Test 2: NET3012 – IP Architectures & Solutions

Winter 2019
MPLS Modules 1-5; SA Module 1, Module 2 (SAPs), Module 3 sections 1-2 (VPLS)

Time: 60 minutes   Test scored out of: 50   Total Marks available: 59
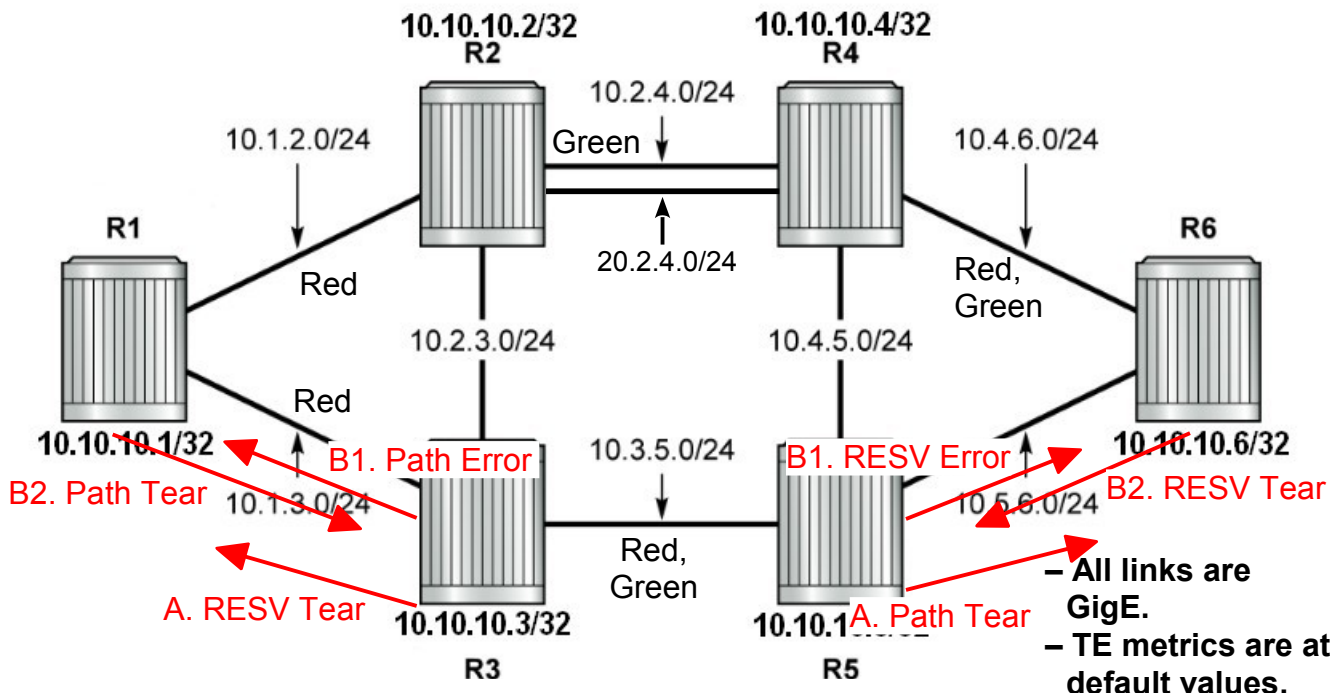
Instructions:

1. <u>BEFORE</u> 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. When the marks for a question are not shown, the question is worth 1 mark.

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.

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Midterm2

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1. [1 mark] How many SDPs in total need to be configured on a local ePipe service?
   How many SAPs in total need to be configured for a local ePipe service?
   Give exact numbers. (Adapted from end-of-chapter review question; SA mod 1, p 92)

   Exactly 0 SDPs; 2 SAPs! Local services do *not* use SDPs; they only use SAPs

2. [2 marks] Based on best practice, place the correct letter on each line: (SA mod 1, p 93)

   SAP ID ___a___   a. Local significance

   SDP ID ___a___   b. Global significance

   VC ID ___c___   c. Point-to-point significance

   Service ID ___b___   **[1 mark: first 3 correct; 1 mark: next two correct]**

   Customer ID ___b___

3. A. [2 marks] **Clearly** define the difference between "explicit NULL" and "implicit NULL" labels by describing how each one works.
   (Each definition requires: sender; recipient; reason/action/effect.)

   Implicit NULL: Label value = 3 sent by PE router, requesting PHP from upstream router; thereafter, **no** labels are used on the customer data from P to egress PE

   Explicit NULL: sent by PE router, requesting upstream router to use label value solely for the purpose of providing QoS via the EXP/Traffic Class bits contained in the MPLS header for data from Penultimate Hop to PE (As required below, Explicit NULL label value is either 0 or 2.)

   B. [1 mark] **Clearly** explain **why** these labels are used!

   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)

   C. [1 mark; all-or-nothing] Give the specific value for each of these labels.

   Implicit NULL = 3;   Explicit NULL = 0 (IPv4) or 2 (IPv6)

4. [8 marks] Study the reference topology on the cover page. All configured TE attributes are shown on the topology. In this question, you are **not** allowed to change any attributes.

A. Use correct CLI syntax to write a definition for an LSP R1 –> R6 which *avoids R2*. (Syntax need *not* be absolutely perfect.) Use whichever TE method/attributes you'd like.

    [2 marks; Simplest method: strict hop to R3 (optionally: add another strict hop to R5)]
```
path "avoidR2"
    hop 10  10.10.10.3  strict
    hop 20  10.10.10.5  strict                      lsp "part-A"
    hop 30  10.10.10.6  strict/loose  # (optional)      to 10.10.10.6
    no shutdown                                         primary "avoidR2"
                                                        no shutdown
```

B. Use correct CLI syntax to write a definition for an LSP R1 –> R6 which passes through at least one of the top routers (R2, R4) and at least one of the bottom routers (R3, R5). (Syntax need *not* be absolutely perfect.) You may **not** use any criteria which are configured in the CLI "path …" context.

    [2 marks for determining that "exclude green" is sufficient and is an acceptable context]
```
lsp "part-B"
    to 10.10.10.6
    cspf
    primary loose
    exclude green
    no shutdown
```

C. **Clearly** explain the resulting status of an LSP R1 –> R6 that uses the single TE spec:

  (i) includes Blue
      [1 mark] LSP fails; no Blue links are available to complete the path.

  (ii) excludes Blue?
      [1 mark] LSP follows the IGP; no link is Blue to prevent the path.

D. [2 marks] For part A above, what message(s) would be sent if an LSP R1–>R6 was up/up and the link 10.3.5.0/24 went down? Assume both R3 and R5 detect the failure. **Draw** and **label** the messages **clearly** on the cover page!!   [Ref: MPLS slide 4-35]

    Need both Path & RESV *Tear* msgs [A], same direction as normal Path/RESV msgs
    OR   Path & RESV *Error* msgs [B], given in opposite direction as normal msgs

5. [2 marks] Study the reference topology on the cover page and think about the goals of traffic engineering.
   – We need two LSPs R1–>R2–>R4–>R6: one for **$$$ clients** and one for **low-cost clients**
   – In the event of a failure of either link R2–>R4, the $$$ LSP must continue to be up/up.
   – In the event of a failure of the top link, the low-cost LSP should go down so that low-cost clients don't congest the remaining link for the $$$ clients.

   Clearly describe how to define each of the two LSPs. (No CLI is necessary.)

   $$$ LSP path is defined using hops through the _system interface addrs_ of the routers
   Low-cost LSP path is defined using hops through the _network interface address_ for R4
   (Either strict or loose hops are permissible if all hops are included in the definition.)

   (Other solutions will be considered, and awarded marks **if** they are suitable.)

6. A. [1 mark] There is a specific technical term for the traffic flooded in a VPLS. **Clearly** define the term and **clearly** identify the kind(s) of traffic to which it applies.

   BUM: Broadcast; _Unknown_ unicast; Multicast
   NOTE: "unicast" on it's own is **not** acceptable, and results in 0 marks.

   B. [2 marks] **Clearly** state the set of three (3) flooding rules for VPLS components.

   Any BUM traffic coming in a SAP gets flooded everywhere (SAP, spoke+mesh SDPs)
   Any BUM traffic coming in a spoke SDP gets flooded everywhere
   Any BUM traffic coming in a mesh-SDP gets flooded to all SAPs and spoke-SDPs

   C. [2 marks] Compare the flooding of traffic (as identified in part B) in a Cisco 3560 vs a VPLS. State whether it is identical or not, and **clearly** explain why or why not.

   A. Statement that it is identical (BUM traffic is flooded everywhere within a VLAN).
   B. Discussion around VPLS is a single VLAN, whereas a 3560 may have multiple VLANs and thus multiple separate flooding domains for BUM traffic.
   C. Not all "ports" in a VPLS learn MAC address of destination from a single request/ reply sequence (subtle, but covered in the slide deck)

   EITHER answer A, B, C is acceptable, provided it is coherently presented and written!
   Note: a VPLS is a _single_ switch, don't confuse SDPs as joining separate switches!

7. **A**. [6 marks] Imagine three routers which implement a Label Switched Path.
Use the diagrams of the routers provided below to:

☐ 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
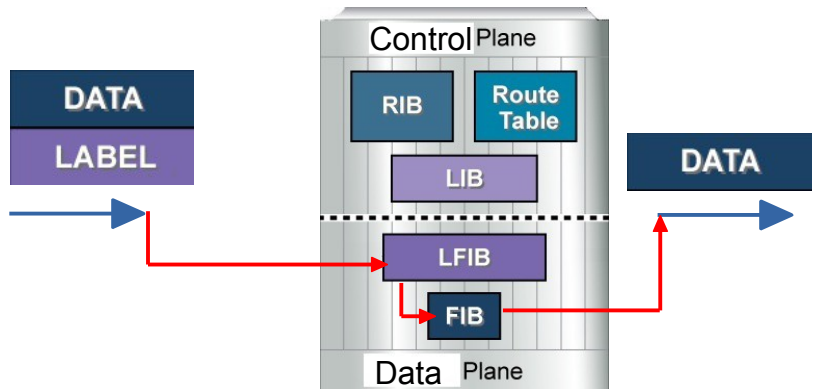process the frame), according to the role labeled for each router. (Ref: Mod 1.39-40)

LSR (Label op = _____Swap_____)

"MPLS egress router performs two lookups: first a label
lookup, and then an IP forwarding lookup to forward the
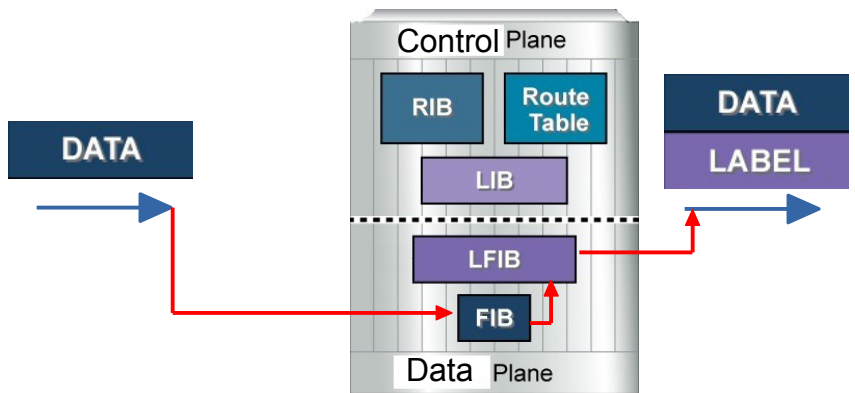unlabeled packet" NRS-II, p. 505

Sample PDU Types
DATA
DATA / LABEL
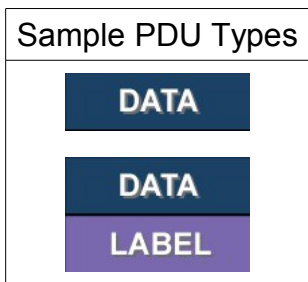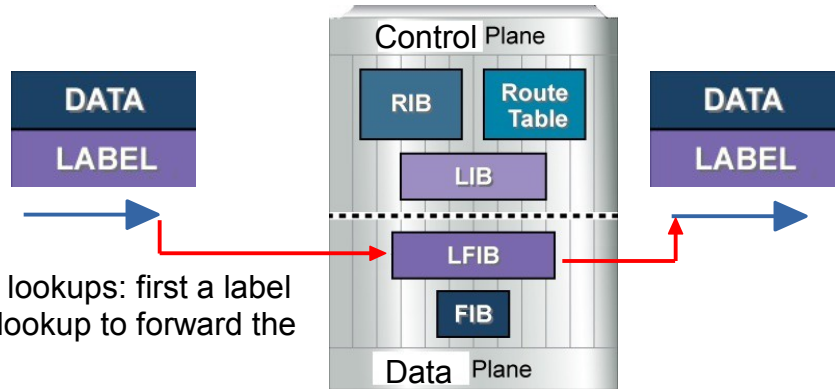
eLER (Label op = _____Pop_____)

iLER (Label op = _____Push_____)

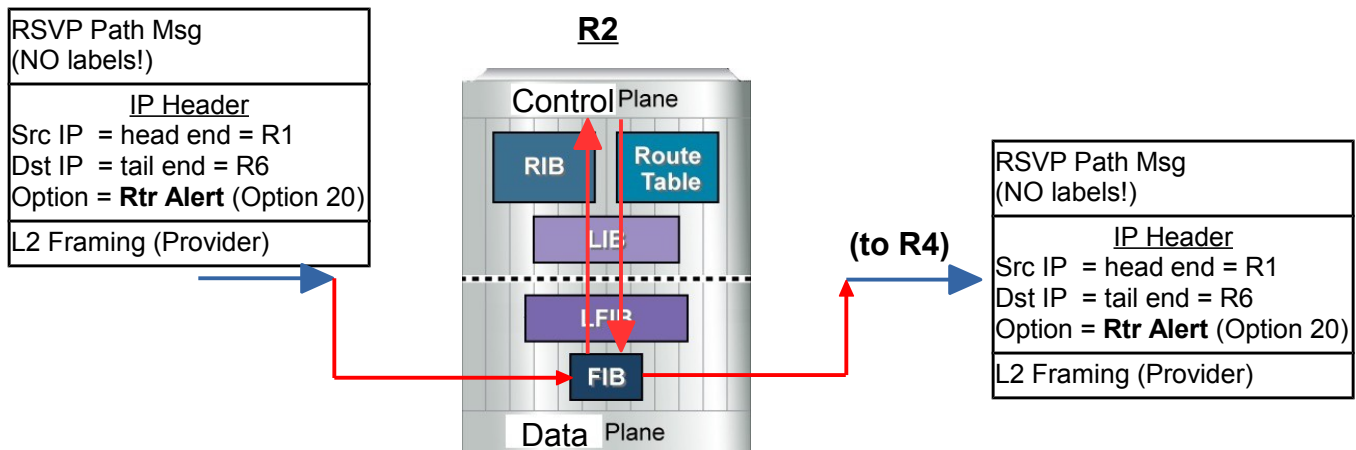**B**. [2 marks] Next, clearly label the different **planes** for each of the three types of routers.

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

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

RSVP Path Msg (NO labels!)
IP Header Src IP = head end = R1 Dst IP = tail end = R6 Option = **Rtr Alert** (Option 20)
L2 Framing (Provider)

R2

Control Plane

RIB | Route Table

LIB

L.FIB

FIB

Data Plane

(to R4)

RSVP Path Msg (NO labels!)
IP Header Src IP = head end = R1 Dst IP = tail end = R6 Option = **Rtr Alert** (Option 20)
L2 Framing (Provider)

Key points: – MUST show initial ingress and egress via FIB
– MUST go up to control plane (but **not** into LIB, RIB, or Route Table!)
(nice to show PSB being created, but that's optional)

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).

9. Given user data with an inner tag of 15 and an outer tag of 30, write the definition for:

A. [1 mark] a fully service-delimiting QinQ SAP on port 1/1/1

sap 1/1/1:30.15

B. [1 mark] a wildcard SAP on port 1/1/1.

sap 1/1/1:30.*

10. [2 marks] **Clearly** explain each of the two "Router Alert" options we've covered:
A. What purpose or use do they serve?
B. In which data field or header are these options? If we've seen actual value(s), what are they?
Purpose: to send the PDU (packet, MPLS payload) up to the control plane

– MPLS "Special Use" label (value 1); for OAM purposes (Mod 2)
– IP header option 20 = "router alert"; used in RSVP "Path" messages (Mod 4)

Do NOT confuse MPLS Label (= 1) with IP Header Option (= 20)!

11. [9 marks] Carefully study the diagram below which illustrates an Epipe deployed with LDP over RSVP. [MPLS slide 5.151]

t-LDP   t-LDP   t-LDP   t-LDP
RVSP RSVP   RSVP   RSVP   RSVP   RSVP   RSVP
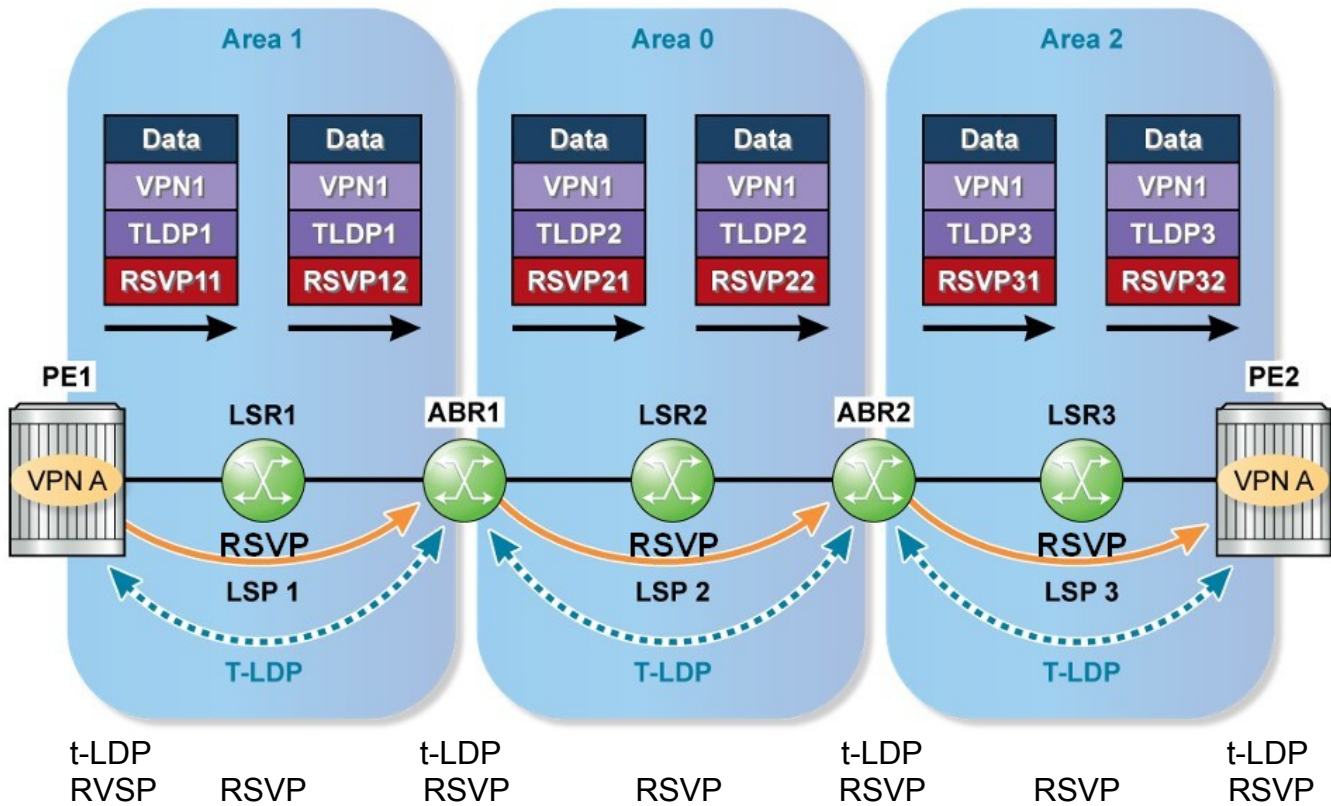
(No need to label OSPF since it's already shown in the diagram)

A. For each of the seven routers, **clearly** identify the protocols which have been configured. (Use the space immediately above this question.) If LDP is used, be specific about the type. Don't forget, it's an Epipe deployed with LDP over RSVP.
   [2 marks: 1 for t-LDP at PE & ABRs, 1 for RSVP everywhere]
B. Assuming that data flows in one direction only, which protocol is responsible for each of the arrows appearing below the routers? Again, **label** the diagram.
   [2 marks: 1 for RSVP (top, orange), 1 for **t-**LDP (bottom, blue)]
C. Two routers in the diagram are unlabeled. Add appropriate labels based on an important role that they serve. Hint: LSR is not the required answer.
   [1 mark: ABR for two OSPF areas]
D. The top of the diagram shows a label stack. Fill in example label values (so that it's clear when label values are identical and when they are different!)
   [2 marks; 1 per row]
E. **Clearly** explain why LDP-over-RSVP is useful / necessary?
   [2 marks] Key points are:
   – TE gives many benefits (including Fast Re-Route mentioned as a driver in Mod 1)
   – TE only works across a single area of an IGP
   – large Service Provider (SP) domains _must_ be divided for manageability and stability
   – (t-)LDP provides a method of stitching together RSVP-TE LSPs across multiple areas

   Bottom line: get full benefits of TE across laaaarge provider networks!

12. Carefully study the diagram below which illustrates a VPN service. [Ref: SA slide 2.14]
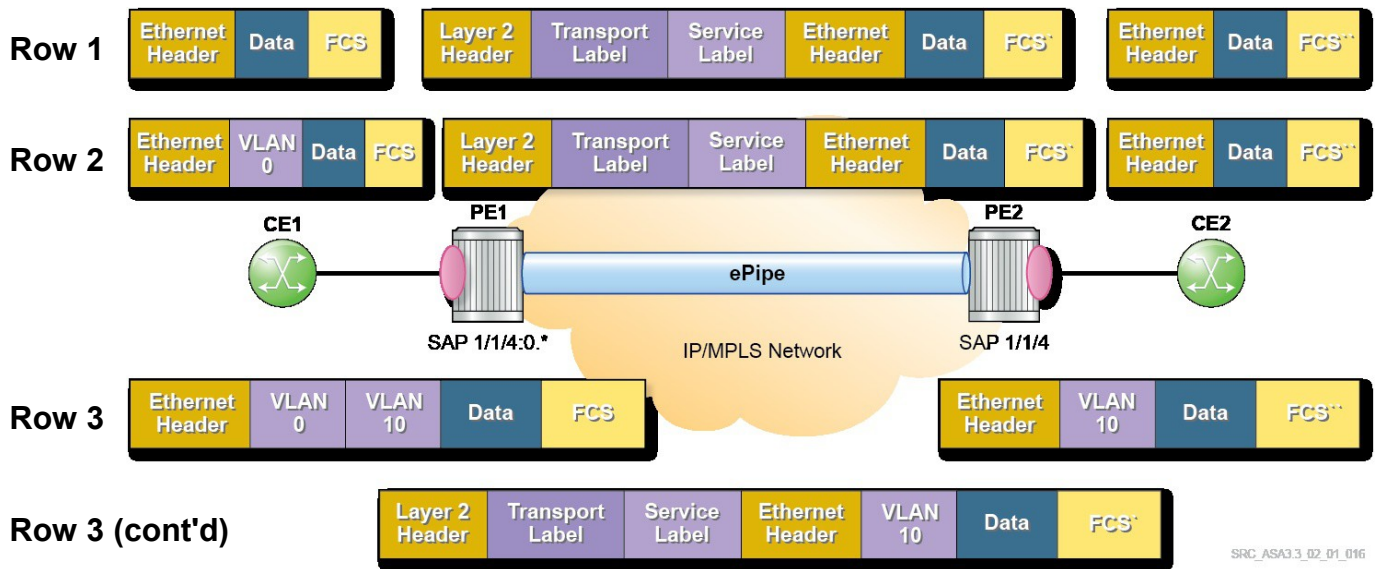
A. [1 mark] For Row 1: the leading field is labeled either "Ethernet Header" or "Layer 2 Header" **Clearly** explain the difference, if any, between the two.

> They're **both** ethernet headers; one is added by the Service Provider ("Layer 2"),
> the other is the customer's ("Ethernet").

B. [2 marks] For Row 1: I grabbed a wireshark capture of frames on the left side, and then frames in the middle. Unfortunately I got the captures mixed up immediately afterwards. **Clearly** explain how I can determine which is which using only the info from the leading field (i.e. 1st Header).   **N.B.** Part B is looking for a different answer/info than Part A.

> Simple: just look at the Ethertype field! If it's 0x8847, then those are the middle frames
> which have an MPLS label as the next item. Anything else are the customer frames from
> the left or right sides, probably containing IP data (e.g. ethertype = 0x800).

C1. For Row 1: Examine the FCS fields carefully.
   – [0 marks] Yes/no: Are the markings correct? (Either no "*", 1 "*", or 2 "*")
   – [2 marks] **Clearly** explain and justify your answer.

> No, because the last marking is **not** correct. It should be _identical_ (e.g. no "*") to the
> ingress frame. This is a L2 service so a null-encapsulated _frame should be unchanged_!

C2. [2 marks] Repeat your analysis of the FCS for Rows 2 and 3.

> [1 mark per row for a correct analysis]

> Both other rows are correct. FCS is always different because VLAN tags
> (and MPLS labels) are stripped/added at each PE router.

D. [1 mark] **Clearly** identify the type of service pictured above. It is a: _____L2 svc_____

F. [1 mark] If I changed the SAP definition on PE2 to **sap 1/1/4:*** would the service still work as pictured? Explain **clearly** why or why not.

    Yes, because of two factors:
    - The dot1Q default SAP basically ignores any/all tags, as does the original PE2 SAP
    - if the service already worked with a mis-match PE1/PE2 for VLAN 0, it will continue
      working every bit as well since nothing actually changes

13. [2 marks] Identify something _important_ that you learned during the field-trip to Alcatel-Lucent. You must also explain **clearly** _why_ it is important! (Continue last page if you need more space.)

    Any reasonable answer is acceptable, provided that the explanation of "why" is clear!

Extra Work