Final Project

VLAN-based Segment Routing

Deadline: 2022/01/12 (WED) 23:59

Outline

- Review of Labs
- Segment Routing
  - IP Routing
  - Workflow of Segment Routing
  - Node Segment
- Final Project
  - Overview
  - Workflow
  - Requirements

Outline

- **Review of Labs**
- Segment Routing
  - IP Routing
  - Workflow of Segment Routing
  - Node Segment
- Final Project
  - Overview
  - Workflow
  - Requirements

Review of Labs

- Lab 4 - Unicast DHCP Application
  - Installing flow rules
  - Routing packets with global view of network
  - Configuring controller

- Lab 5 – Proxy ARP
  - Constructing packets and sending directly to switches

- Note: All of these labs would be used in final project

Outline

- Review of Labs
- **Segment Routing**
  - IP Routing
  - Workflow of Segment Routing
  - Node Segment
- Final Project
  - Overview
  - Workflow
  - Requirements

IP Routing

- Network devices route packets with IP address
  - Maintain routing information on each device
  - Look up IP table when packets arrive
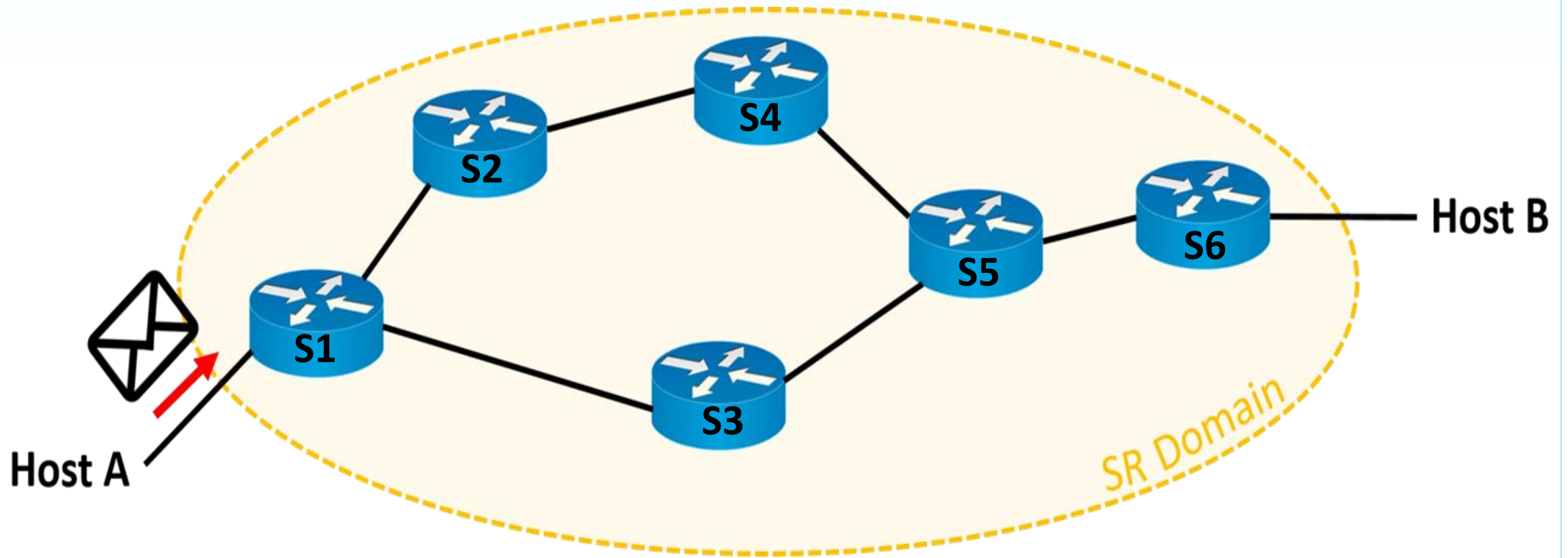- Determine paths while forwarding packets

192.168.1.2

10.0.0.3

Host A

Look up routing table

Host B
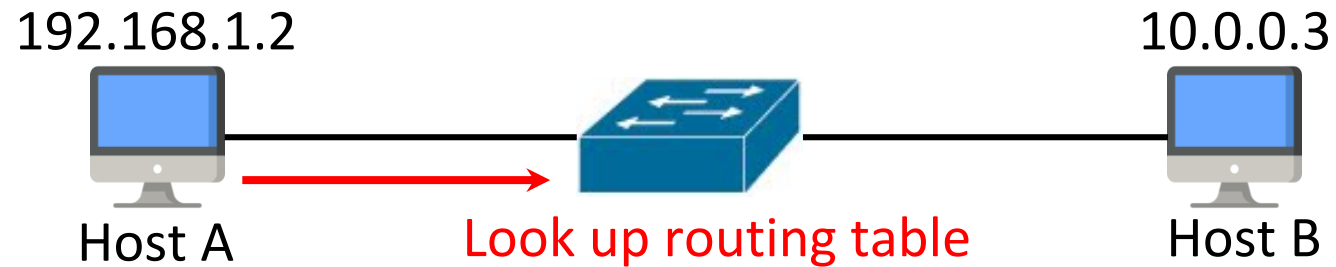
Segment Routing (SR)

- Use ==label (segment) switching== instead of IP address
- Sender (or ingress node) of packets specifies routes of packets
- Features:
  - Sender
    - Choose a path
    - Encode it in the packet header as an ordered list of segments
  - The rest of network devices
    - Execute the encoded instructions (labels)
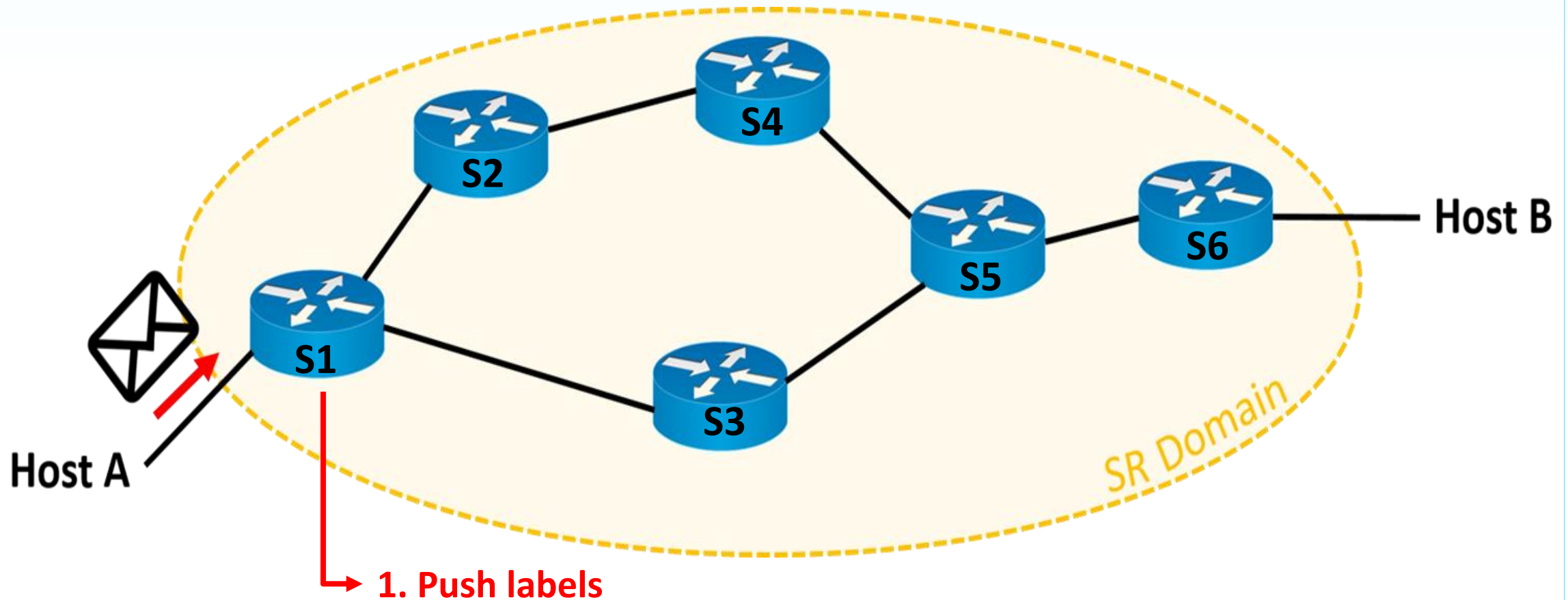   - i.e., forwarding

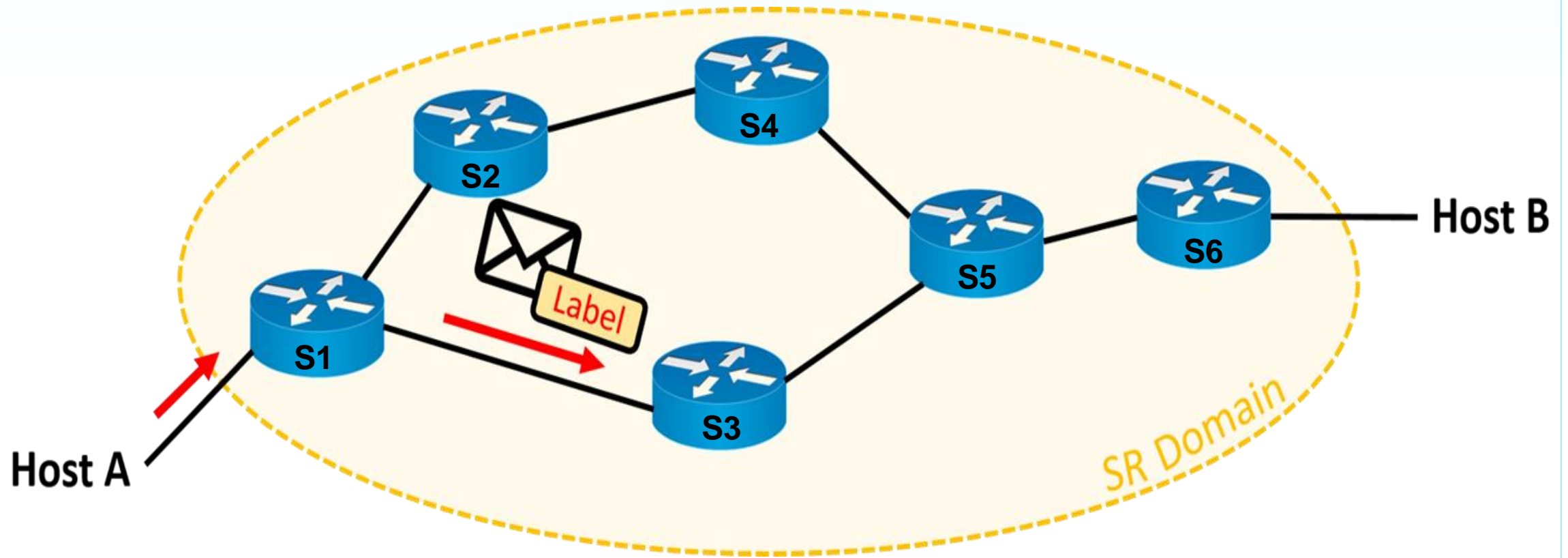# Segment Routing – Workflow (1/9)

- Host A sends packet to Host B

- The edge switch S1 pushes the label of destination device S6

1. Push labels

● The edge switch S1 forwards packet with label

- Switch S3 receives packet with label and lookups flow table

2. Label lookup

- Switch S3 forwards packet with label

- Switch S5 receives packet with label and lookups flow table

- Switch S5 forwards packet with label

- Switch S6 receives packet with label and pops label

● Switch S6 forwards the original packet to Host B
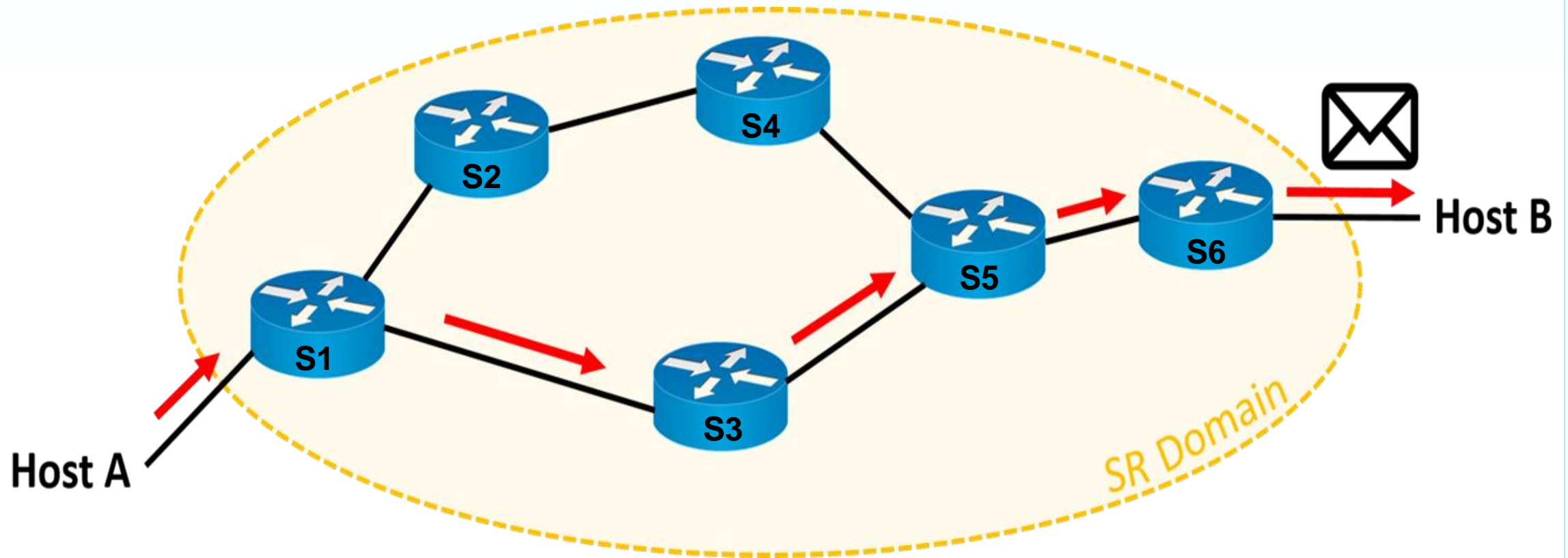
Node Segment

- Node segment ID is globally unique within a SR domain
- Typically multi-hop
  - Shortest-path first (SPF) route to designated node
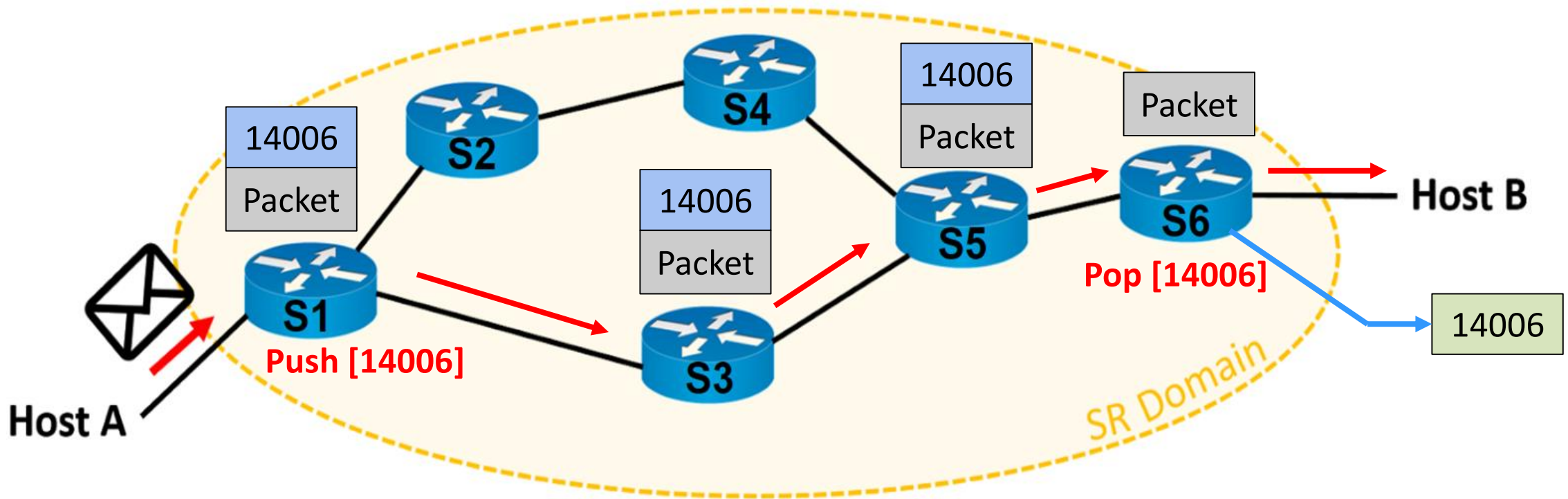
VLAN

- Segment routing uses labels to route packets
- We will use **VID** field in VLAN (802.1Q) header as label
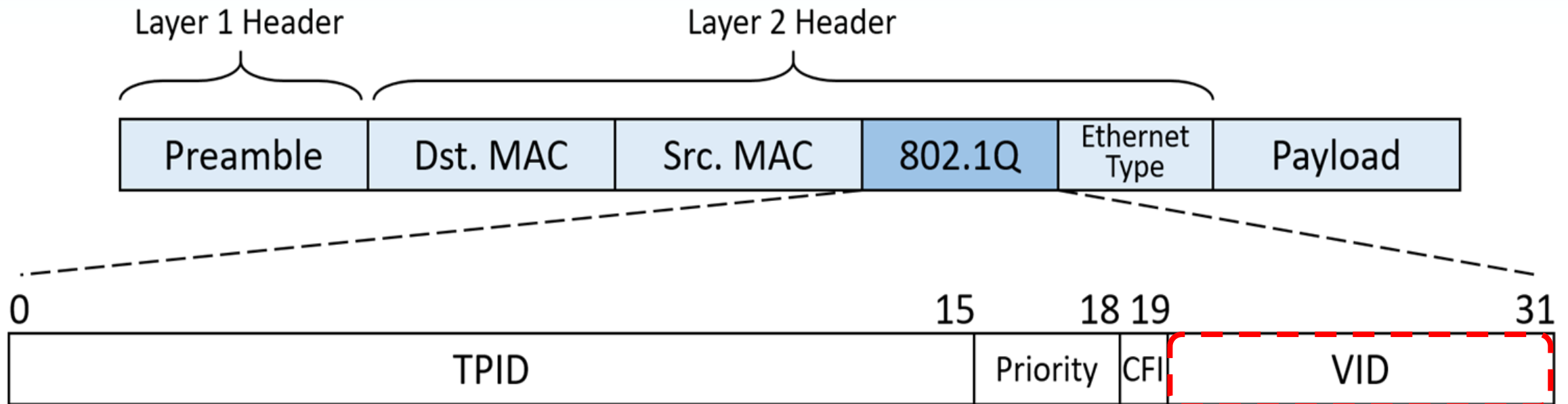
TPID: Tag protocol identifier (0x8100)
CFI: Canonical Format Indicator
VID: VLAN Identifier

Outline

- Review of Labs
- Segment Routing
  - IP Routing
  - Workflow of Segment Routing
  - Node Segment
- Final Project
  - Overview
  - Workflow
  - Requirements

Overview

- You need to implement an VLAN-based segment routing app
  - Configure network
    - DHCP server location,
    - segment ID for each switch, and
    - subnet attached to edge switches
  - Compute path to each edge switches
    - Install flow rules to forward packets

Configure Network – in Mininet

- Mininet topology
  - Hosts are configured under the same subnet

Controller

10.0.0.0/16
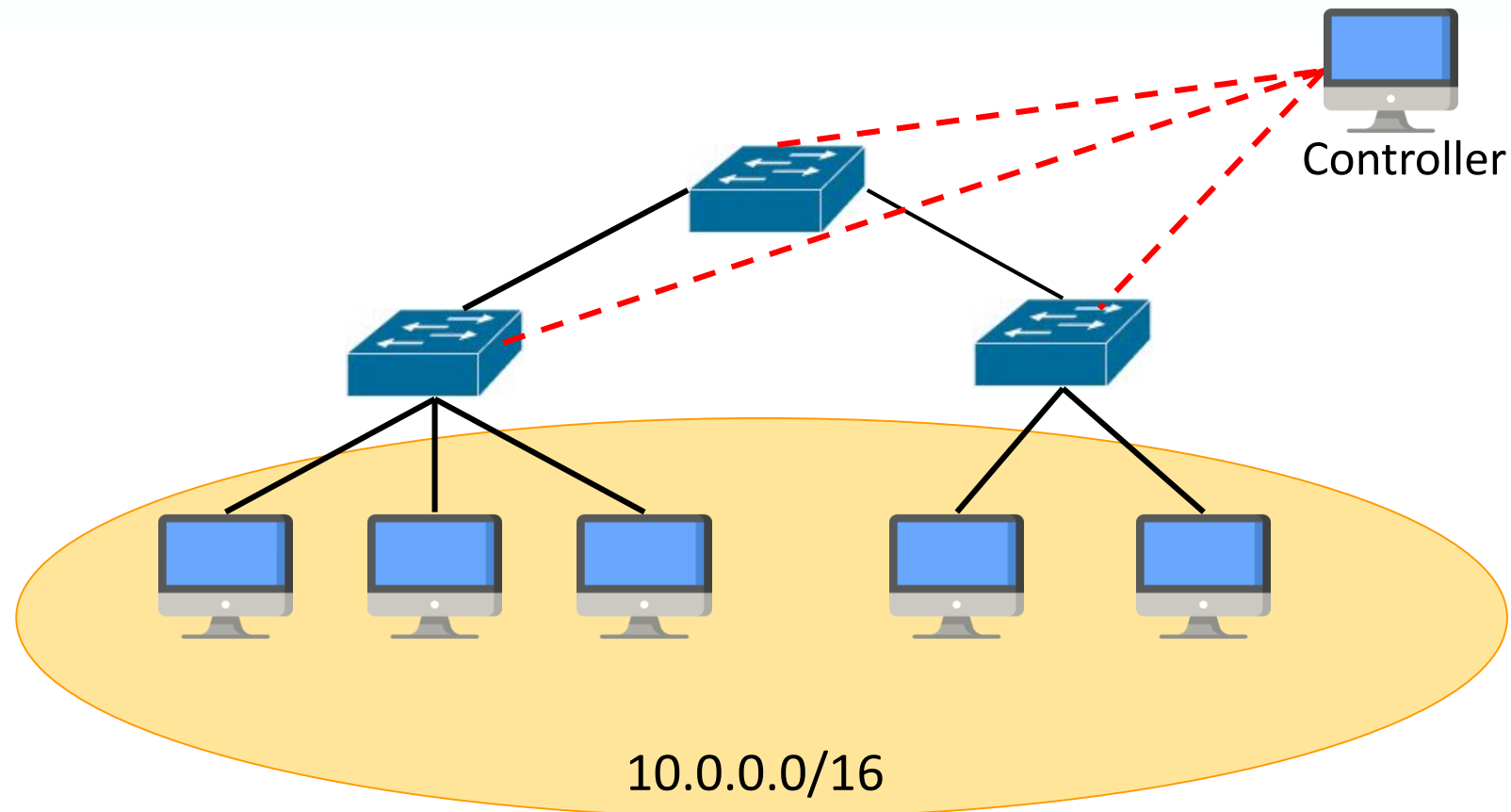
Configure Network – for Controller

- Controller view
  - Hosts are configured under the **different** subnet

Controller

10.0.2.0/24

10.0.3.0/24

10.0.0.0/16
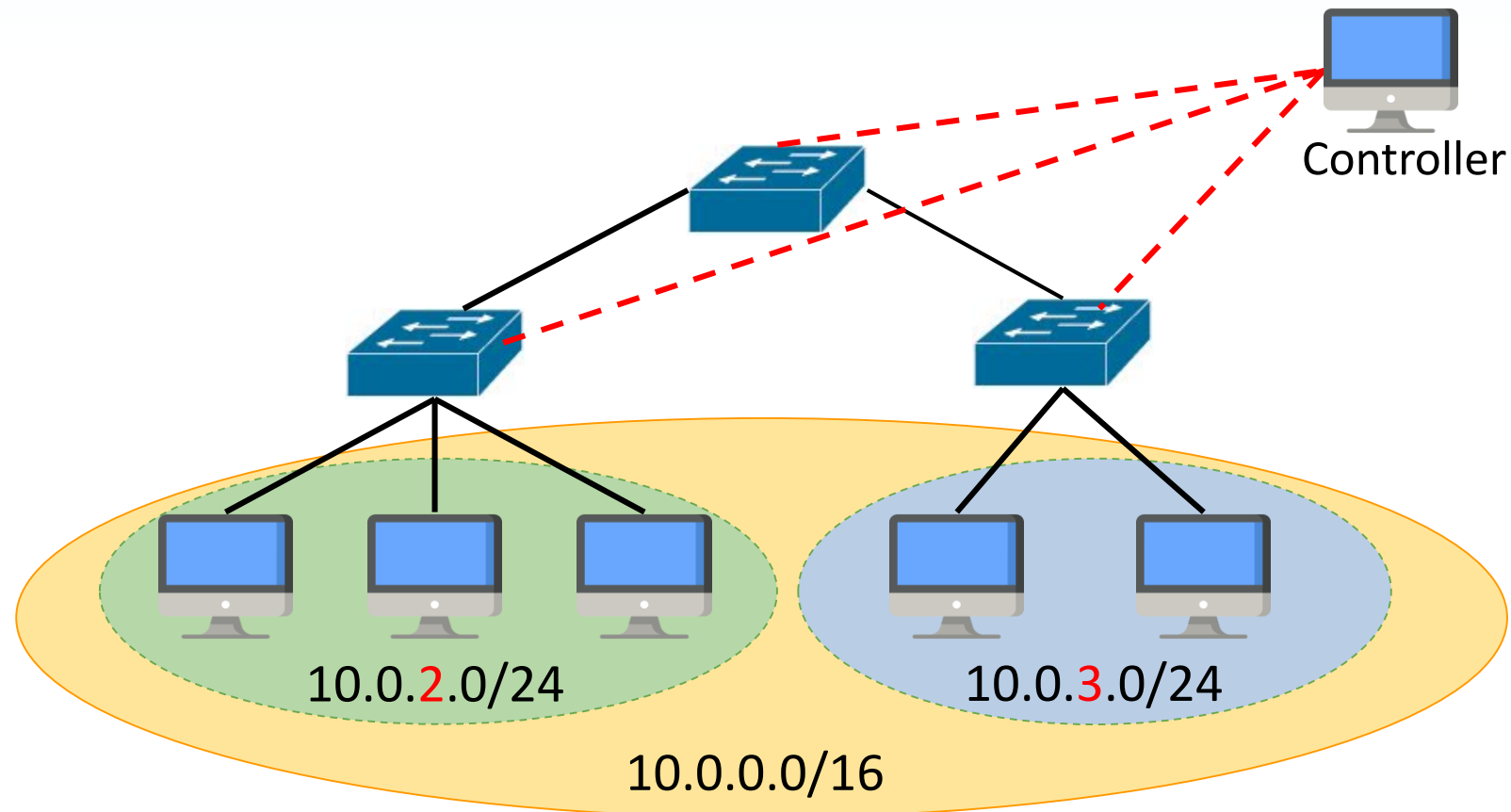
Configure Network – Upload Configuration

- Upload configuration to controller
  - DHCP server location
  - Segment ID for switch (node segment)
  - IP subnet on edge switch
  - Other configuration as you wish
    - E.g., indication of edge switch (to make implementation easier)
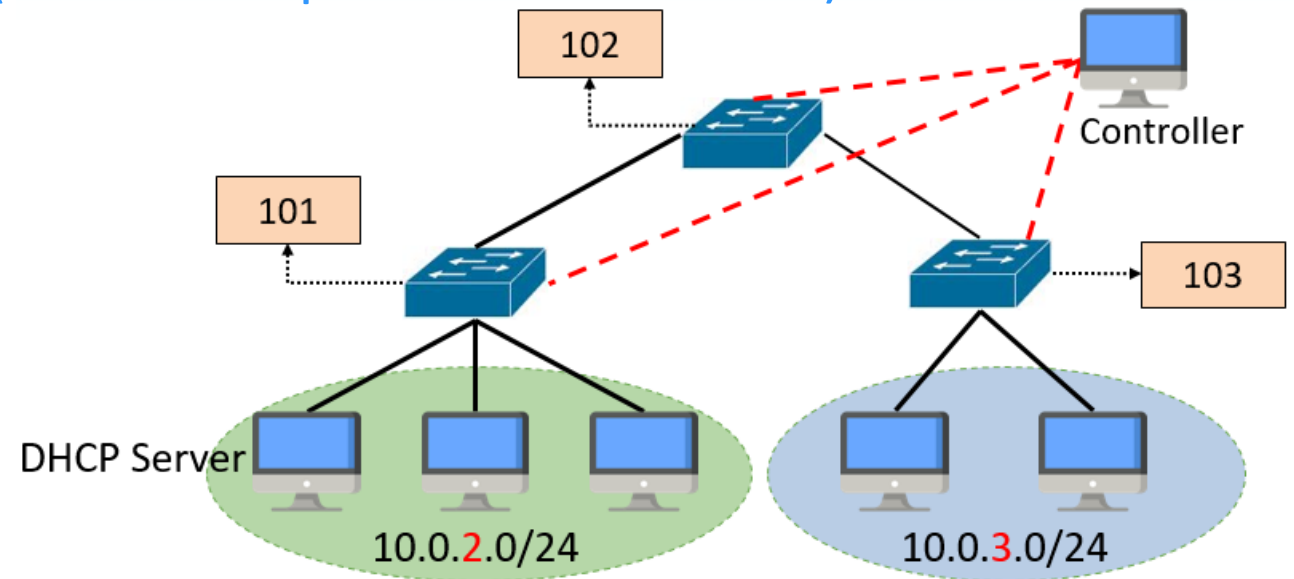
Compute Path and Install Flow Rules

- Compute a path for each pair of edge nodes
- Install flow rules for all paths

Match: VLAN_ID: 103
Action: OUTPUT: 2

Controller

Match: IP_DST: 10.0.3.0/24
Action: PUSH_VLAN: 103,
OUTPUT: 1

Match: VLAN_ID: 103
Action: POP_VLAN

1   2

1

103

10.0.2.0/24   10.0.3.0/24

10.0.0.0/16
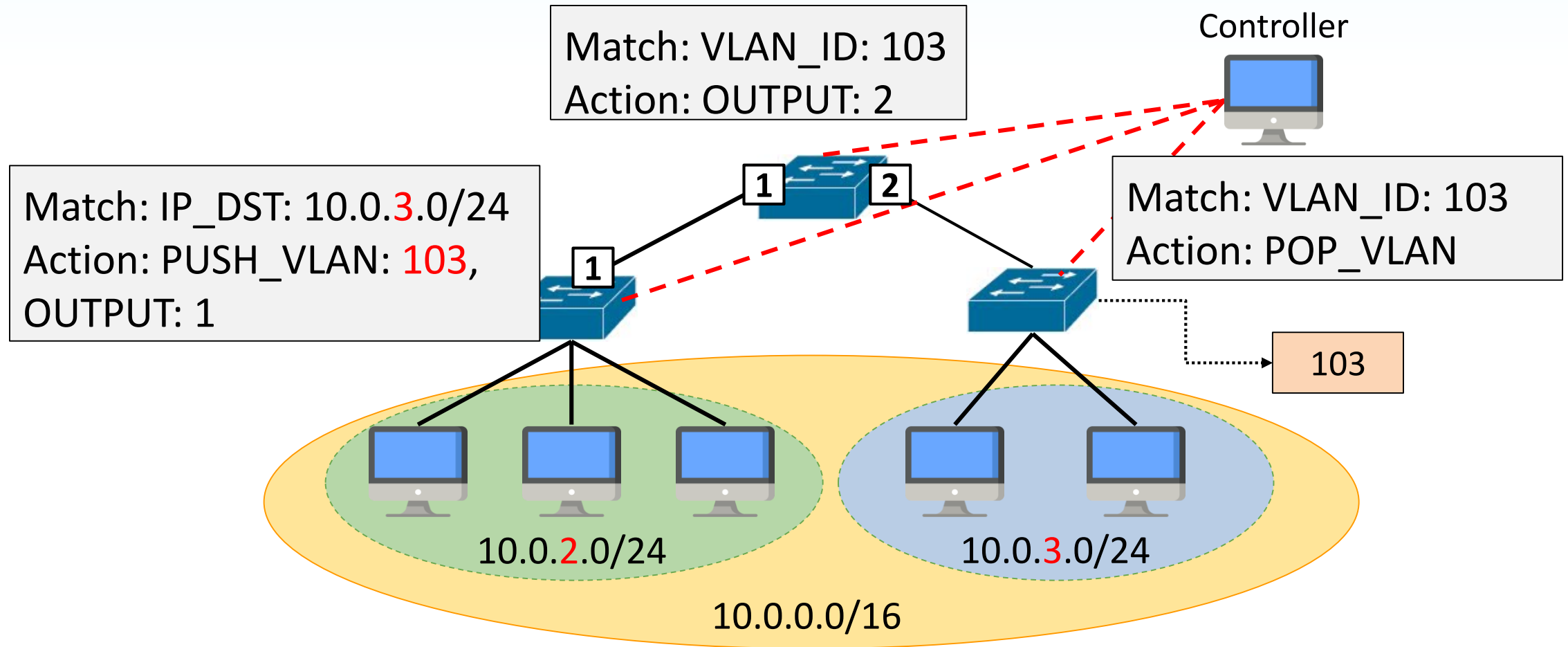
- New host could request IP address from DHCP server
  - This is what you done in lab 4

Only provide IP under 10.0.2.0/24

DHCP Server

S1

S2

S3

103

New Host

Host D

10.0.2.0/24

10.0.3.0/24

10.0.0.0/16
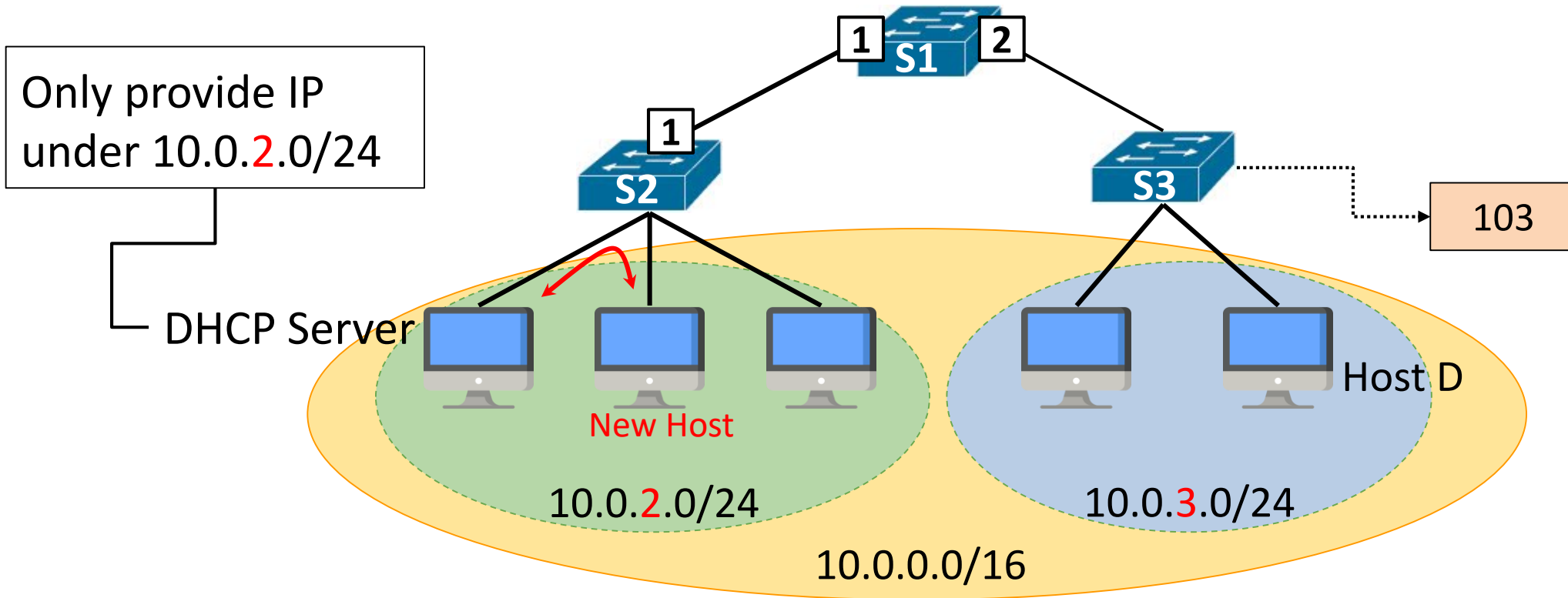
Workflow (2/6) – Host to Host Communication

- Assume new host sends packet to Host D
- Edge Switch S2:
  - Match subnet of destination address
  - Push VLAN tag to packet according to destination edge node
  - Then output to port 1

Match: IP_DST: 10.0.3.0/24
Action: PUSH_VLAN: 103,
OUTPUT: 1

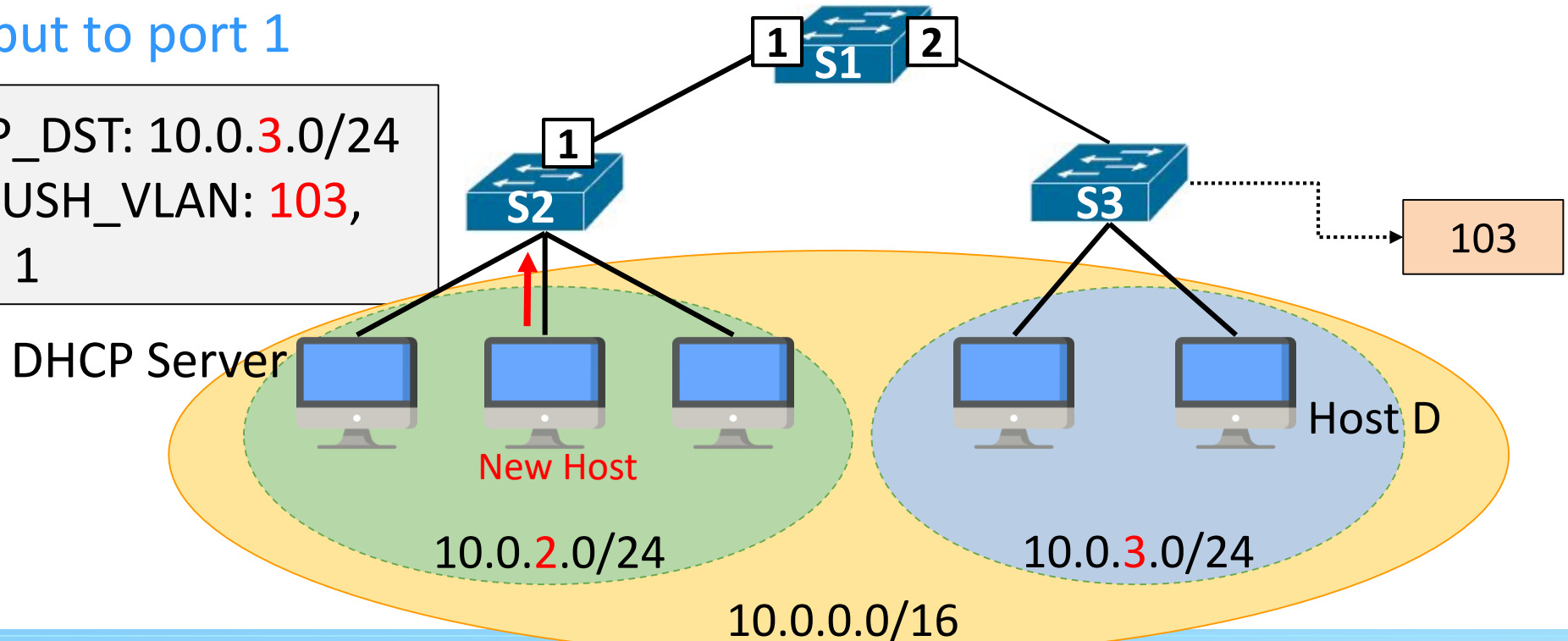**1** **S1** **2**

1

S2

S3

103

DHCP Server

New Host

Host D

10.0.2.0/24

10.0.3.0/24

10.0.0.0/16

- S1 receives VLAN tagged packet
  - Match VLAN tag and forward tagged packet via port 2

Match: VLAN_ID: 103
Action: OUTPUT: 2

Labeled

S1

S2

S3

103

DHCP Server

New Host

Host D

10.0.2.0/24

10.0.3.0/24

10.0.0.0/16
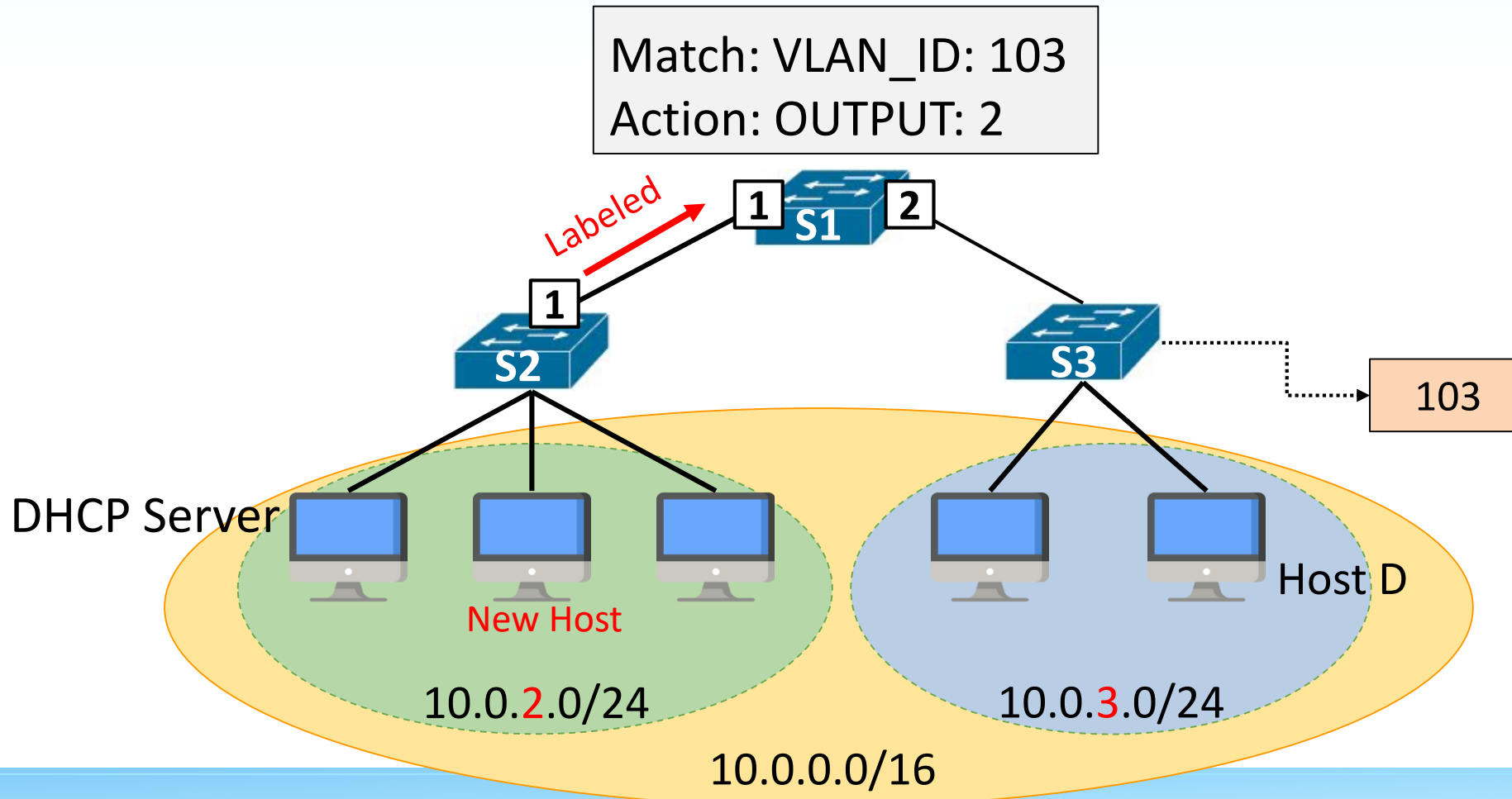
Workflow (4/6) – Label Popping

- When destination edge switch S3 receives tagged packet
  - Pop VLAN tag
  - Forward original (untagged) packet to Host D (next slide)

Match: VLAN_ID: 103
Action: POP_VLAN

Labeled

S1

S2

S3

DHCP Server

New Host

Host D

103

10.0.2.0/24

10.0.3.0/24

10.0.0.0/16
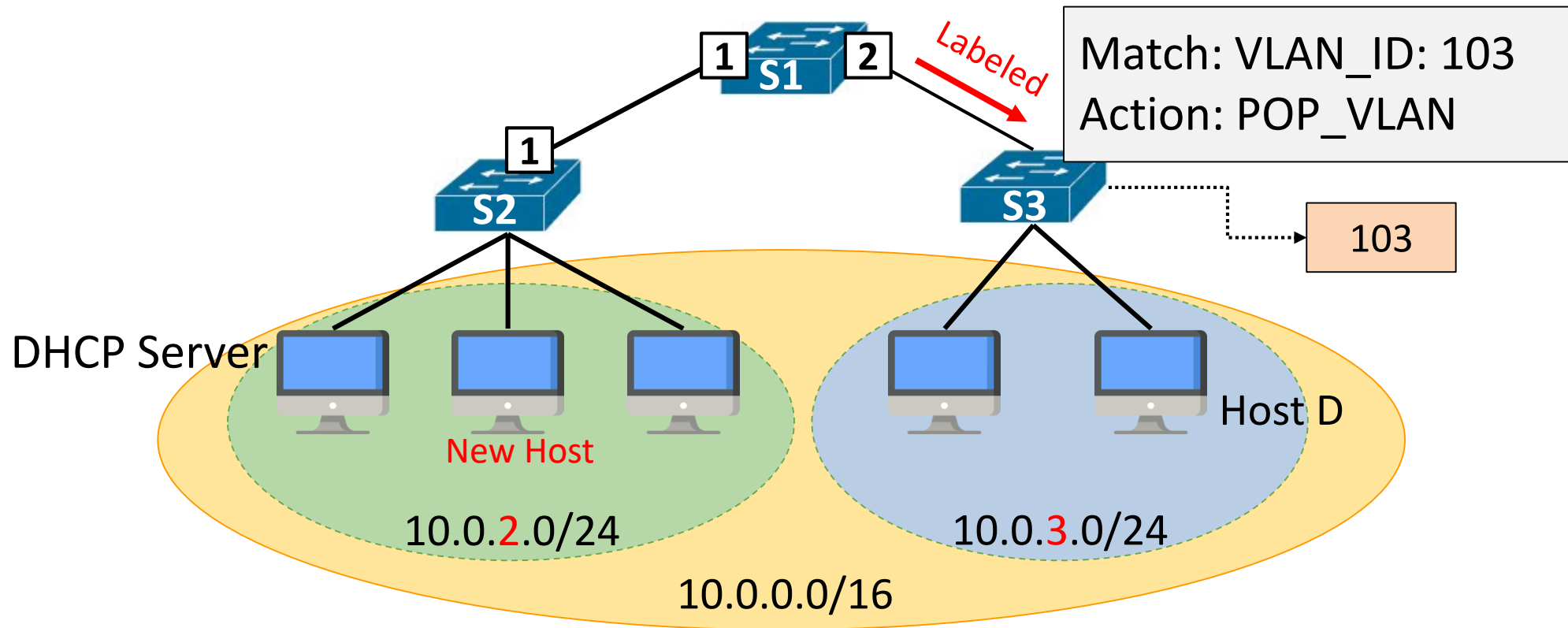
Workflow (5/6) – IP/MAC Forwarding

● After label popping, S3 forwards original packet by matching Layer 2 or L3 address
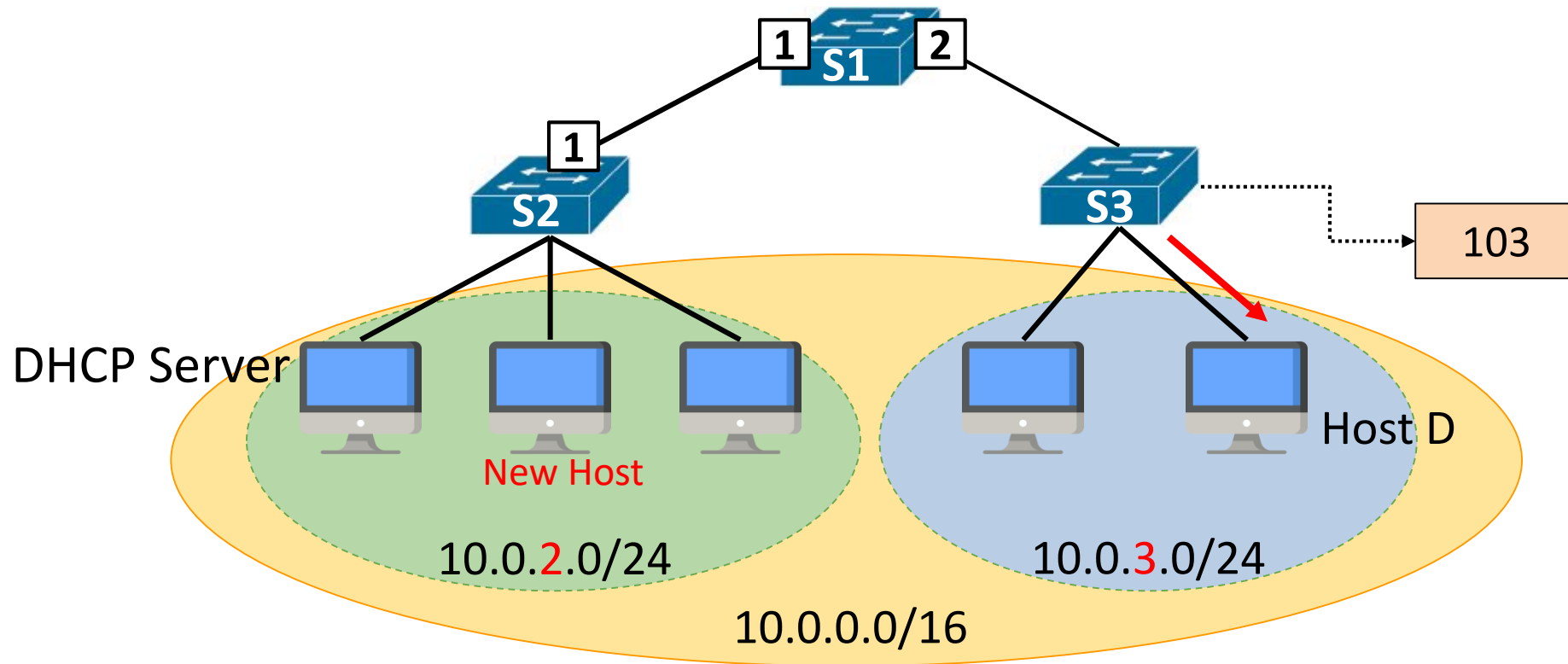
- Intra-device packet could be forwarded by matching Layer 2 or L3 address directly
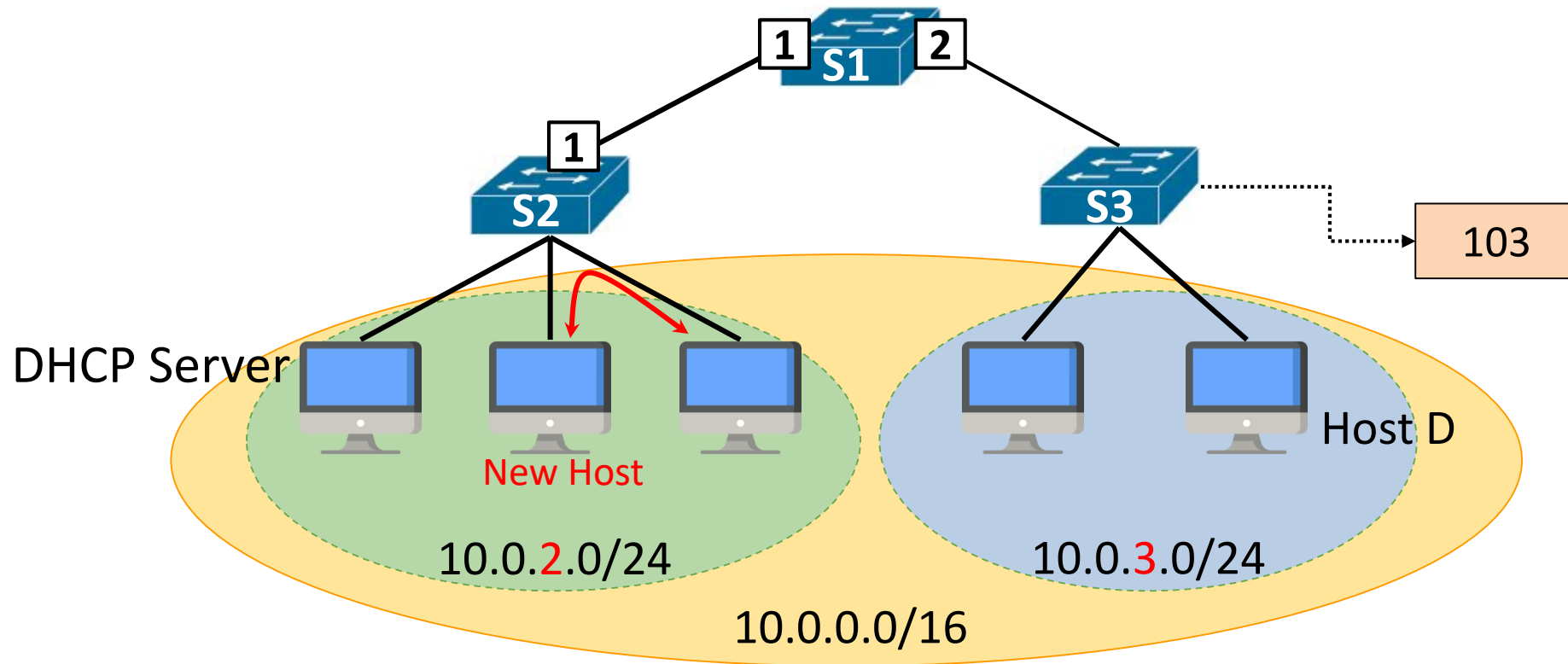
Requirements

- The following three applications should be activated
  - DHCP Unicast (lab 4)
  - Proxy ARP (lab 5)
  - VLAN-based Segment Routing (this project)
- You should not activate any other application except OpenFlow-related applications on ONOS
- Install all flow rules when controller receives configuration
- Flow rules for forwarding packets must match VLAN tag
  - Except for intra-subnet forwarding

Issues

- Controller may not be able to install correct flow rules when receiving configuration
  - Since controller does not know hosts at the beginning
- First solution
  - Send packets to let controller know host information before uploading configuration
- Second solution
  - Add host information in configuration
- You can figure out other solutions on your own

Naming Requirement

- You should follow the Maven project naming format below, or your project will not be scored
  - `<groupId>:`   `nctu.winlab`
  - `<artifactId>:` `vlanbasedsr`
  - `<version>:`   `<use default> (1.0-SNAPSHOT)`
  - `<Package>:`   `nctu.winlab.vlanbasedsr`

Scoring Criteria

- Report: Previous Labs Parts
  - DHCP Unicast and Proxy ARP (5%)
- Report: Final Project Part
  - Activated applications (10%)
    - Only activate DHCP unicast, Proxy ARP, vlanbasedsr, and OpenFlow-related applications
  - Flow rules (25%)
    - Must use VLAN tag to forward packets
  - Connectivity (10%)
    - Hosts under different subnets can send labeled packets to each other
- Demo (50%)
  - TA will produce a different topology to test your app

Submission

- Files:
  - All files in Vlan-based Segment Routing app
  - No need to submit DHCP Unicast and Proxy ARP app
- Submit:
  - Upload a ".zip" file to e3
    - Named: final_<studentID>.zip
  - Incorrect naming convention or format will not be scored