523353 – Computer Networks

Lecture 4: Ethernet LANs Part2

Dr. Parin Sornlertlamvanich

CompTIA Security+

Huawei Certified HCIA-Datacom

parin.s@sut.ac.th

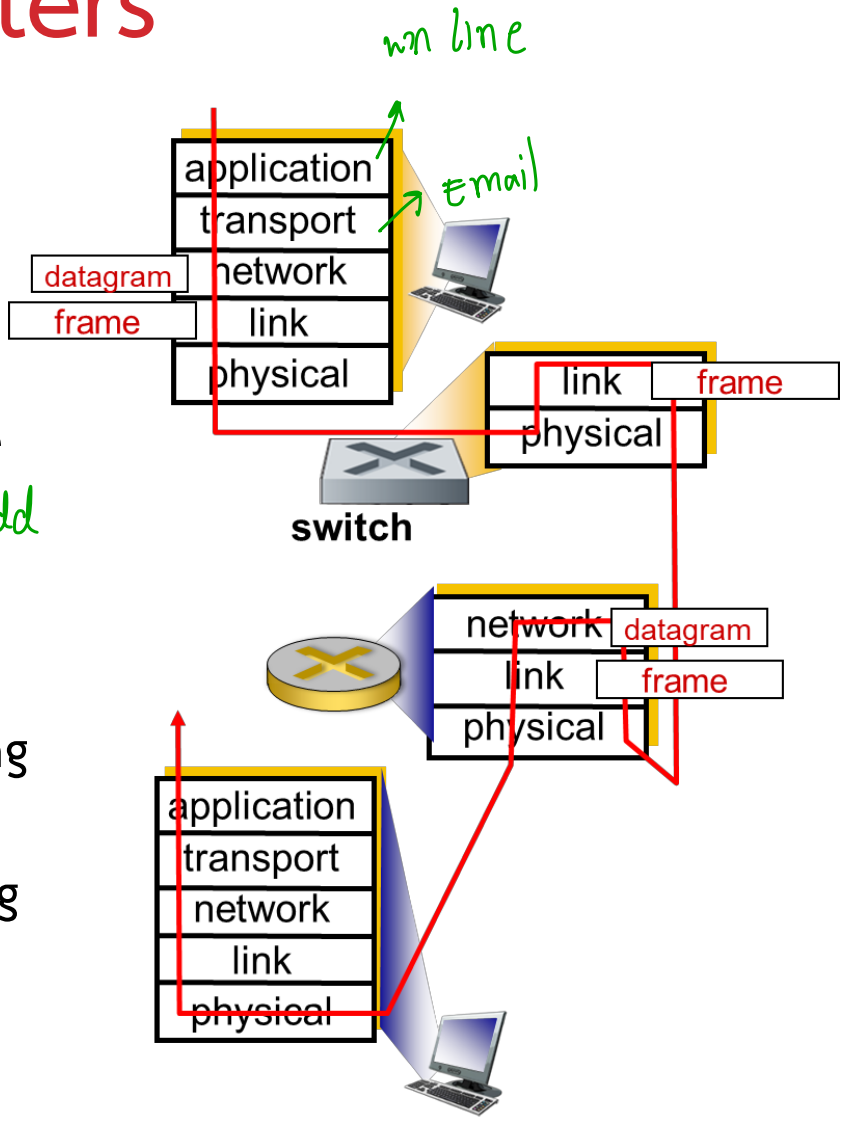
Switches vs. Routers

Both are store-and-forward:

- Routers: network-layer devices (examine network-layer headers)
- Switches: link-layer devices (examine link-layer headers)

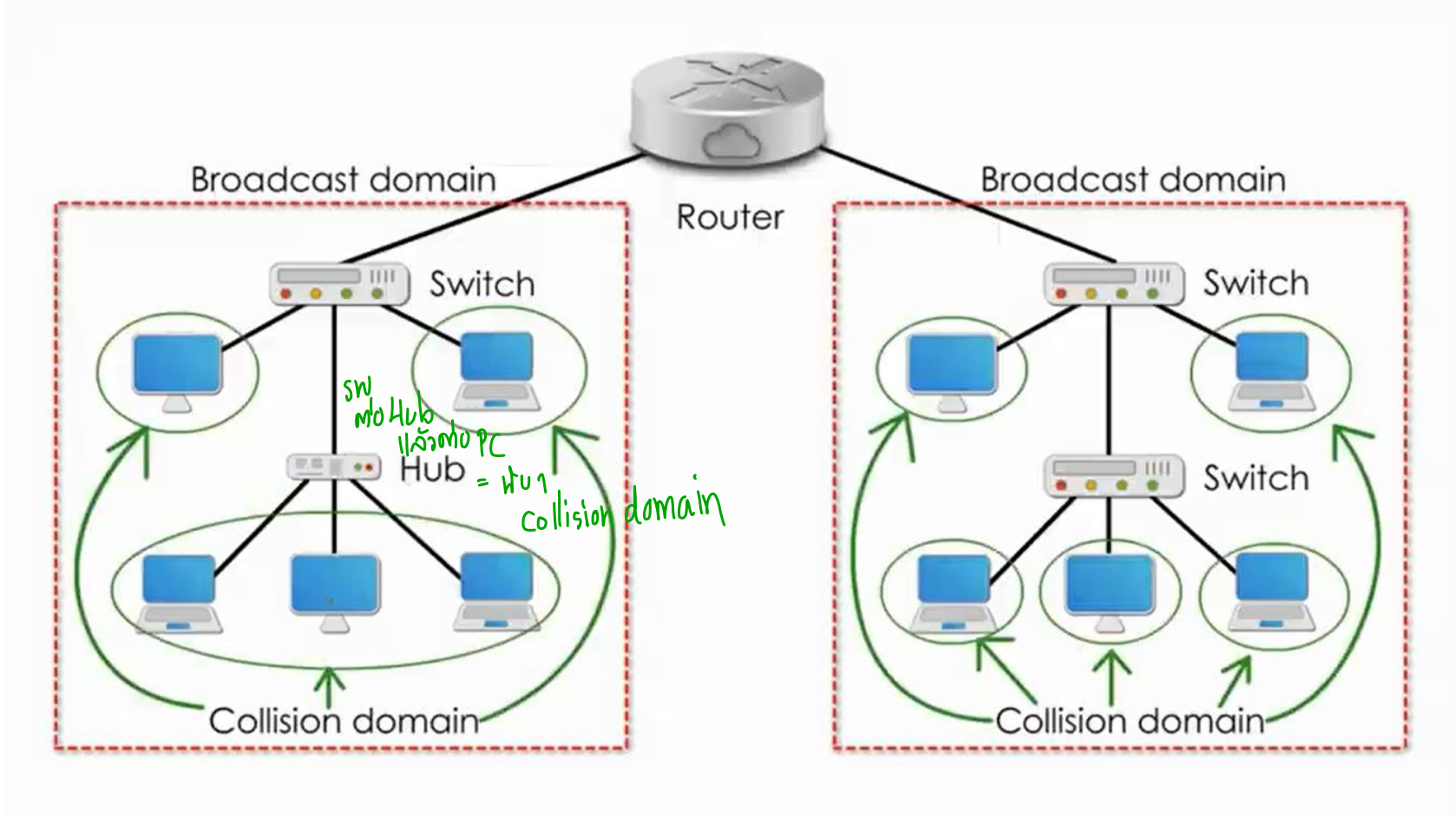
Both have forwarding tables:

- Routers: compute tables using routing algorithms, IP addresses
- Switches: learn forwarding table using flooding, learning, MAC addresses



Subnet → (192.168.0.0/24) 1-254

Collision domain vs. Broadcast domain



Ethernet Virtual LANs (VLANs)

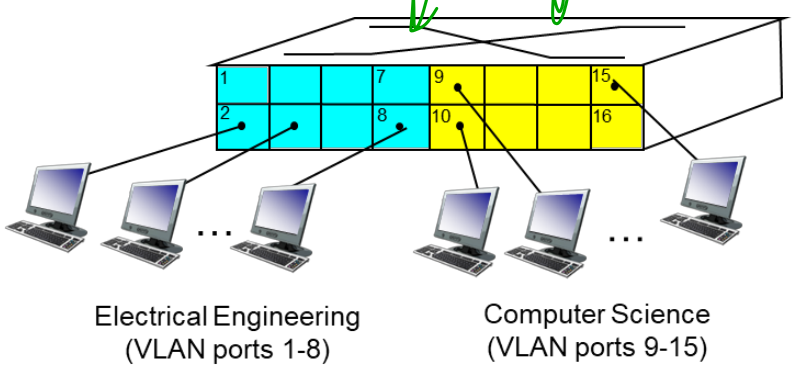
Virtual Local Area Network (VLANs)

Virtual Local Area Network

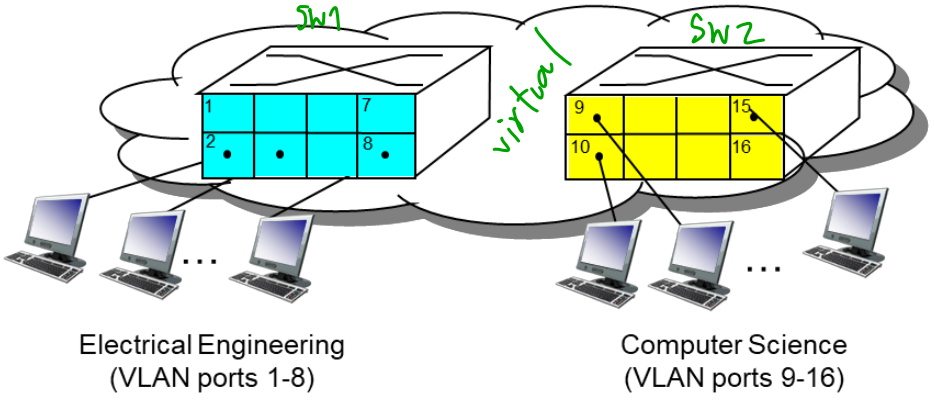
switch(es) supporting VLAN capabilities can be configured to define multiple *virtual* LANs over single physical LAN infrastructure.

Port-based VLAN:

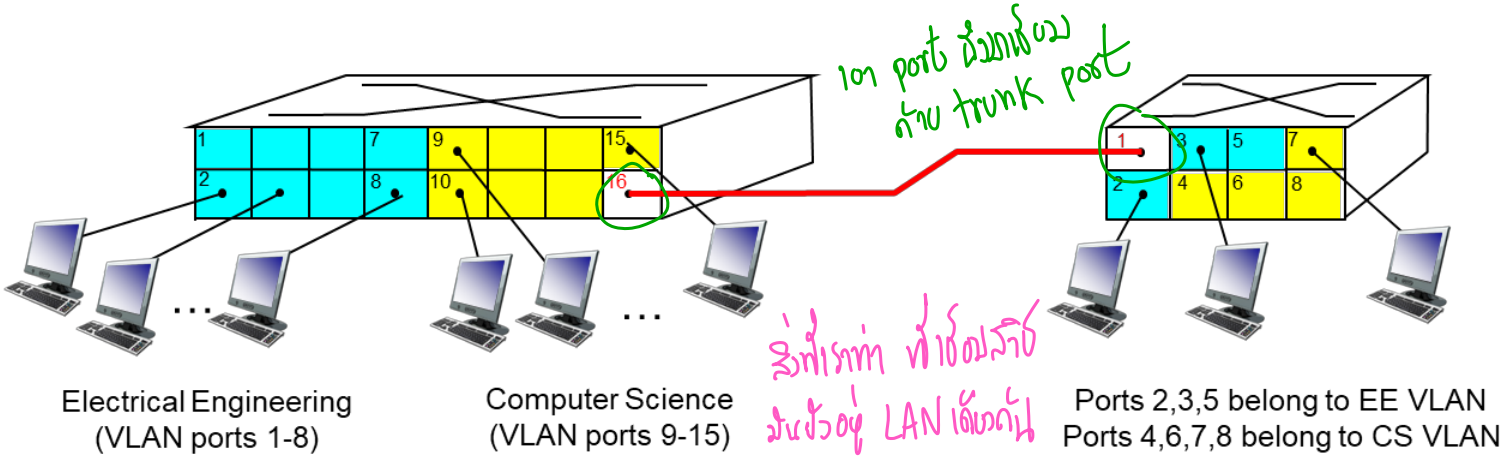
switch ports grouped (by switch management software) so that single physical switch .....



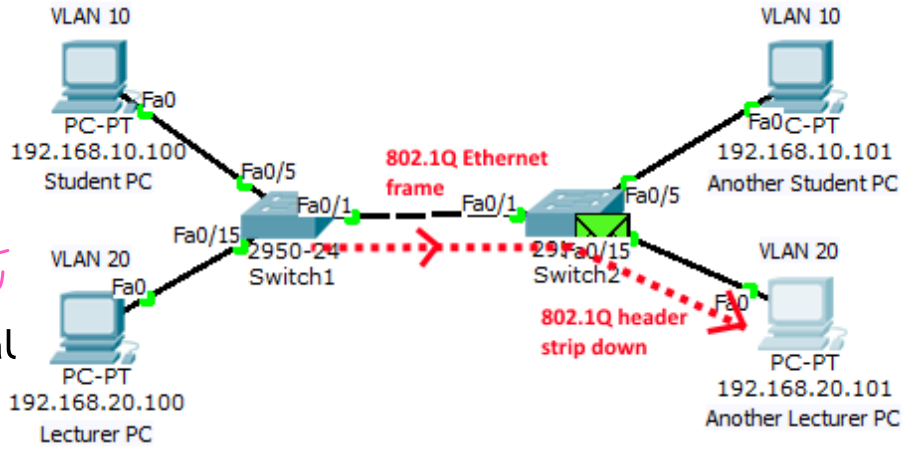
... operates as multiple virtual switches



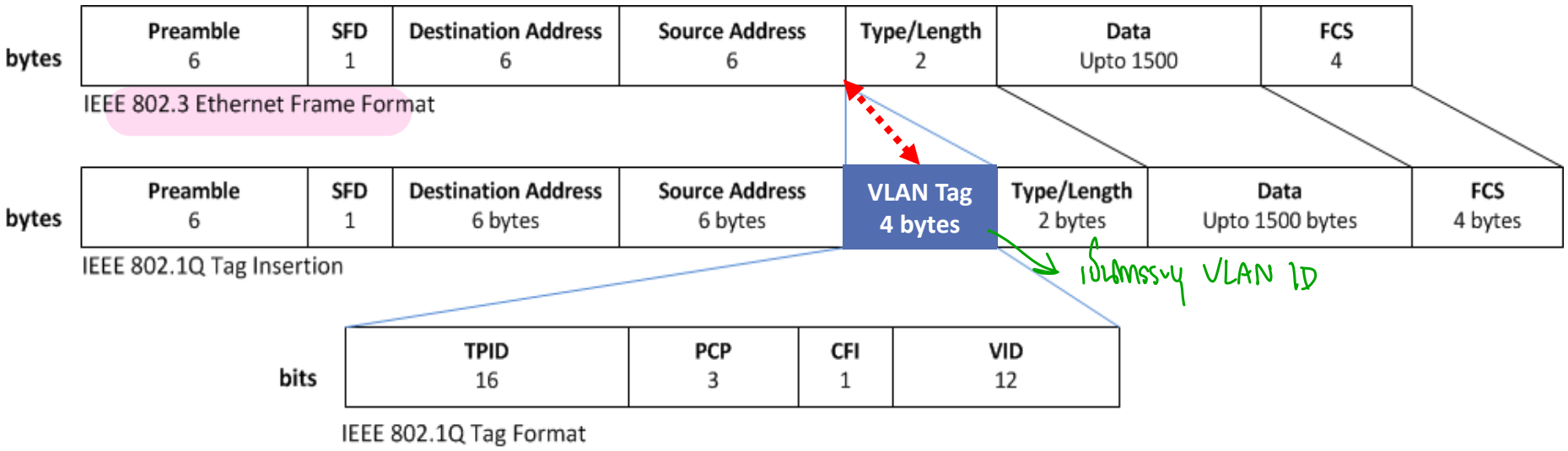
VLANS spanning multiple switches



- **Trunk port:** carries frames between VLANS defined over multiple physical switches
  - frames forwarded within VLAN between switches can't be vanilla 802.1 frames (must carry VLAN ID info)
  - 802.1q protocol adds/removed additional header fields for frames forwarded between trunk ports



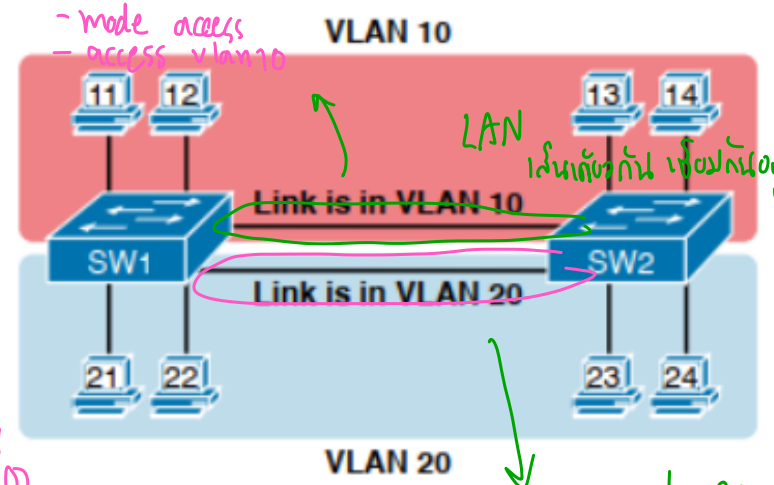
802.1Q VLAN frame format



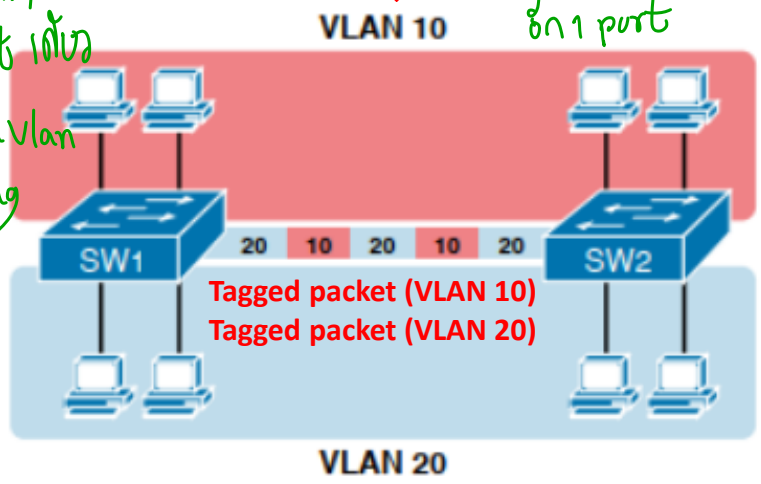
- IEEE 802.3 Ethernet standard frame
  - It is adopted with the VLAN (IEEE 802.1Q) standard
- The new IEEE 802.1Q frame format
  - TPID - To distinguish the frame from untagged frames (Native VLAN)
  - VID - A 12-bit field specifying the VLAN
    - 0 and 4095 (0x000 and 0xFFF in HEX)
    - 0x000 indicates that the frame does not carry a VLAN ID

Multi-switch VLAN

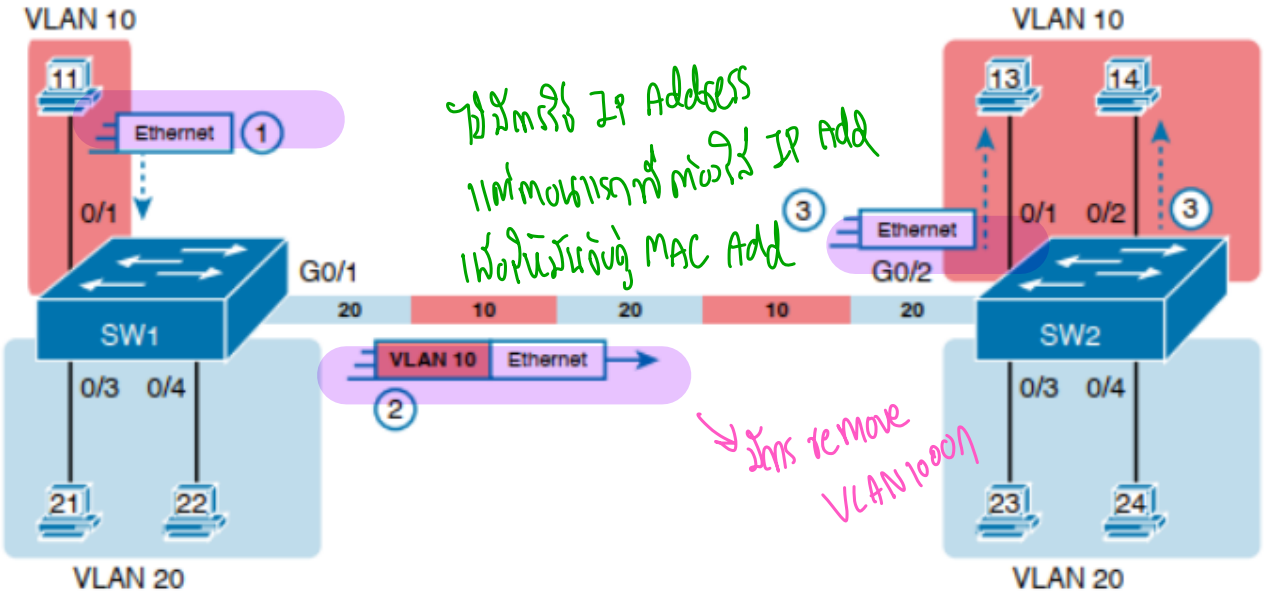
- Muti-switch without VLAN trucking
  - It requires one physical link between switches to support every VLAN
  - 10 VLANs: you would need 10 links between switches, and you use 10 switch ports (on each switch) for those links



- Muti-switch with VLAN trucking
  - To allow switches to forward frames from multiple VLANs over a single physical connection
  - SW will tag packet for their correct VLANs

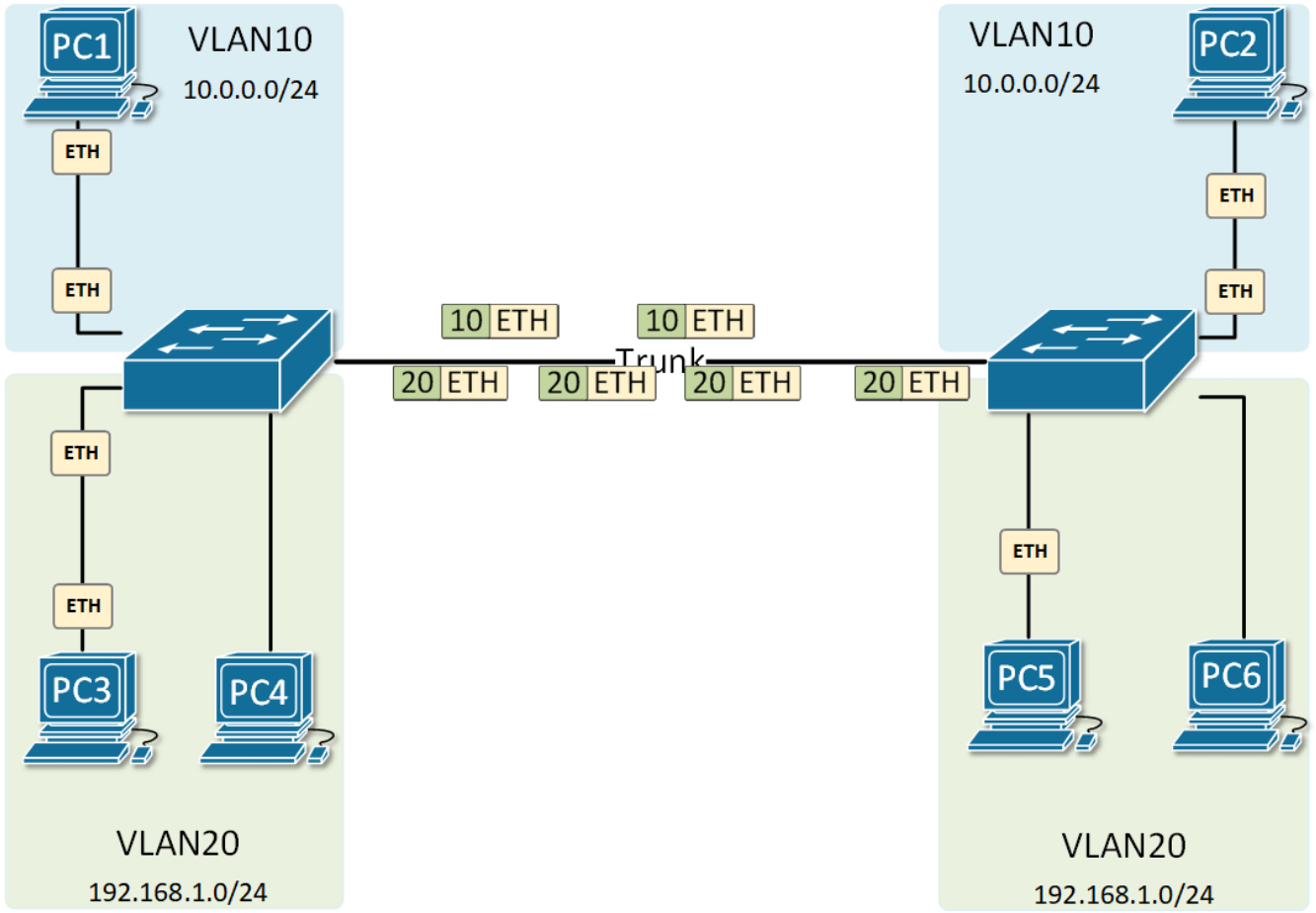


VLAN Trunking between two SW



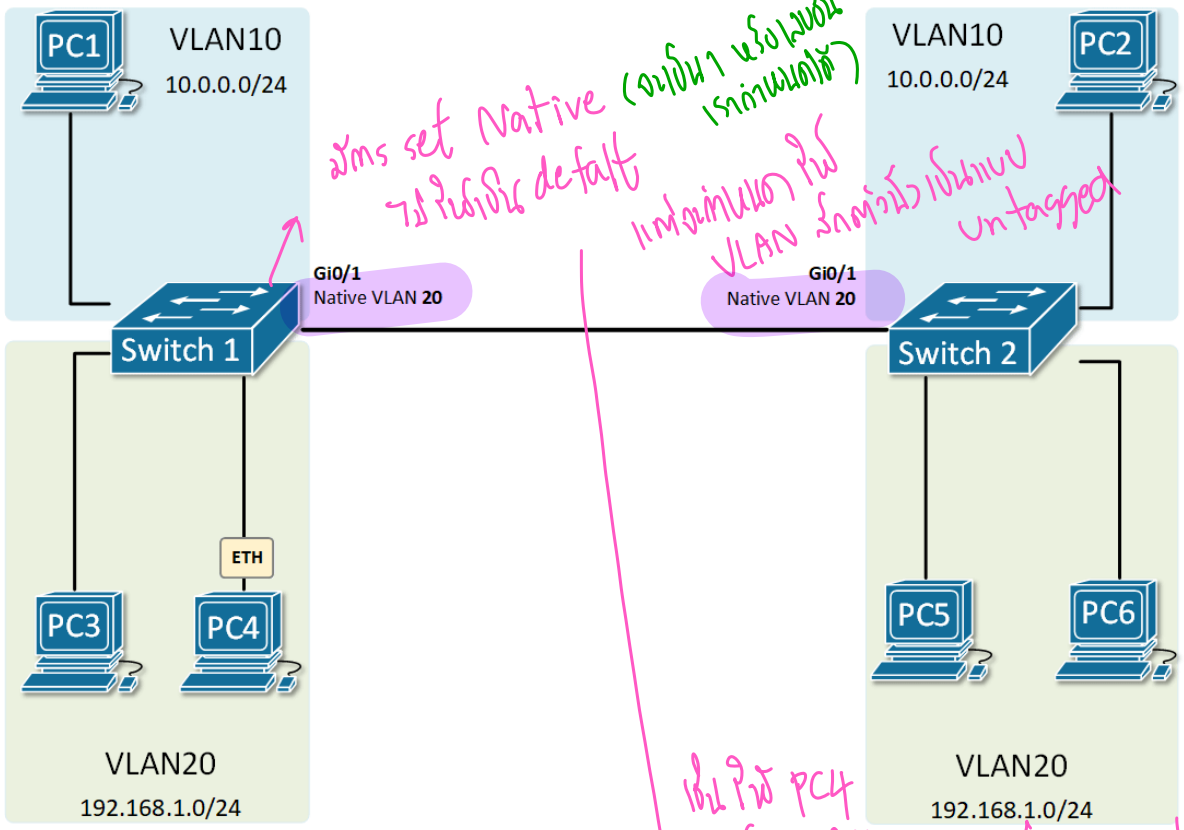
- PC11 sending a broadcast frame on its interface
- SW1 adds a VLAN header to the original Ethernet frame
  - VLAN header listing a VLAN ID of 10
  - SW2 then removes the VLAN header, forwarding the original frame out its interfaces in VLAN 10

VLAN Trunking between two SW (2)



มันก็คือการมี table MAC Addr

Trunk Native VLAN

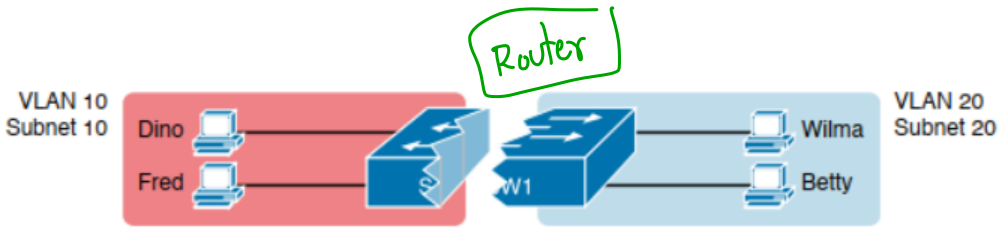


- Native VLAN is configured per trunk port
  - "if SW receive an untagged data, forward it as the Native VLAN number"
- Example: Native VLAN on a trunk = 20
  - PC4 is sending untagged frames – to be forwarded into VLAN 20 (Native VLAN)

Routing between VLANs

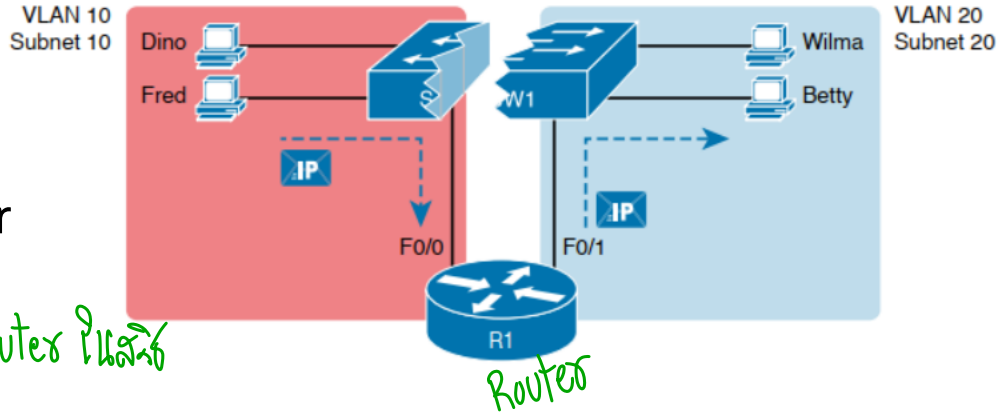
การเชื่อมต่อข้าม VLAN มี 2 วิธี (Inter-VLAN Routing)

- Layer 2 switches will not forward data between two VLANs
  - SW acts like two separate switches



- Routing Packets Between VLANs with a Router (Layer3)
  - Or multilayer switch or Layer 3 switch

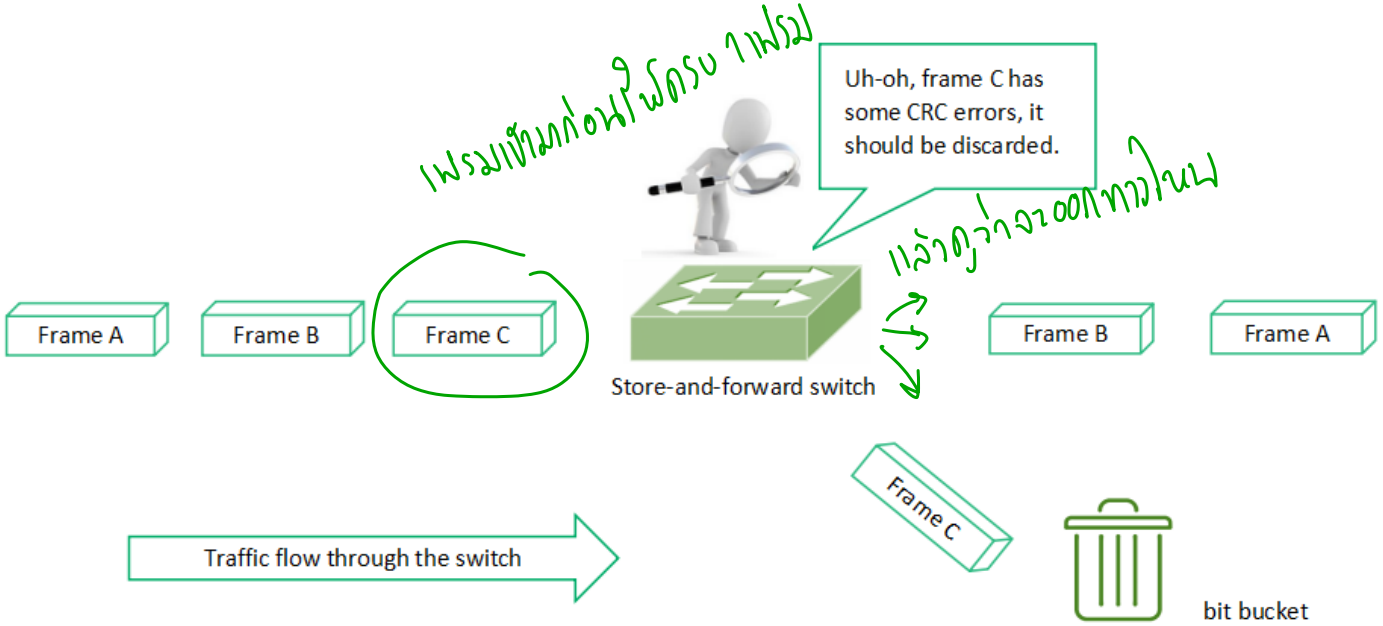
multi switch ที่มี Router ในตัว



Switching Techniques เทคนิคสวิช

1. Store and Forward
2. Cut-Through
3. Fragment-free

① Store and Forward

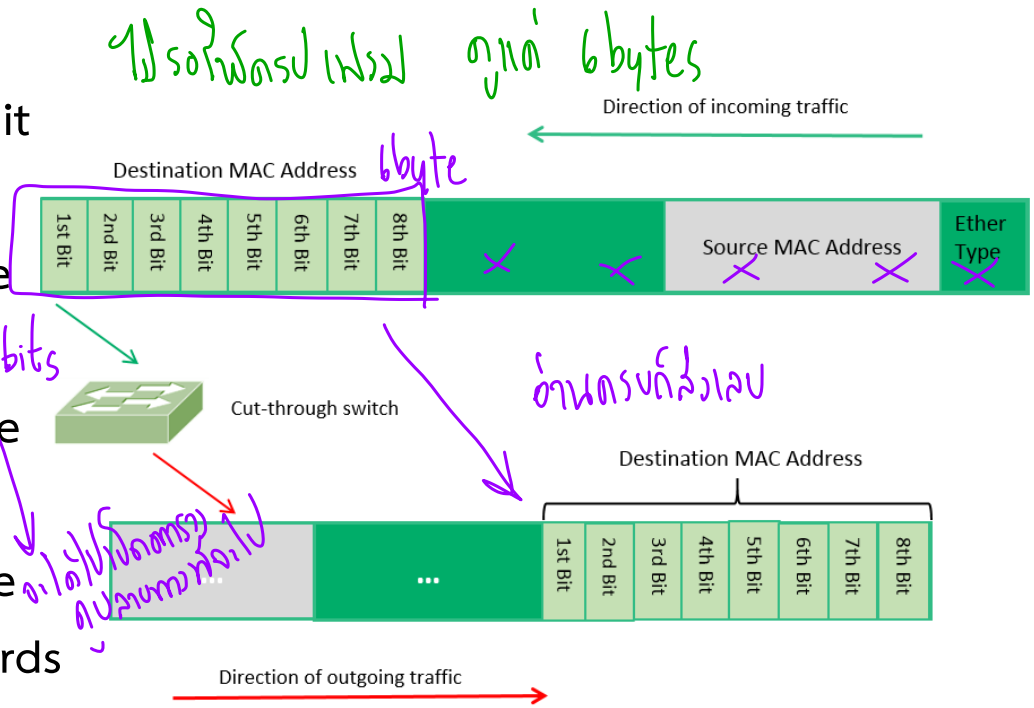


- Switching will wait until the entire frame has arrived before forwarding it
- CRC
  - If no errors are present, the frame will be forwarded to the destination address

https://community.fs.com/blog/comparison-between-store-and-forward-switching-and-cut-through-switching.html

② Cut-Through

- When switches receive the frame, it will look up its first 6 bytes of the frame that following the preamble
- Then the LAN switch will check the destination MAC address in its switching table, and determine the outgoing interface port, and forwards the frame to its destination



- No CRC error-checking

https://community.fs.com/blog/comparison-between-store-and-forward-switching-and-cut-through-switching.html

③ Fragment-Free

ผสมวิธี 1 และ 2

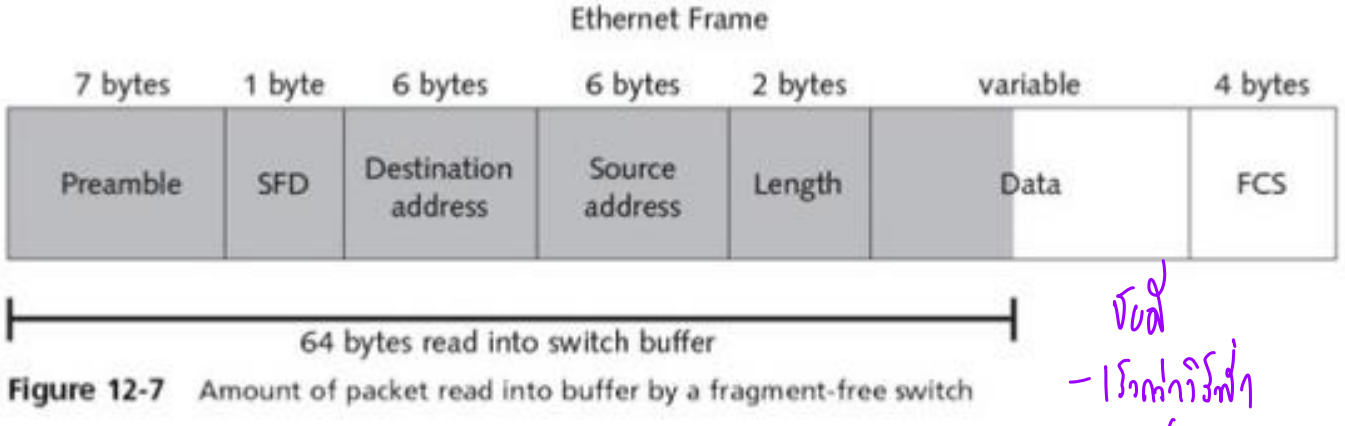


Figure 12-7 Amount of packet read into buffer by a fragment-free switch

ข้อดี
- เร็วกว่าวิธีที่ 1
- ข้อน้อย

เสีย
- ไม่มี checksum
- ช้ากว่าวิธีที่ 2

② + ①

- A hybrid of cut-through and store-and-forward switching

46 bits ครบ frame

- Fragment free is a variation on cut-through switching that partially addresses this problem by assuring that collision fragments are not forwarded

วิธีนี้ มั่นใจว่า 64 bytes แรก (เพราะถ้ามั่นใจว่า มั่นคงเกิดตั้งแต่ 64 bytes แรก)

- SW examines the first 64 bytes of the frame
  - then make a forwarding decision
  - In an Ethernet LAN, collision fragments are detected in the first 64 bytes

จะเร็วกว่าข้อแรก Scaling ของ Network (มากกว่าแน่นอน)

Switch: multiple simultaneous transmissions

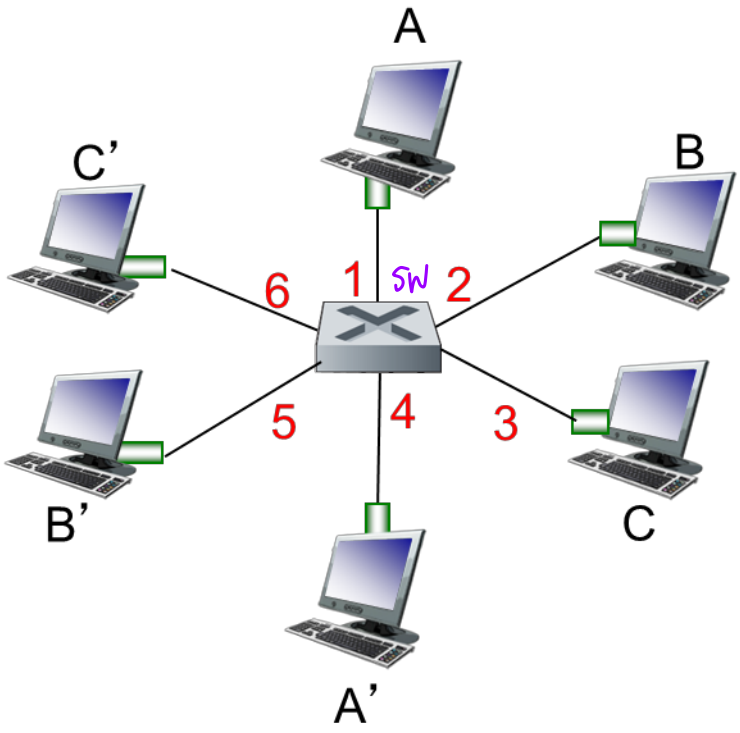
- Hosts have dedicated, direct connection to switch

ต้องเก็บ frame ก่อน แล้วเช็ค CRC

- Switches buffer packets

- Ethernet protocol used on each incoming link, but no collisions; full duplex
  - Each link is its own collision domain

- Switching: A-to-A' and B-to-B' can transmit simultaneously, without collisions

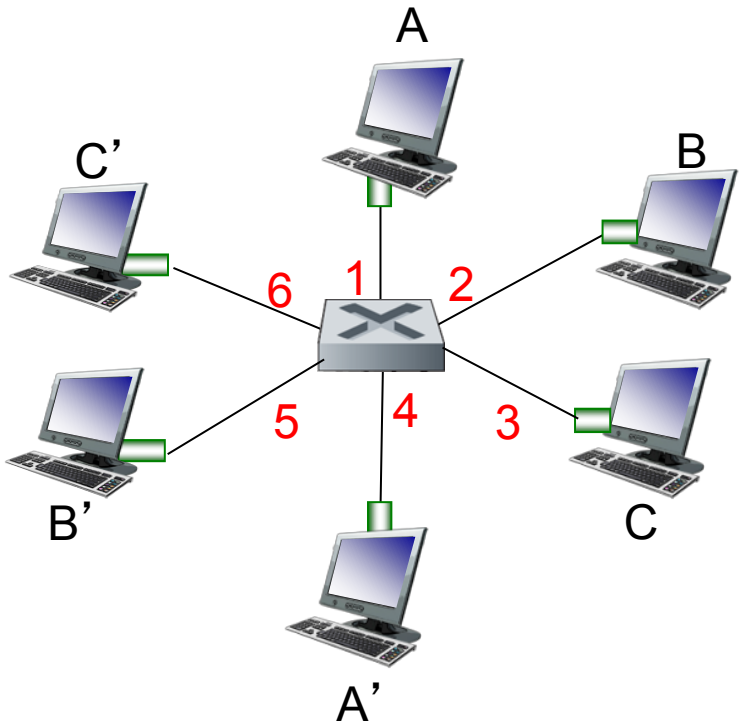


switch with six interfaces (1,2,3,4,5,6)

Switch forwarding table

- Q: how does switch know A' reachable via interface 4, B' reachable via interface 5?
  - Ans: Each switch has a switch table, (MAC table) each entry:
    - (MAC address of host, interface to reach host, time stamp)
    - looks like a routing table!

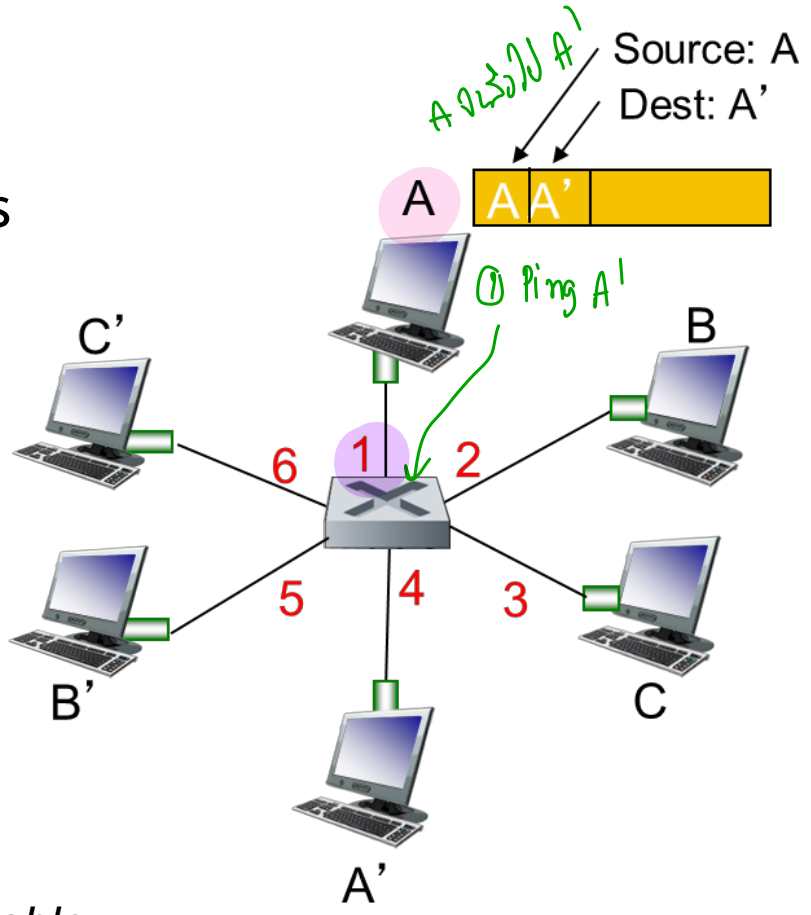
- Q: how are entries created, maintained in switch table?
  - something like a routing protocol?



switch with six interfaces (1,2,3,4,5,6)

Switch: self-learning เรียนเพื่อสร้าง Switch table

- Switch learns which hosts can be reached through which interfaces
  - when frame received, switch "learns" location of sender: incoming LAN segment
  - records sender/location pair in switch table



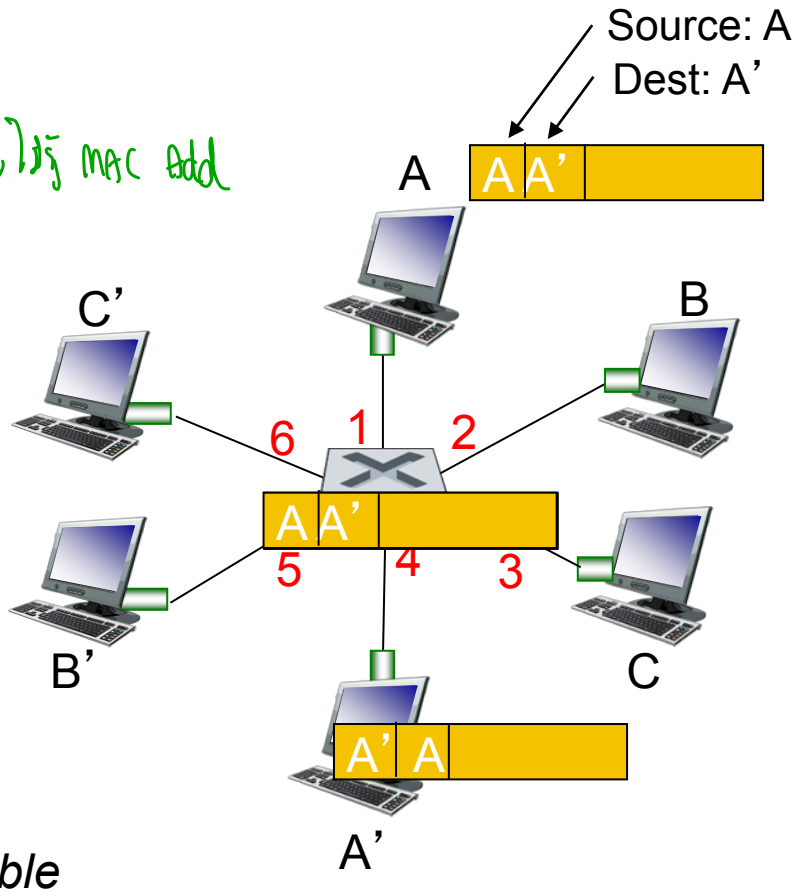
สร้าง table ของ MAC Address ที่เห็น

MAC addr	interface (port)	TTL
A	1	60

Switch table (initially empty)

Self-learning, forwarding: example

- frame destination, A', location unknown: *flood* (2) → ไม่รู้ปลายทาง, ไม่รู้ MAC addr
- Destination A location known: selectively send on just one link



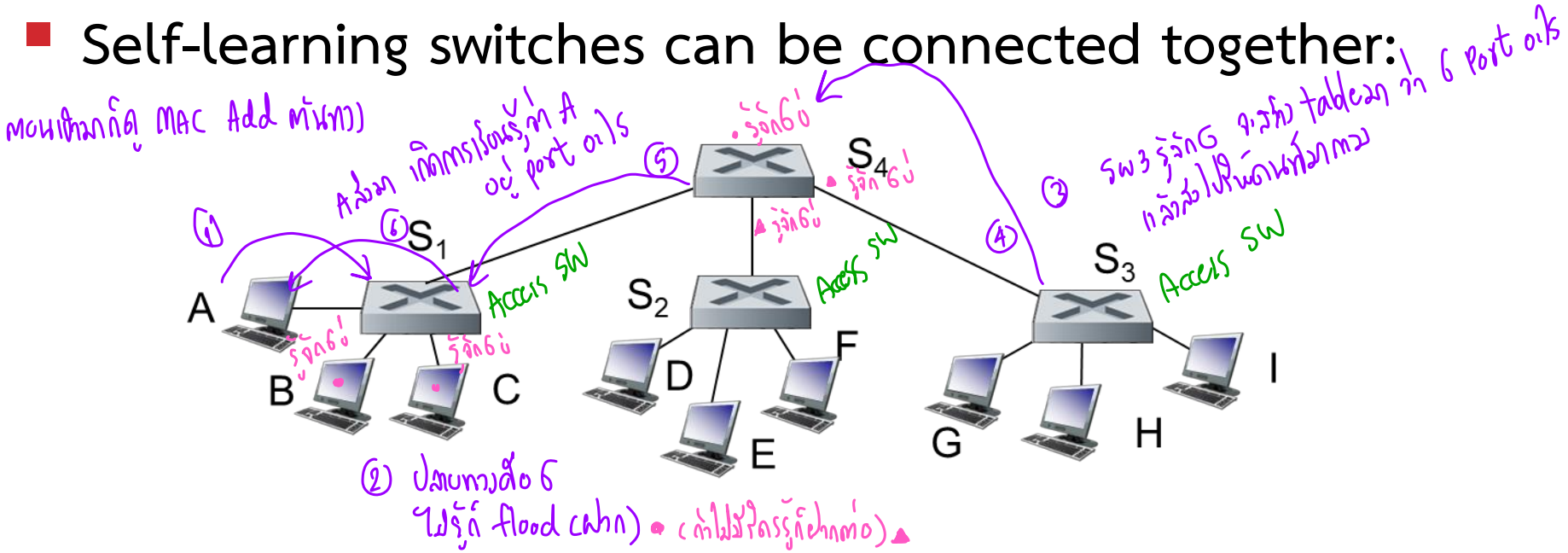
MAC addr	interface	TTL
A	*1*	*60*
A'	*4*	*60*

switch table (initially empty)

มองว่า A ส่ง ping ไป A' A' ได้รับและ Reply กลับมา

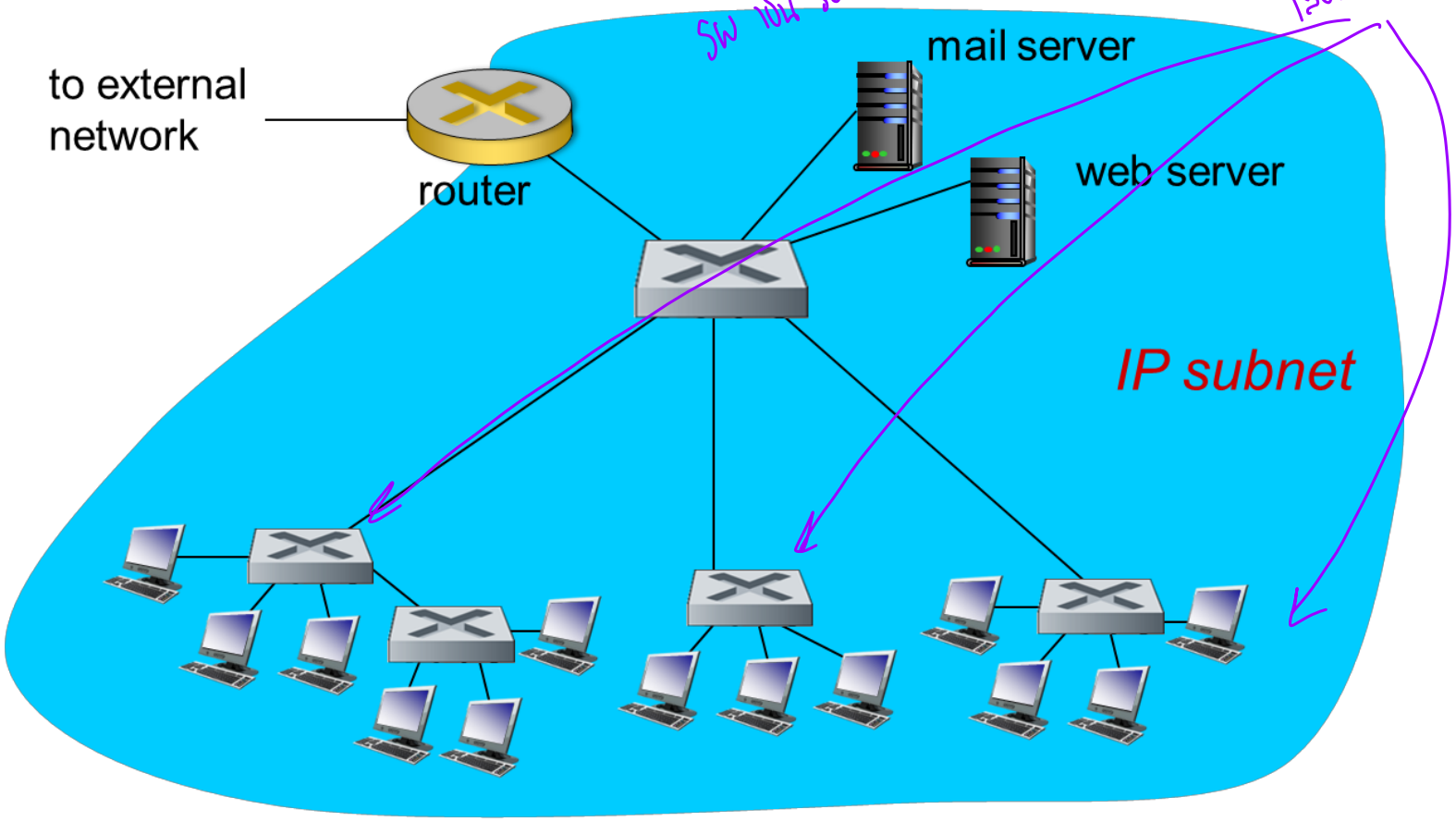
Interconnecting switches

- Self-learning switches can be connected together:



- *Q:* Sending from A to G - how does S_1 know to forward frame destined to G via S_4 and S_3?

Institutional network

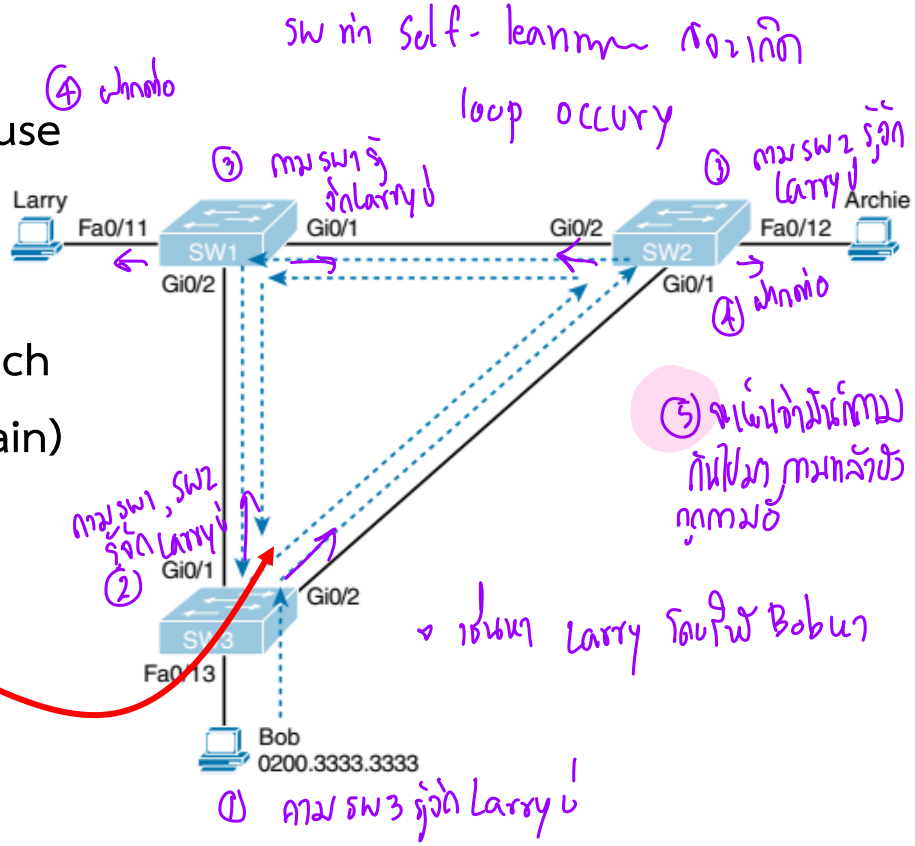


Spanning Tree Protocol

The Need for Spanning Tree

- Without Spanning Tree Protocol (STP) or Rapid STP (RSTP)
  - a LAN with redundant links would cause Ethernet frames to loop
  - Switches to flood broadcasts out all interfaces except the interface in which the frame arrived (in broadcast domain)

- 1) Broadcast storms happen
- 2) MAC table instability
  - MAC address tables keep changing
  - 0200.3333.3333 Fa0/13 VLAN 1
  - 0200.3333.3333 Gi0/1 VLAN 1



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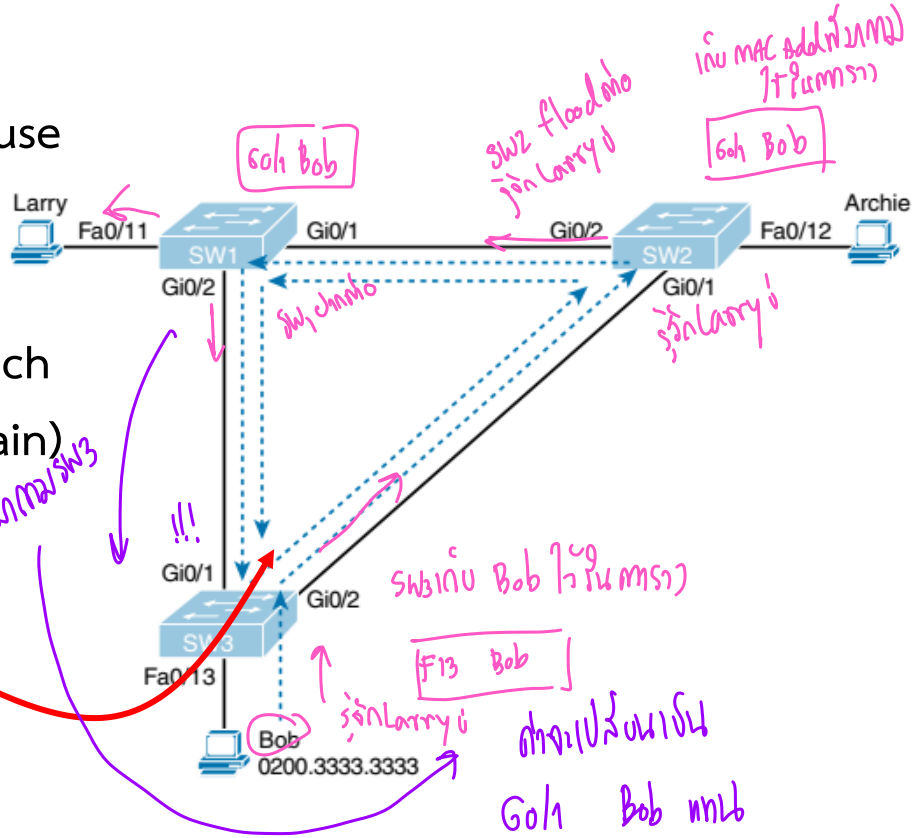
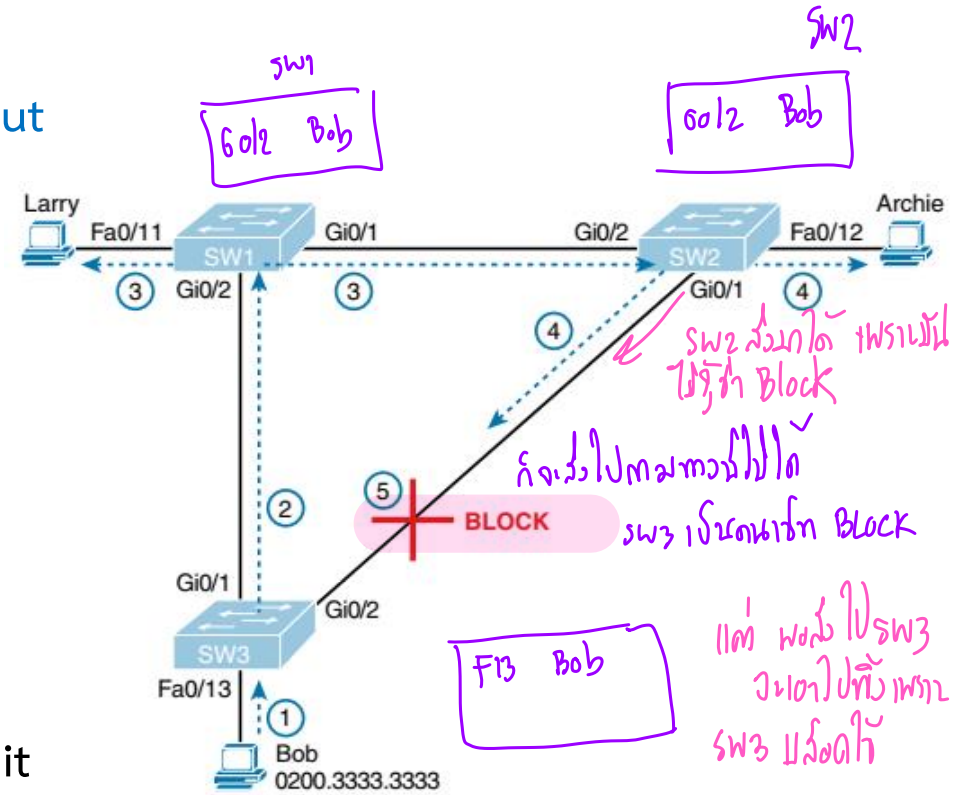


- 1) Broadcast storms happen
- 2) MAC table instability
  - MAC address tables keep changing
  - 0200.3333.3333 Fa0/13 VLAN 1
  - 0200.3333.3333 Gi0/1 VLAN 1

What Spanning Tree does

1) Bob sends the frame to SW3
2) SW3 forwards the frame only to SW1, but not out Gi0/2 to SW2, because SW3's Gi0/2 interface is in a blocking state
3) SW1 floods the frame out both Fa0/11 and Gi0/1
4) SW2 floods the frame out Fa0/12 and Gi0/1
5) SW3 physically receives the frame, but it ignores because SW3's Gi0/2 interface is in a blocking state



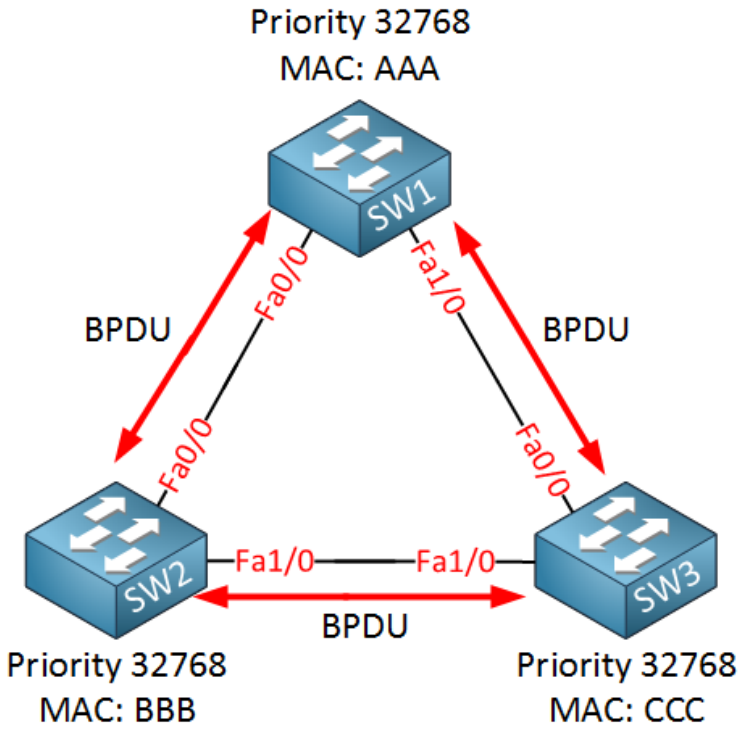
SW3 defines a Blocking state at Gi0/2

How spanning-tree solves loops

ต้องการ Block Port ตัวไหน

- All switches will send a special frame to each other called a BPDU (Bridge Protocol Data Unit) Message หรือไฟล์ วิ่งไปมา
  - MAC address
  - Priority (32768)
- MAC address and the priority together make up the bridge ID = Priority + MAC
  - Example: 32768.AAA

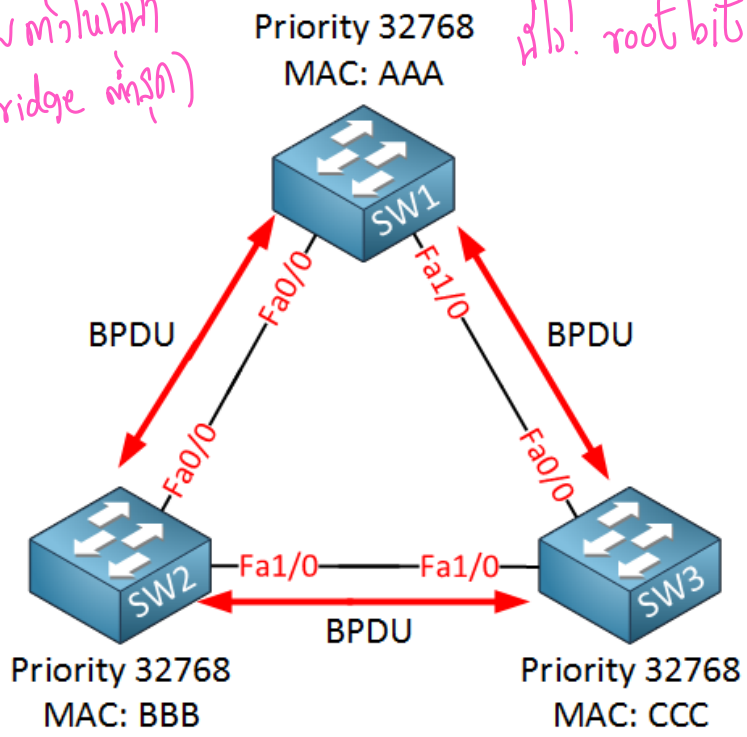
ถ้า SW2 จะเป็น 32768.BBB
SW3 จะเป็น 32768.CCC



How spanning-tree solves loops (cont.)

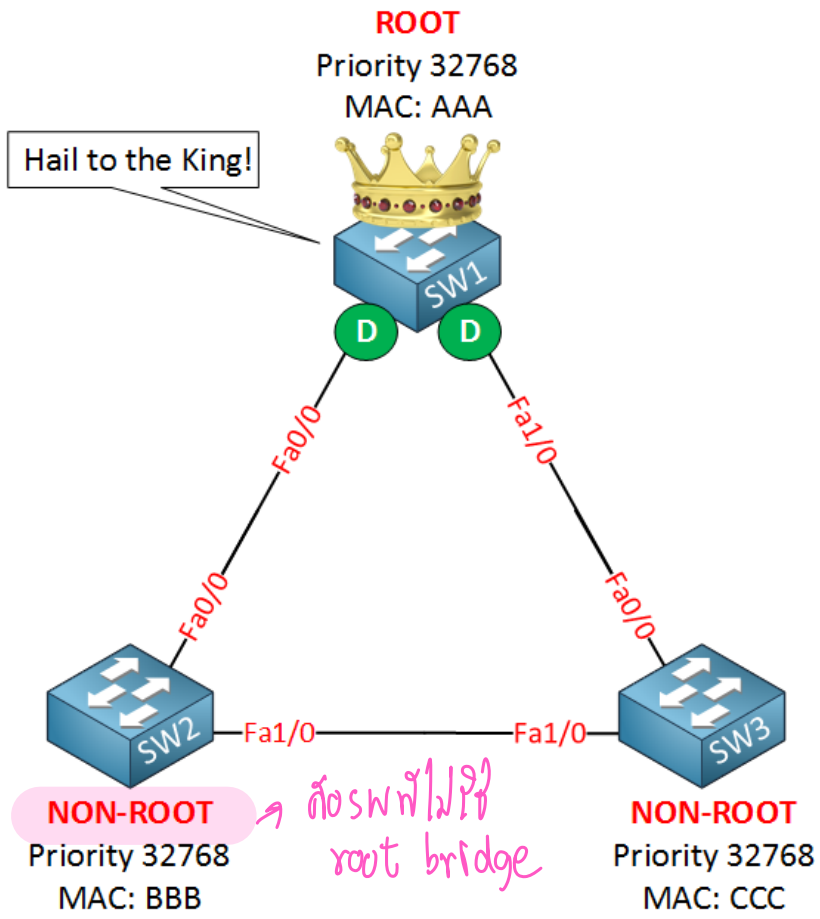
- To elect a root bridge
  - Root-bridge will be the one that has the best "bridge ID"
  - The switch with the lowest bridge ID is the best one
  - 32768 = default the priority

- So who will become the root bridge?
  - SW1 will become the root bridge!



How spanning-tree solves loops (cont.)

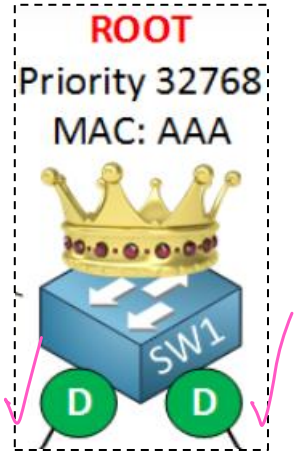
- So who will become the root bridge?



- SW1 will become the root bridge! = 32768.AAA
  - The priority is the same on all switches
  - SW1 has the lowest MAC address
    - -> The best bridge ID

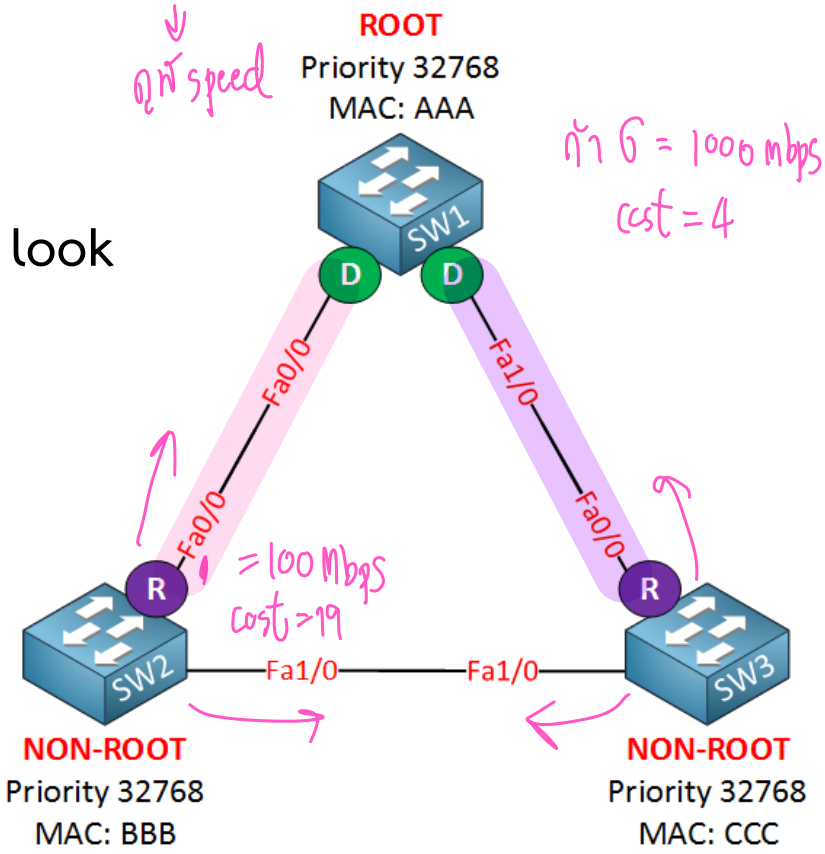
How spanning-tree solves loops (cont.)

- The ports on our root bridge are always designated which means they are in a Forwarding state
  - "D" on the interfaces stands for designated



How spanning-tree solves loops (cont.)

- "non-root" bridges will have to find the shortest path to our Root bridge!
  - called the "Root Port"
  - A switch has only one "Root Port"
- "Shortest path" means it will actually look at the speed of the interface
  - 10 Mbit = Cost 100
  - 100 Mbit = Cost 19
  - 1000 Mbit = Cost 4

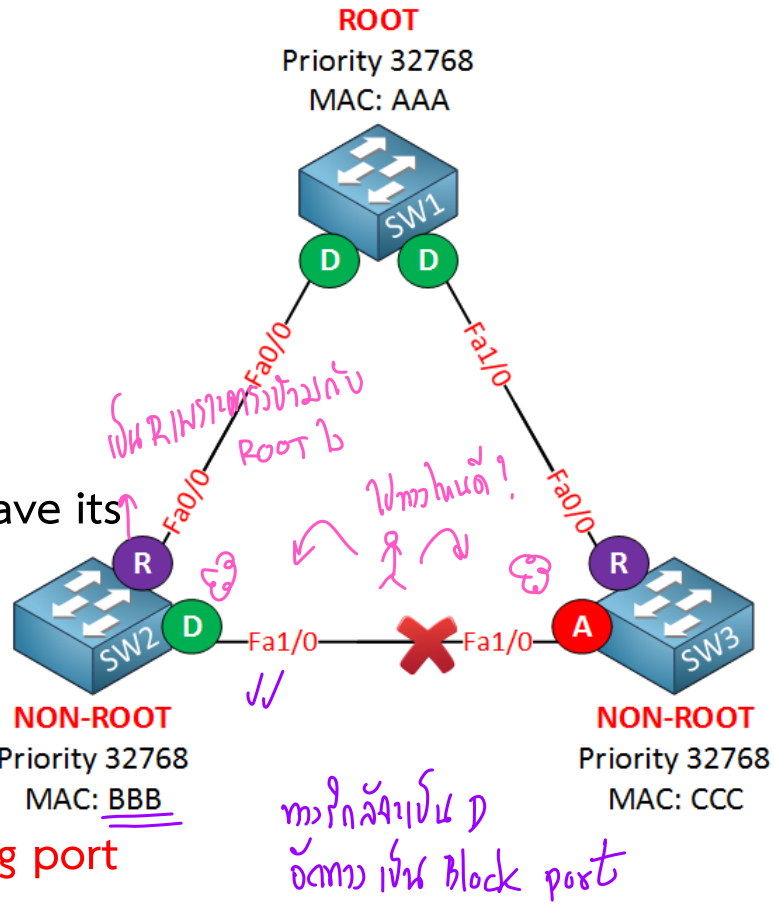


- Looking at the cost of each link
  - SW2-SW1 = 19 <- Root Port (R)
    - ~~SW2-SW3-SW1 = 38~~
  - SW3-SW1 = 19 <- Root Port (R)
    - ~~SW3-SW2-SW1 = 38~~

How spanning-tree solves loops (cont.)

- Check?
  - Designated ports opposite to Root Ports

- Next, to choose the one Designed port between SW2 and SW3
  1) The SW with the lowest root path cost will have its port in Designated mode
  2) The Best bridge ID
     - MAC address of SW2 is lower
     - Designed Port (Fa1/0 of SW2)
     - Worst bridge ID would be put into Blocking port



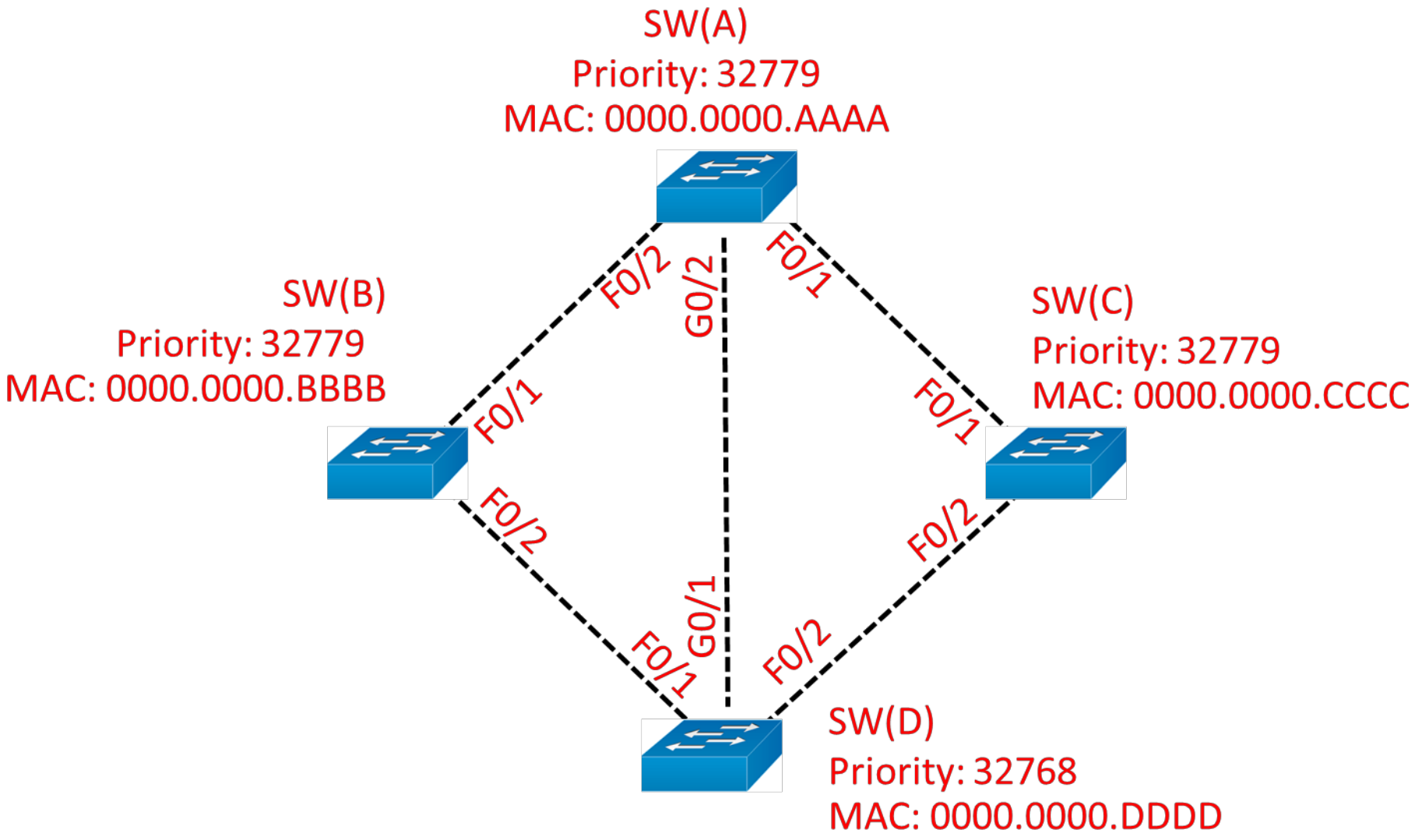
- Blocking State (Fa1/0 of SW3)

How spanning-tree solves loops (cont.)

Step:

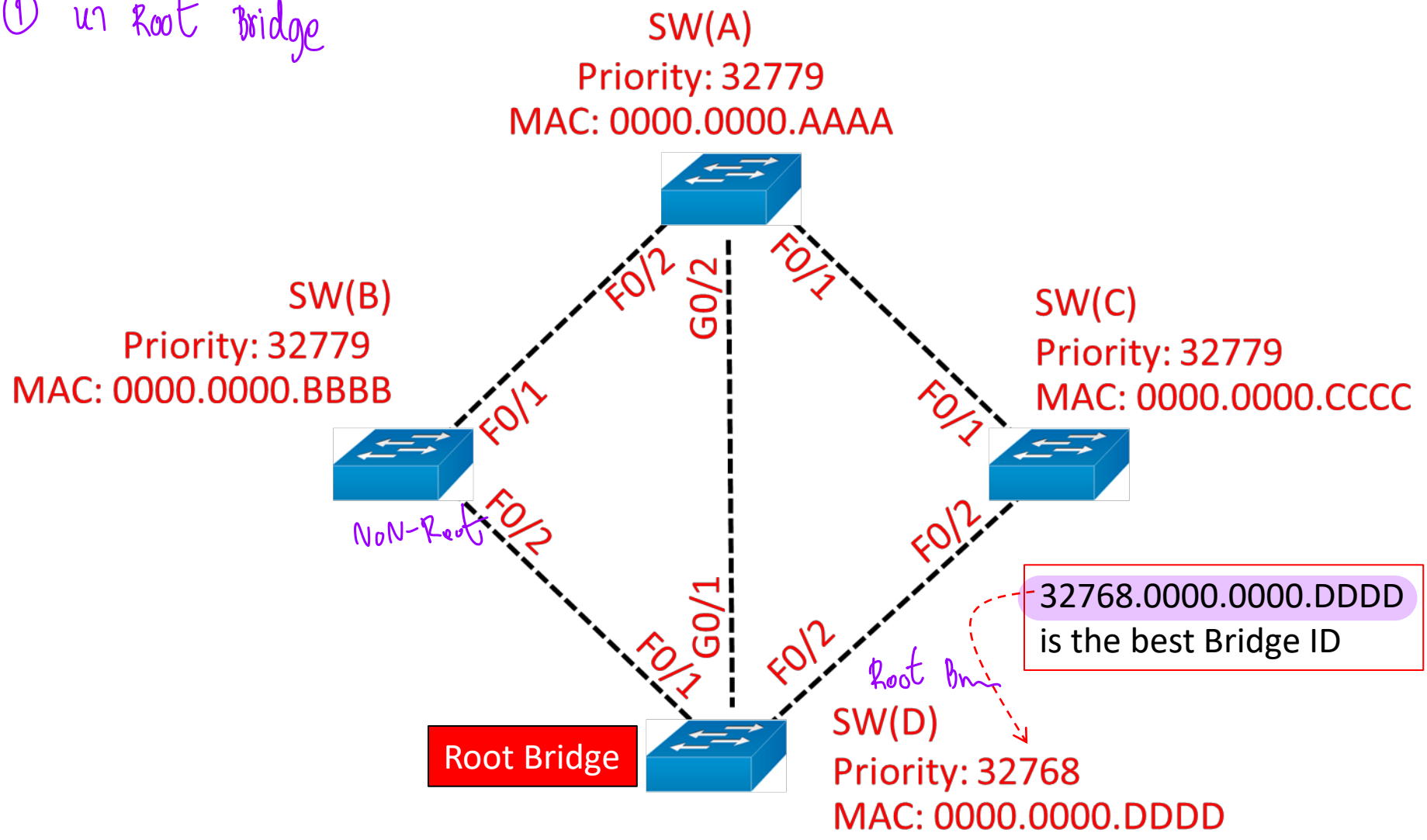
1) To elect a Root Bridge
   - The best Bridge ID
2) Root interface into a Forwarding state (Designated ports) FWD
3) Each non-root switch selects its Root Port
   - The least-cost path to send frames to the root switch
   - The best Bridge ID
   - The lowest internal interface number เช่น f0/1 หรือ f0/2 เลือก f0/1 ข้าง
   3.1) Optional - Designated ports opposite to Root Ports
4) Remaining links choose a Designated Port (each LAN segment)
   - The SW with the lowest root path cost
   - The best Bridge ID
   - The lowest internal interface number
5) All other ports are put into a Blocking state

Another example



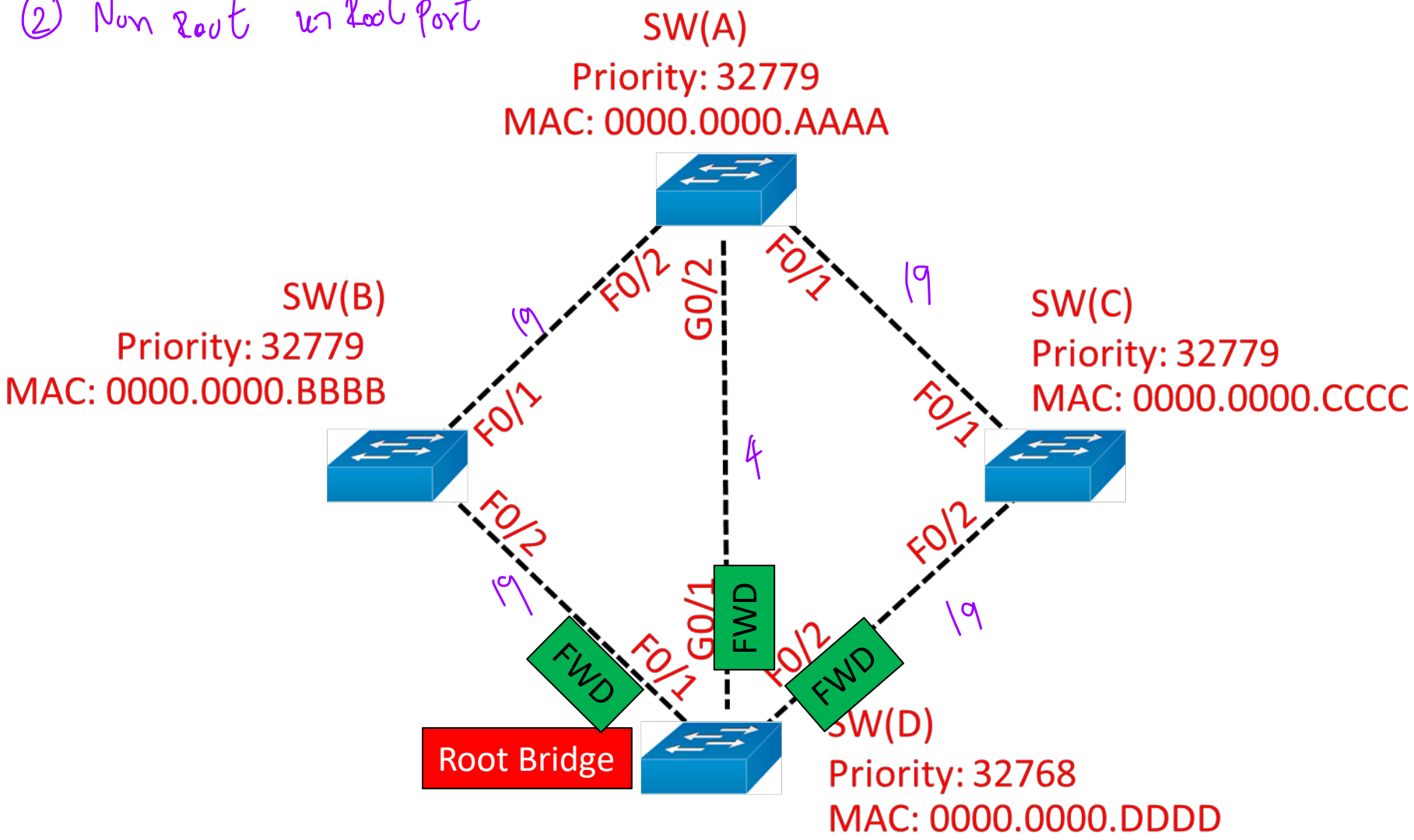
Another example (cont.)

① 以 Root Bridge



Another example (cont.)

② Non Root 의 Root Port



Another example (cont.)

(ทุก port ที่ตรวจพบ root port จะเป็น FWD เสมอ)
(แต่อันนี้ไม่มี)

SW(A)
Priority: 32779
MAC: 0000.0000.AAAA

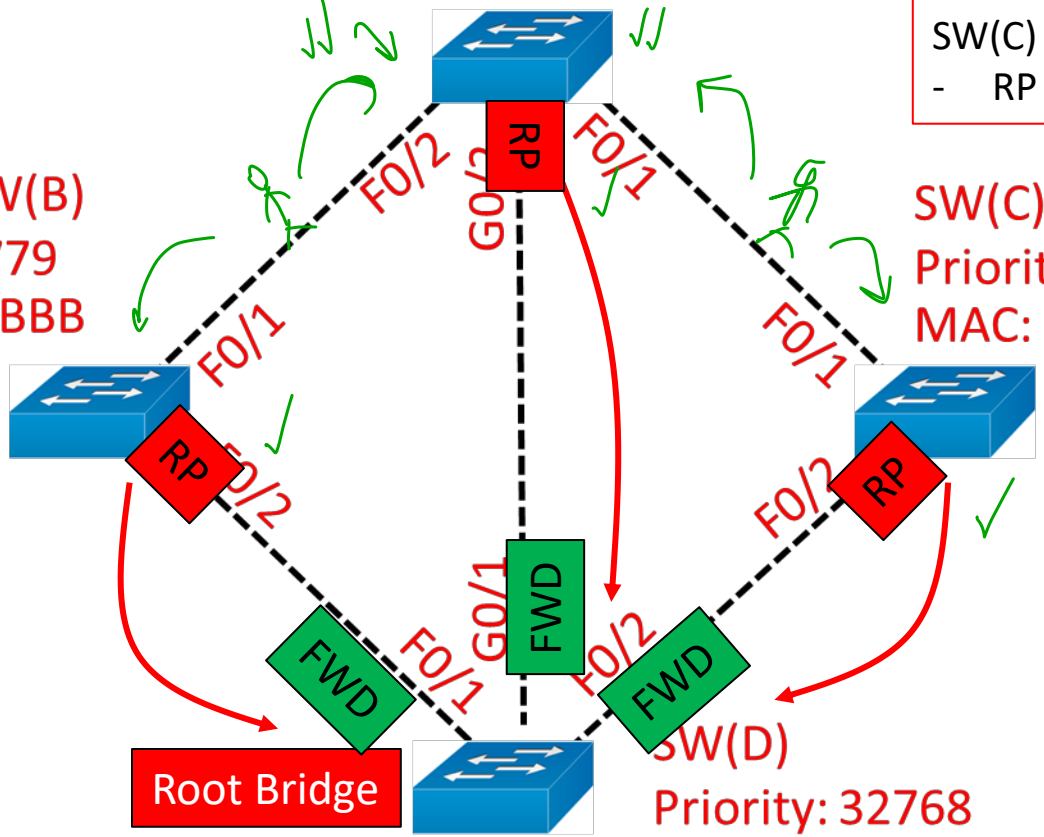
SW(B) F0/2
- RP = 19

SW(A) G0/2
- RP = 4

SW(C) F0/2
- RP =19

SW(B)
Priority: 32779
MAC: 0000.0000.BBBB

SW(C)
Priority: 32779
MAC: 0000.0000.CCCC

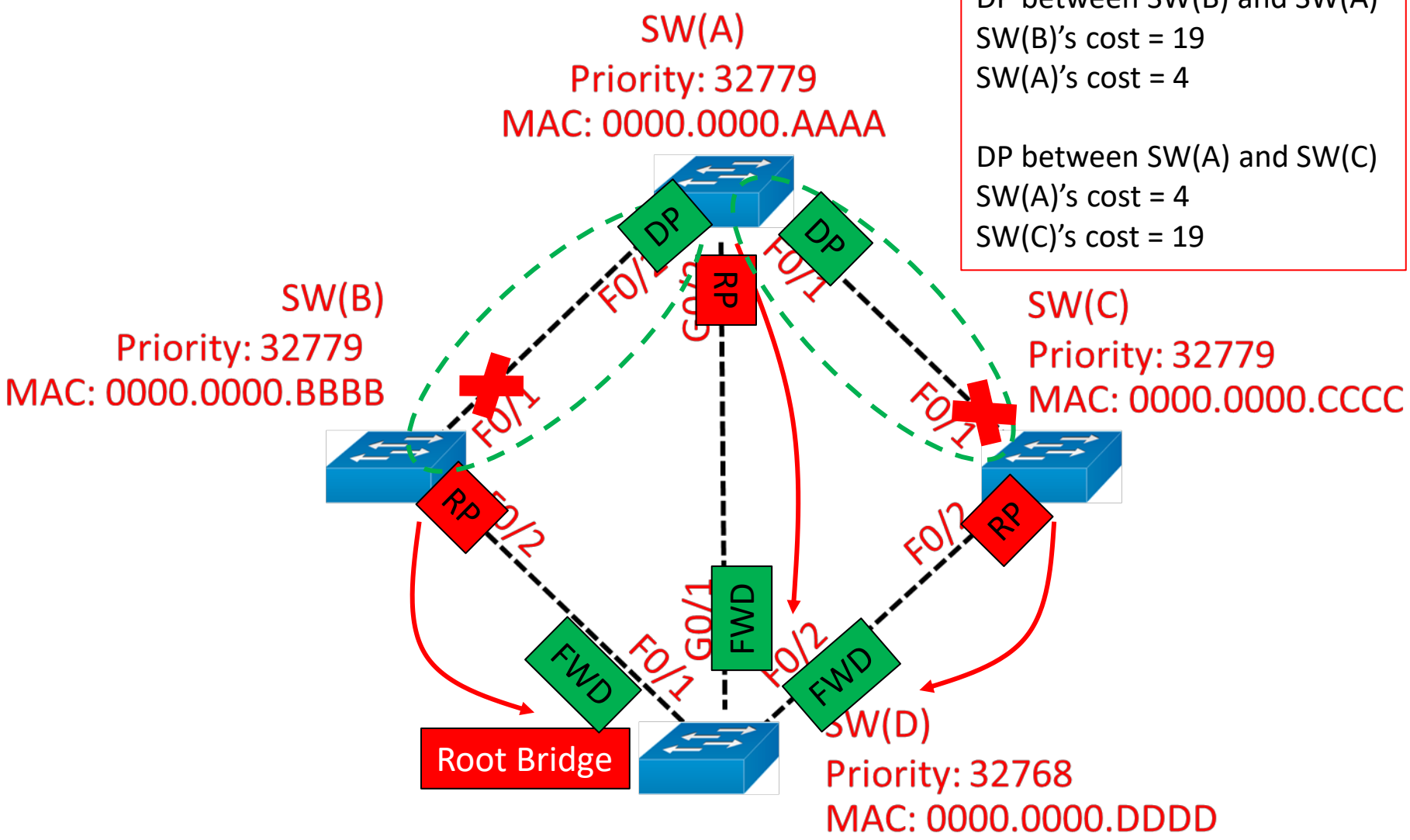


SW(D)
Priority: 32768
MAC: 0000.0000.DDDD

Another example (cont.)

DP between SW(B) and SW(A)
SW(B)'s cost = 19
SW(A)'s cost = 4

DP between SW(A) and SW(C)
SW(A)'s cost = 4
SW(C)'s cost = 19



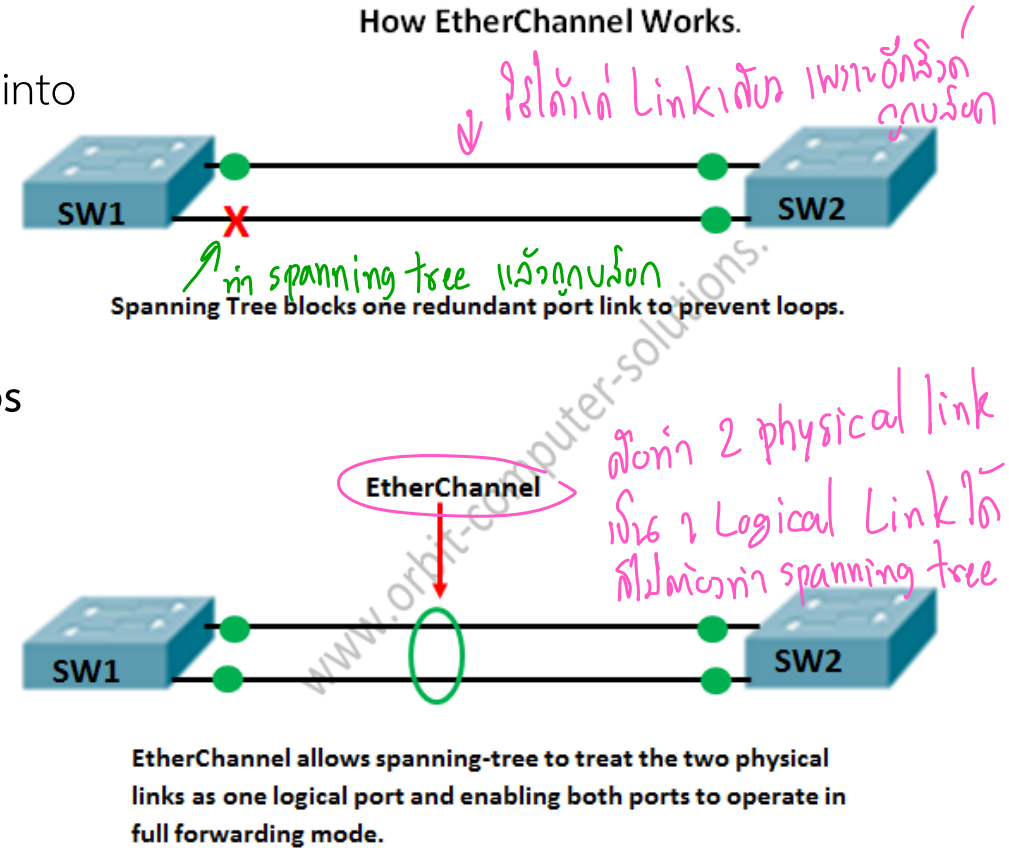
EtherChannel เพิ่มประสิทธิภาพ แก้ปัญ splanm tree

- To bundle ports together in an ethernet switch (Link aggregation)
  - For grouping several Ethernet ports into one logical channel

ข้อดี : ป้องกัน loop
ข้อเสีย : perform ลด

- Spanning-Tree Protocol blocks one redundant link to avoid Layer 2 loops
  - To prevent STP convergence

- Etherchannels does is to use load balancing on traffic between the redundant links



EtherChannel (cont.)

- Cisco's version is called Port Aggregation Protocol (PAgP)

  Mode:

  - Desirable: actively ask if the other side can/will
  - Auto: passively wait for other side to ask
  - Off: EtherChannel not configured on interface

- IEEE 802.3ad standard is called Link Aggregation Control Protocol (LACP)

  Mode:

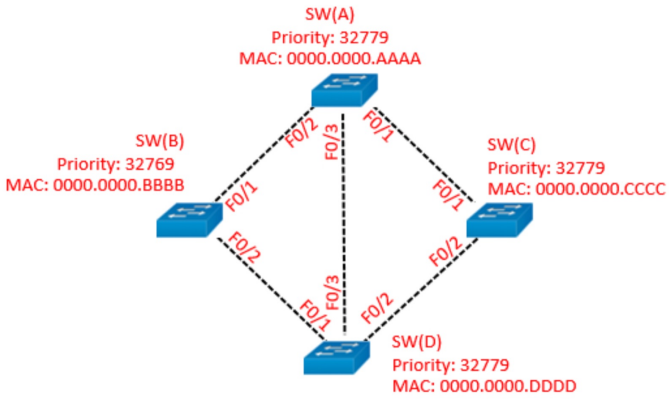
  - Active: actively ask if the other side can/will
  - Passive: passively wait for other side to ask
  - Off: EtherChannel not configured on interface

Reference

- CCNA 200-301 Official Cert Guide, Volume 1 (2019)
  - By Wendell Odom
- Computer Networking Problems and Solutions (2017)
  - By Russ, Ethan Banks
- Computer Networking: A Top-Down Approach, Global Edition (2016)
  - By Keith Ross James Kurose

Classroom 4

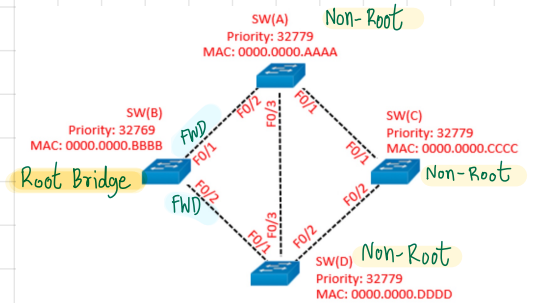
นางสาวนัฐชยา ผ่องกุศล B6226718



1. หา Root Bridge

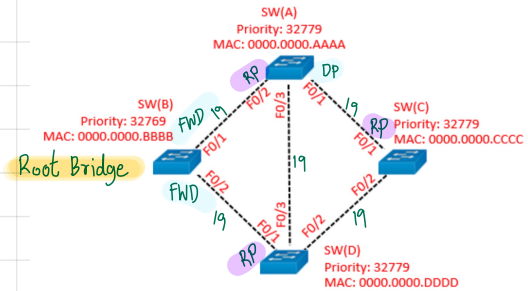
จะเห็นว่า SW(B) มี Pariority ต่ำสุด

∴ SW(B) = Root Bridge



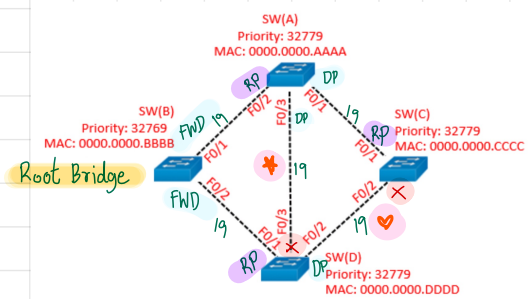
2. จาก Non-Root หา Root Port

- SW(A) เลือกทางที่ cost ต่ำสุด
- SW(D) เลือกทางที่ cost ต่ำสุด
- SW(C) ทั้ง 2 มี cost เท่ากันให้เลือก Bridge ID ที่ต่ำกว่า (optional : ตรงข้ามกับ RP จะเป็น D)



3. หา Block Port

- ที่ * ทั้งสองทางมี cost เท่ากัน ให้เลือก Bridge ID ที่ต่ำกว่า และทางที่ไม่ถูกเลือกจะเป็น Block Port
- ที่ ♥ เลือกทางที่ cost ต่ำสุด และทางที่ไม่ถูกเลือก จะเป็น Block Port



จะได้ดังนี้