] **Clearly** define at least one difference between pipe mode and uniform mode.
    Is the difference relevant to L2 VPNs?
    Is the difference relevant to L3 VPNs?

    For uniform mode, customer TTL gets decremented at every hop
    For pipe mode, customer TTL gets decremented only at iLER and eLER but not LSRs
    Only relevant for L3 VPN; customer TTL never decremented for L2 VPNs

17. [2 marks] **Clearly** identify at least two differences between Link LDP and Targeted-LDP.

    Link LDP only possible between directly connected neighbours; no restriction on T-LDP
    Hello sent multicast (224.0.0.2) in Link vs unicast (system IP) in T-LDP
    Link LDP only used for transport tunnels; T-LDP only used for service labels (for L2 VPN)
    Link LDP is discovery based; T-LDP neighbours must be explicitly configured

18. [1 mark] **Clearly** differentiate LDP Hello messages vs keep-alive messages. e.g. When is each one used?
    Ref: slides 3-7, 3-20, 3.31, 3.97; difference is most apparent with multiple parallel links
    Hello messages are sent over a UDP connection; they maintain the adjacency
    Keep-alive messages are sent over a TCP connection; they maintain the session

19. [1 mark] **Clearly** explain what happens if the configured Hello timeout values do **not** match between neighbouring LDP routers.

    Does *not* prevent an adjacency; both neighbours simply use the lowest value.

20. [1 mark] We say that LDP provides full-mesh connectivity. Where / to what specifically does it provide connectivity?

    LDP only provides connectivity to FECs, which by default is *all system interfaces*

21. Examine the CLI output provided below. It is obtained from R4 in the reference topology, *very shortly* after LDP is enabled. To simplify this question, assume that *time is frozen* immediately after the output was obtained.

```
A:R4# show router ldp bindings
===============================================================================
LDP Prefix Bindings
===============================================================================
Prefix           Peer         IngLbl   EgrLbl EgrIntf/   EgrNextHop
-------------------------------------------------------------------------------
10.10.10.6/32    10.10.10.2   131070     --     --          --
10.10.10.6/32    10.10.10.5   131070     --     --          --
10.10.10.6/32    10.10.10.6     --     131071 1/1/4       10.4.6.6
-------------------------------------------------------------------------------
```

A. [1 mark] Two label values are identical. Is that simply coincidental or must they always be identical? **Clearly** explain why!

Per-platform label space! Any/all interfaces receive the *same label* for a given FEC.

B. [1 mark] If ECMP had been enabled on all routers, **clearly** explain what changes, if any, would have appeared in the table above.

No changes. There are no (other) *equal cost* paths from R4 to R6, so no extra labels.

22. Examine the CLI output provided below. It is obtained from the reference topology for R1. Assume that the both the IGP and LDP are fully converged.

```
A:R1# show router ldp bindings active
===============================================================================
Prefix           Op    IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
10.10.10.1/32    Pop   131070      --        --             --
10.10.10.2/32    Push    --      131071    1/1/4          10.1.2.2
10.10.10.2/32    Swap  131071    131071    1/1/4          10.1.2.2
10.10.10.3/32    Push    --      131071    1/1/3          10.1.3.3
10.10.10.3/32    Swap  131069    131071    1/1/3          10.1.3.3
10.10.10.4/32    Push    --      131070    1/1/4          10.1.2.2
10.10.10.4/32    Swap  131068    131070    1/1/4          10.1.2.2
10.10.10.5/32    Push    --      131068    1/1/3          10.1.3.3
10.10.10.5/32    Swap  131067    131068    1/1/3          10.1.3.3
10.10.10.6/32    Push    --      131068    1/1/4          10.1.2.2
10.10.10.6/32    Swap  131066    131068    1/1/4          10.1.2.2
-------------------------------------------------------------------------------
```

[2 marks] If ECMP was enabled on all routers, **clearly** explain what changes, if any, would appear in the table above.

[1 mark] An extra pair of labels to R6, since it is the only *equal cost* FEC in the table.
[1 mark] The labels would egress to R3 (1/1/3 – 10.1.3.3) [R2 labels already exist].

23. An article from Tue Feb 2, 2016: *"Fujitsu and the Tokyo Institute of Technology have achieved a wireless transmission of 56Gbps over a 10cm distance using millimeter-wave (mmWave) frequencies located between 30-300GHz. While cellular capacity is improved in some [geographical] areas through the addition of new mobile masts and small cells, the fibre networks used to link these [cell tower] sites to the wider network is either absent or not feasible to deploy in urban locations or on difficult terrain. … It is claimed that by pairing the technology developed with a high-output amplifier, the same effect can be achieved outdoors and could be commercialised for mobile operators by 2020."*
http://tech.slashdot.org/story/16/02/02/1442210/japanese-researchers-achieve-record-56gbps-wireless-transmission

    [2 marks] Based on material presented in this course, **clearly** define PHP and discuss it's relevance to the situation described above.

    PHP is Penultimate Hop Popping, or popping any/all labels just before the tunnel destination. PHP is used by "small" LER devices with fewer resources (RAM, CPU) so that they have only a single forwarding type of operation per packet.
    Cell phone towers are terminal devices, and most likely *not* beefy devices. They are numerous and thus good candidates for using PHP (save $$$ with a cheaper device!)

24. [1 mark] In the reference topology, are all the IP addresses private IP's (eg. RFC1918), including the system interfaces?

    No! There's a link 20.2.4.0/24 that isn't a private IP. READ the instructions!

Extra Work