



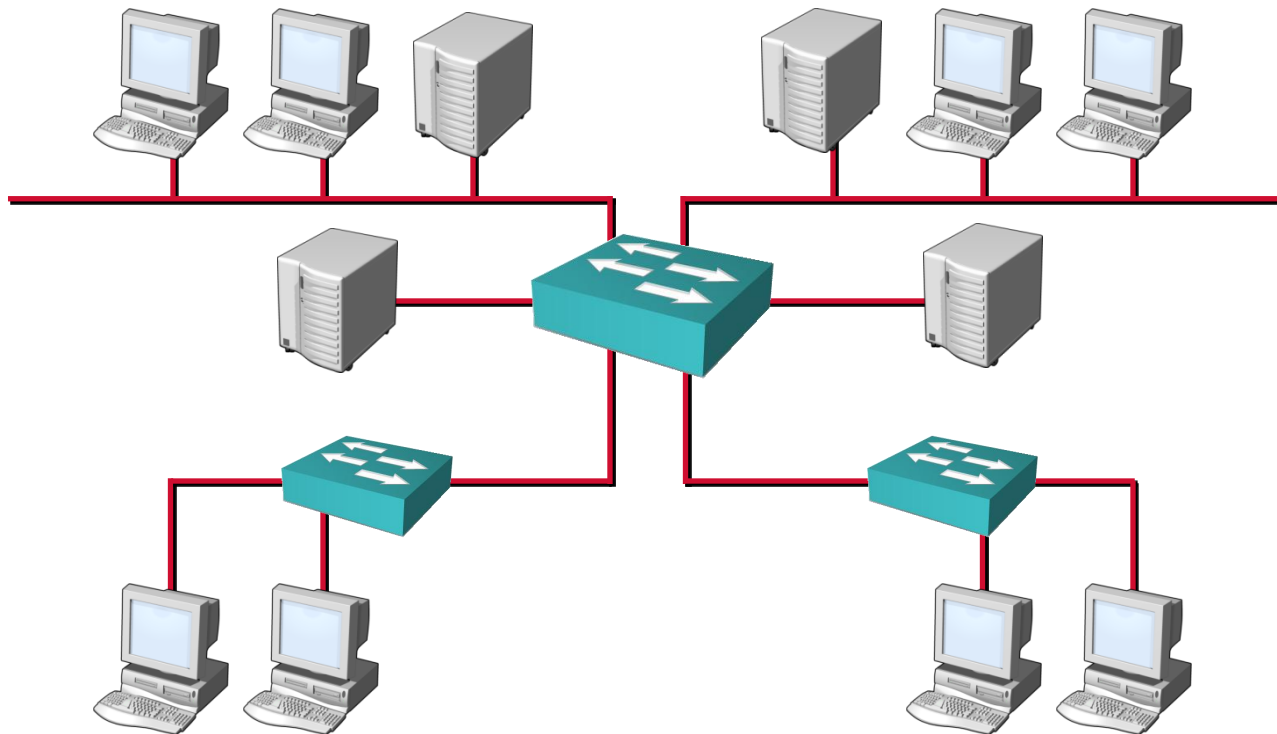
Module 3

Layer 2 Switching



Basic Layer 2 Switching and Bridging Function

Ethernet Switches and Bridges

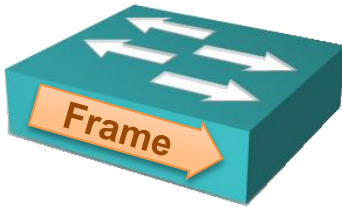


- Address learning
- Forward/filter decision
- Loop avoidance

Transmitting Frames

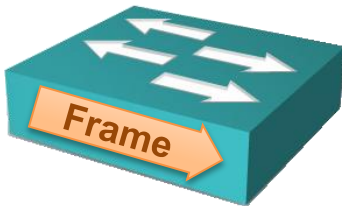
▪ Cut-Through

- Switch가 목적지 주소를 확인한 후 즉시 전달하는 방법



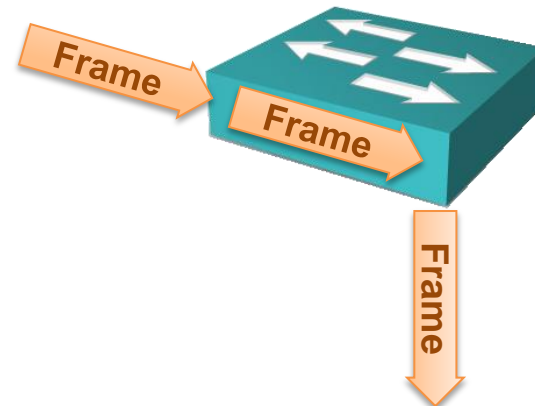
▪ Fragment-Free

- Switch가 프레임에 64byte까지 검사한 후 즉시 전달을 시작한다

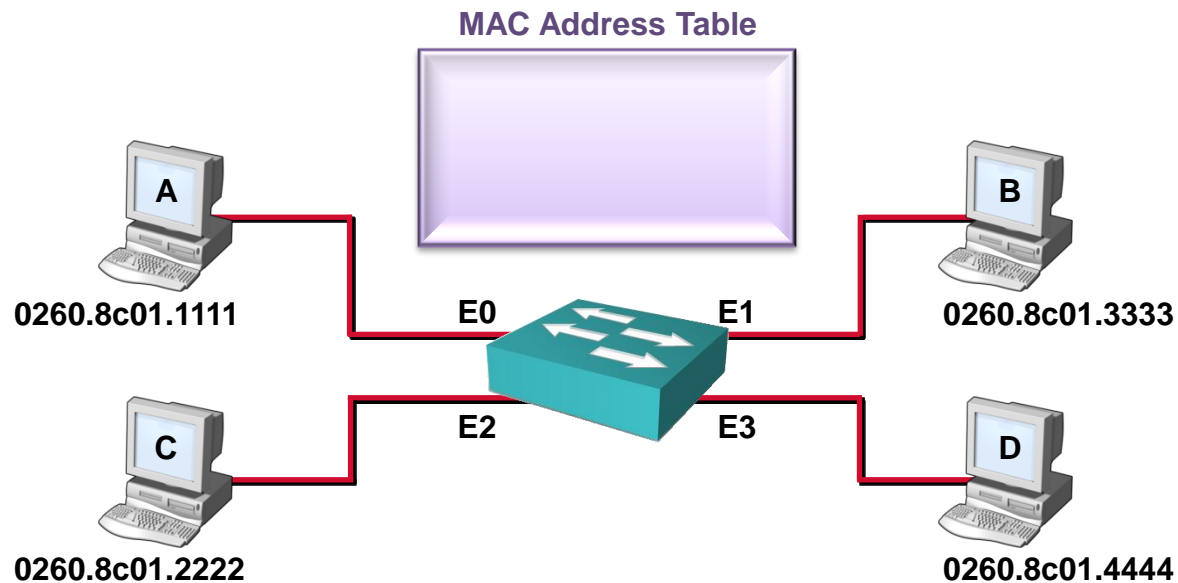


▪ Store and Forward

- 프레임을 모두 전송 받아 검사 후에 전달한다

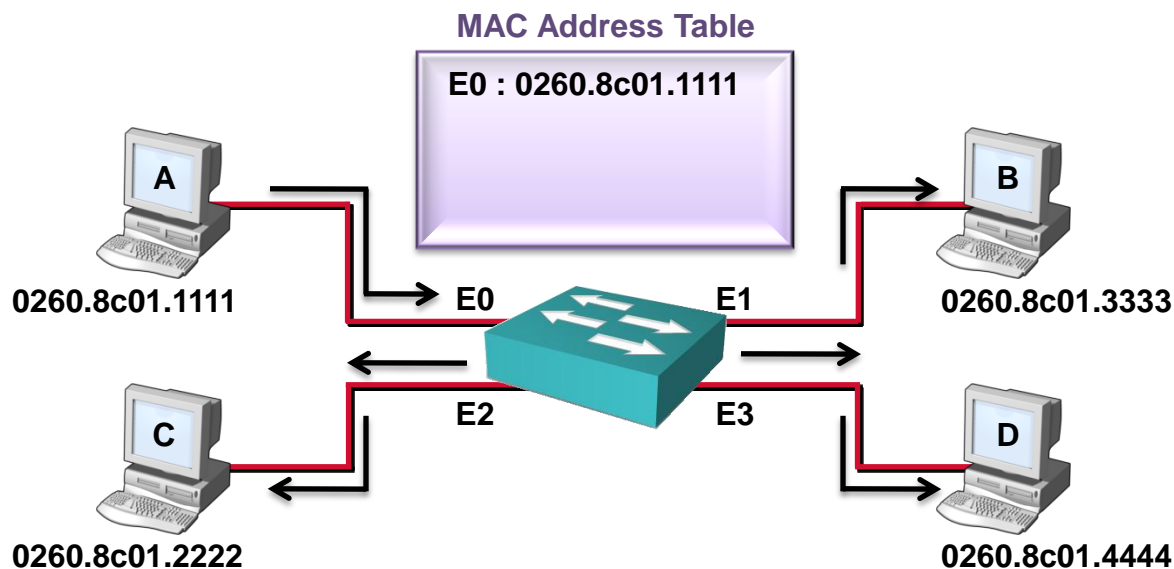


MAC Address Table



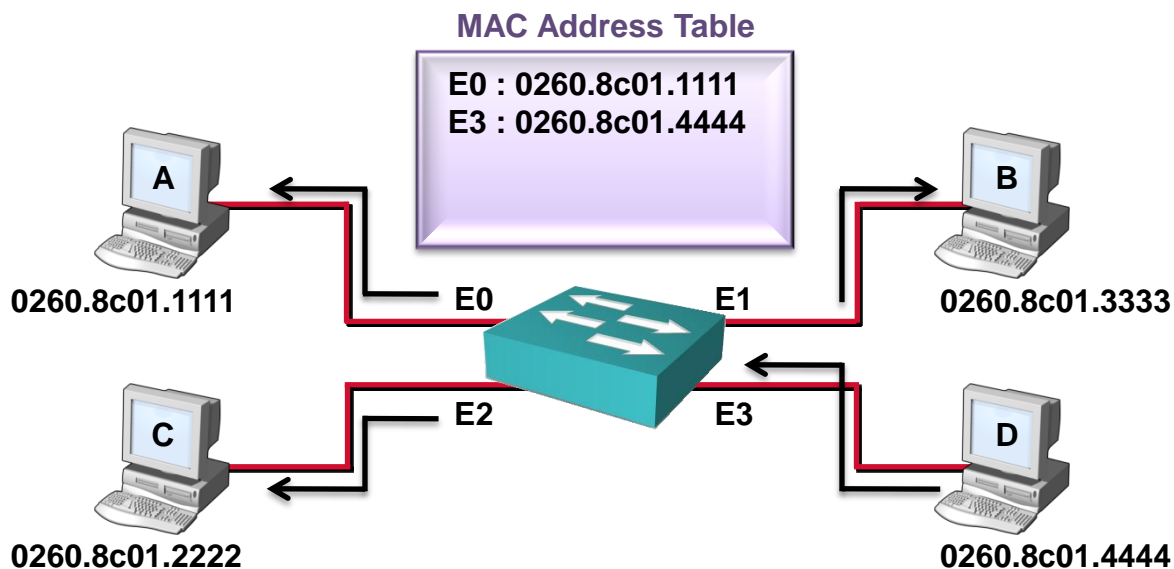
- 초기에는 MAC Address Table이 비어 있다

Learning Addresses



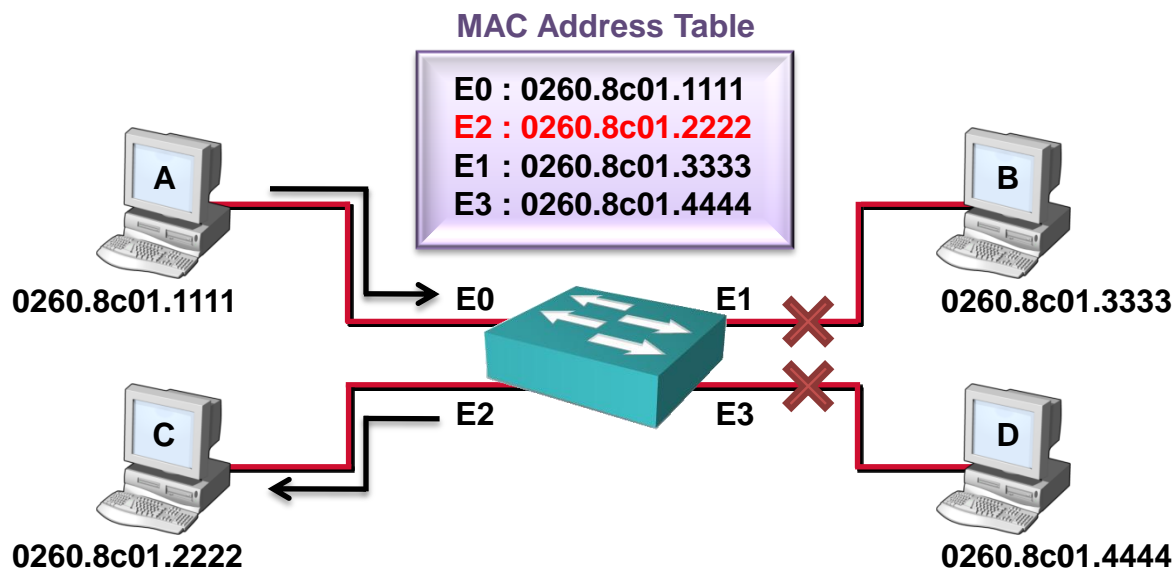
- Host A가 Host B에게 Frame을 전달한다
- Switch는 MAC Address Table이 비어 있기 때문에 Frame을 모든 포트에 Flooding한다
- Host A에서 온 Frame을 Flooding하는 동안 스위치는 E0에 Host A의 MAC Address를 학습한다
- Host A에 대한 MAC Address Table 정보는 Cache에 저장된다 (Aging Time 300초)

Learning Addresses (Cont.)



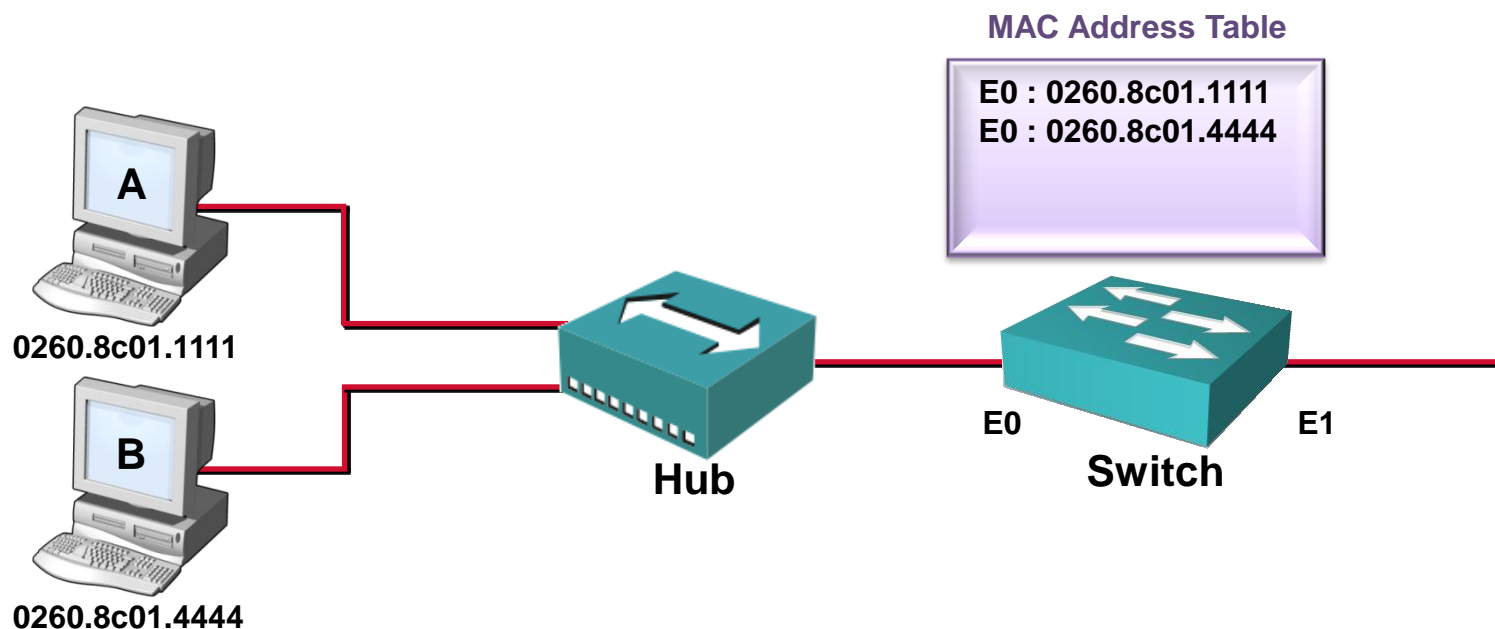
- Host D가 Host C에게 Frame을 전달한다
- Switch는 MAC Address Table에 목적지 MAC Address에 대한 정보가 없기 때문에 Frame을 전달된 포트를 제외한 모든 포트에 Flooding한다
- Host D에서 온 Frame을 Flooding하는 동안 스위치는 E3에 Host D의 MAC Address를 학습한다
- Host D에 대한 MAC Address Table 정보는 Cache에 저장된다 (Aging Time 300초)

Filtering Frames



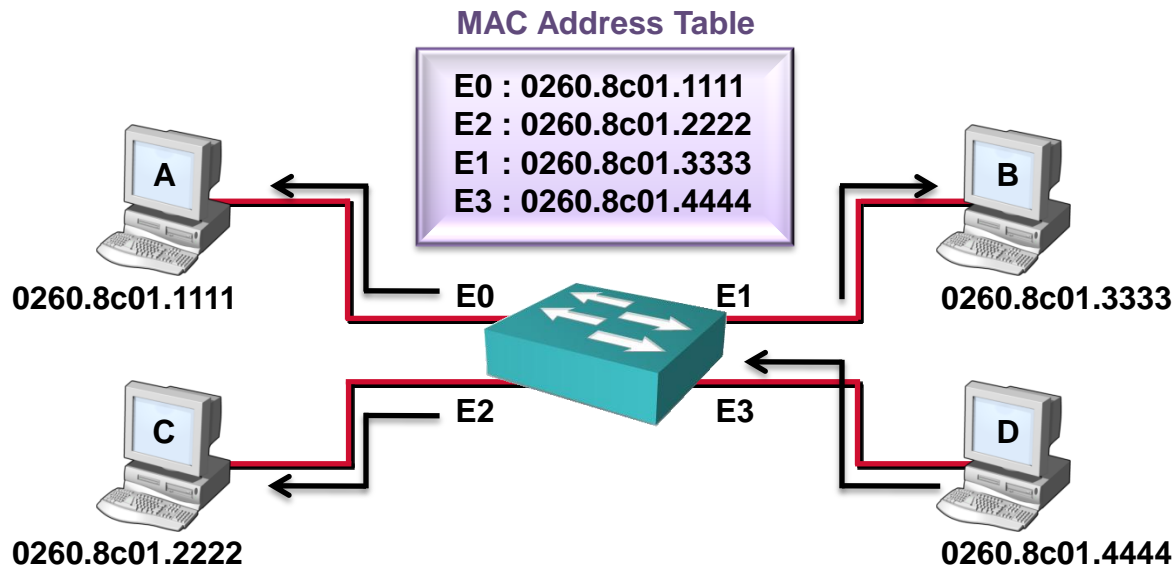
- Host A가 Host C에게 Frame을 전달한다
- Switch는 MAC Address Table에 목적지 MAC Address에 대한 정보를 찾아 해당하는 포트인 E2로 Frame을 전달한다
- E2에 대한 Aging Time이 초기화 된다

Filtering Frames (Cont.)



- Host A가 Host B에게 Frame을 보낸다
- Switch는 MAC Address Table에 Host B의 MAC Address를 추가한다

Broadcast and Multicast Frames

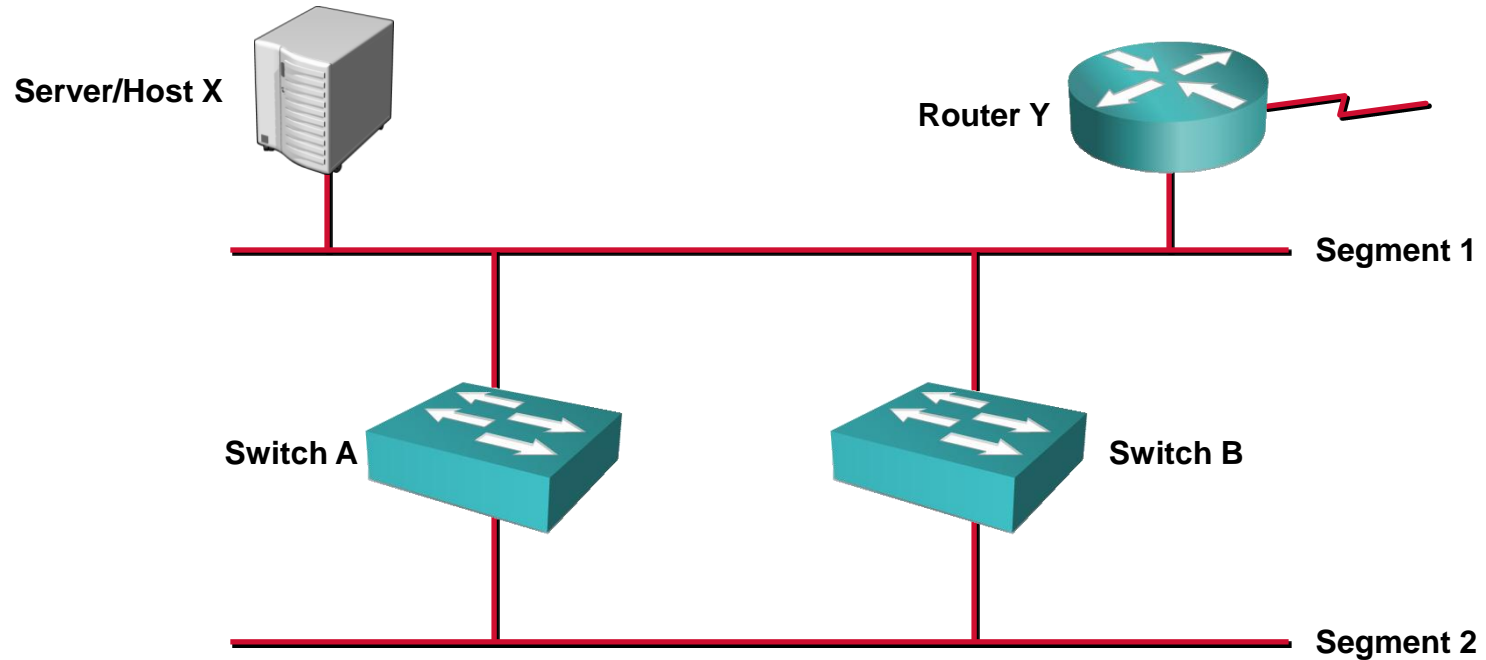


- Host D가 Broadcast또는 Multicast를 보낸다
- Broadcast나 Multicast는 전달된 포트를 제외한 모든 포트에 Flooding 된다



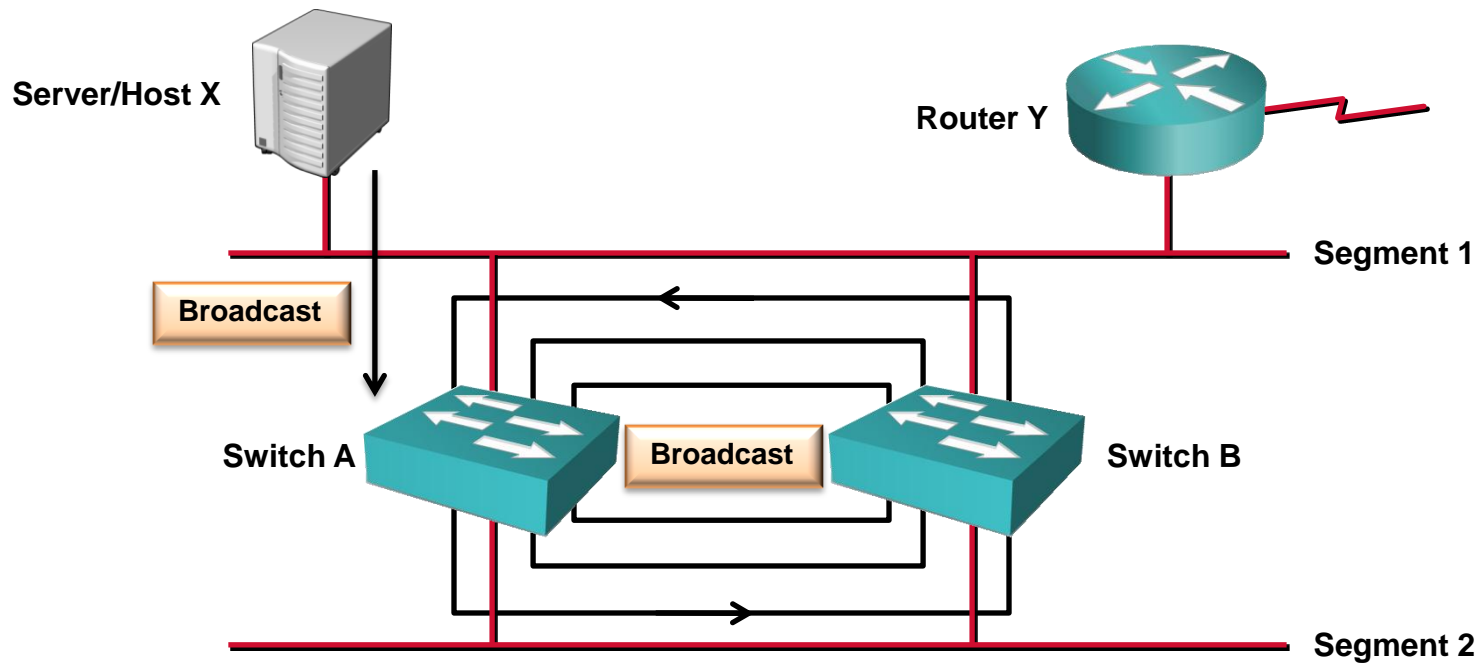
Redundant Topology Overview

Redundant Topology



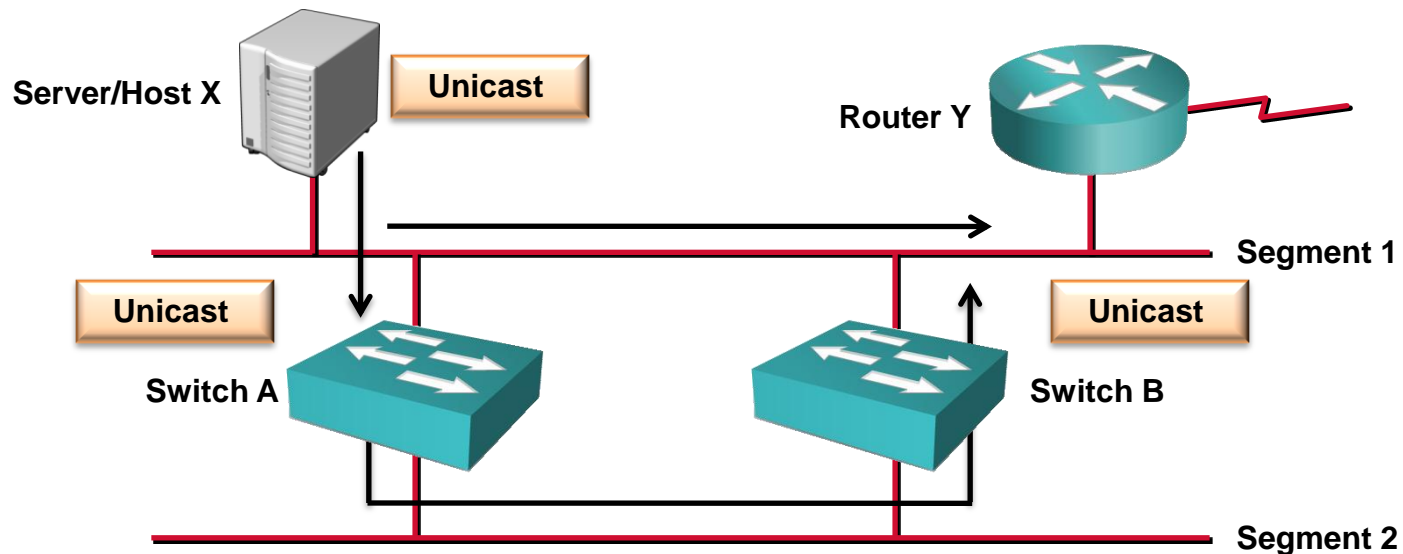
- 링크 이중화는 한 지점에서의 장애로 인해 네트워크의 기능 상실을 방지한다
- 링크 이중화는 Broadcast Storm, Multiple frame 복사, MAC Address Table 불안정성 문제가 발생한다

Broadcast Storms



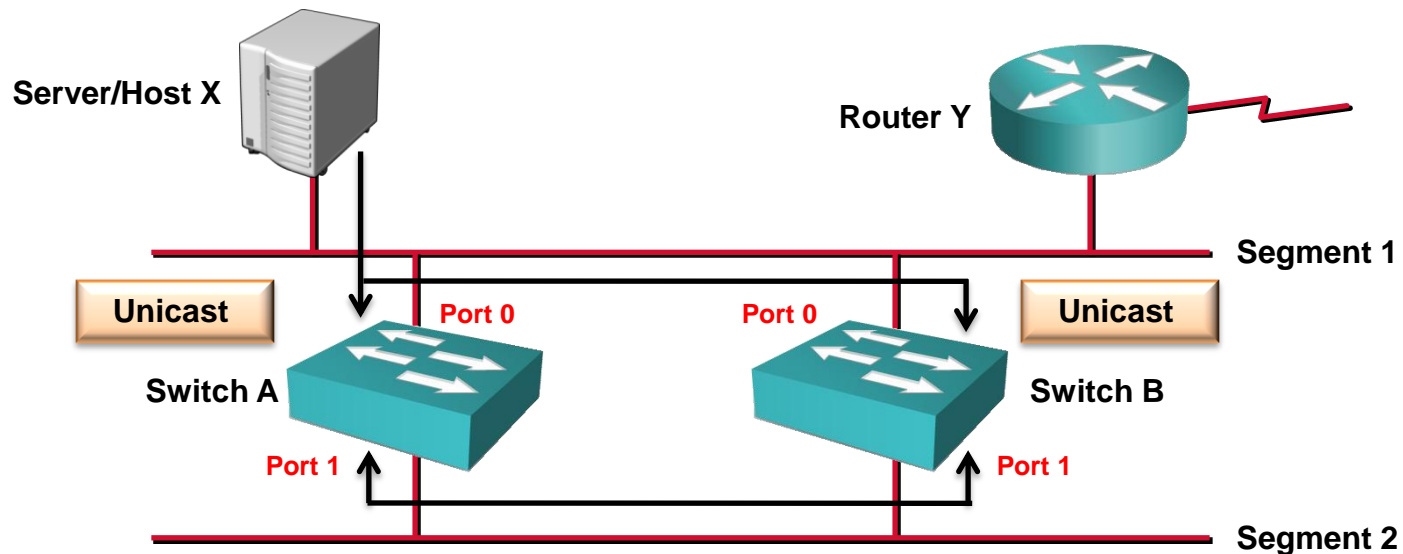
- Host X가 Broadcast를 보낸다
- Switch는 계속해서 Broadcast traffic을 서로에게 전파한다

Multiple Frame Copies



- Host X가 Unicast Frame을 Router Y에게 보낸다
- Router Y와 Switch A는 Frame을 받게 된다. Switch A는 MAC Table에 Host X에 대한 MAC Address가 없기 때문에 Flooding한다
- Switch A로부터 Flooding된 Frame을 Switch B가 받아 다시 Flooding한다
- Router Y는 복사된 동일한 Frame을 다시 받게 된다

MAC Database Instability

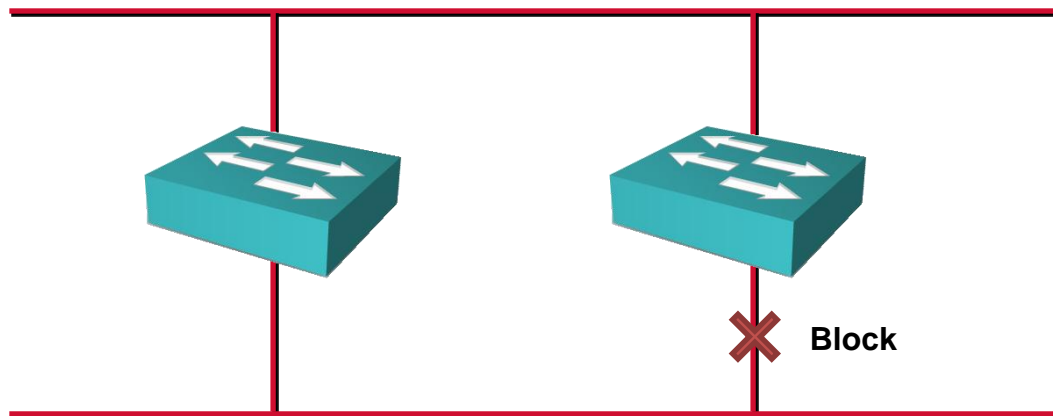


- Host X가 Unicast Frame을 Router Y에게 보낸다
- 아직 Router Y의 MAC Address를 학습한 Switch가 없다
- Switch A와 Switch B는 Port 0에 Host X에 MAC Address를 학습한다
- 두 Switch에서 Router Y로 가는 Frame이 Flooding 된다
- Switch A와 Switch B가 Port 1에서 Host X에 MAC Address를 부정확 하게 학습한다


















Spanning-Tree Protocol Overview

Spanning-Tree Protocol

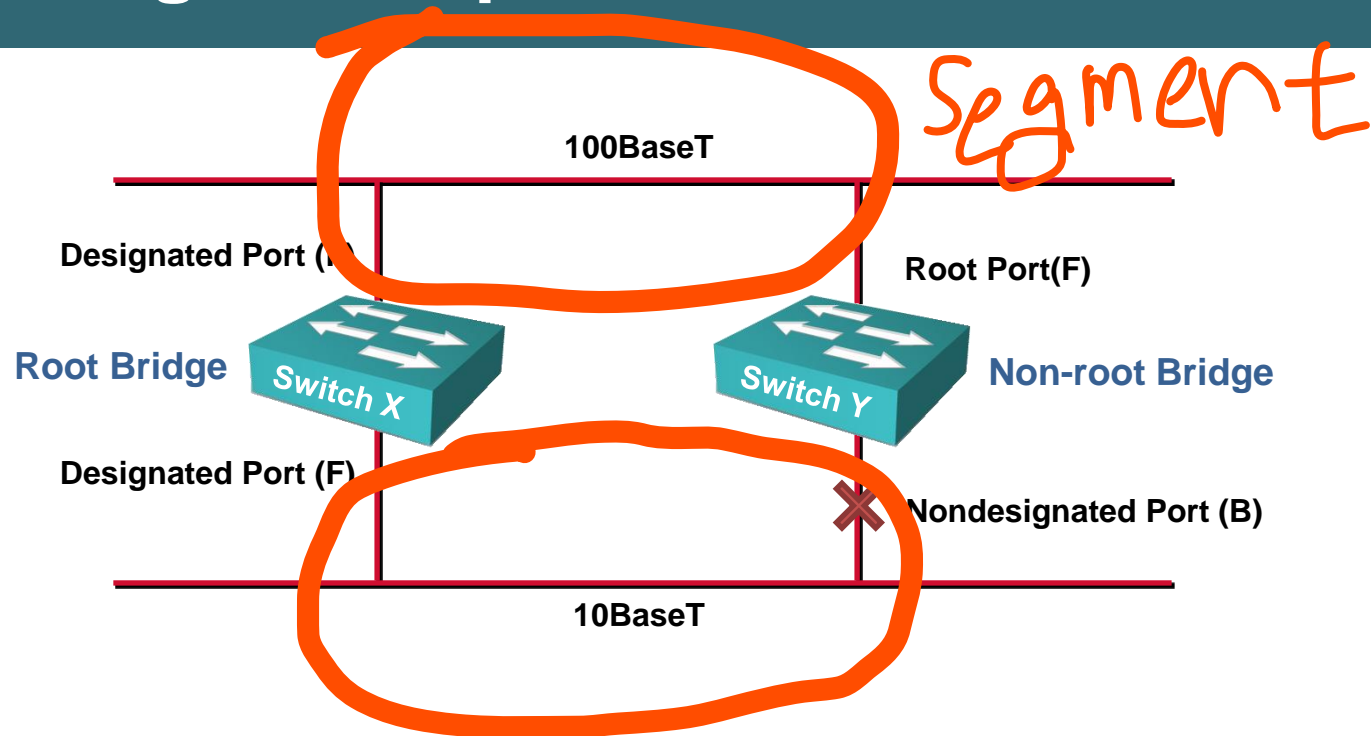


- STP는 Switch가 Topology내의 루프를 인식하고 하나의 Link를 차단하고 있는 상태에서 Loop를 제거한다
- STP는 포트를 계속 모니터링 하다가 다른 포트에 장애나 토폴로지 변경이 발생하는 경우 포트를 재 설정하여 연결의 완전 손실이나 새로운 루프를 막는다

BPDUs (802.1d)

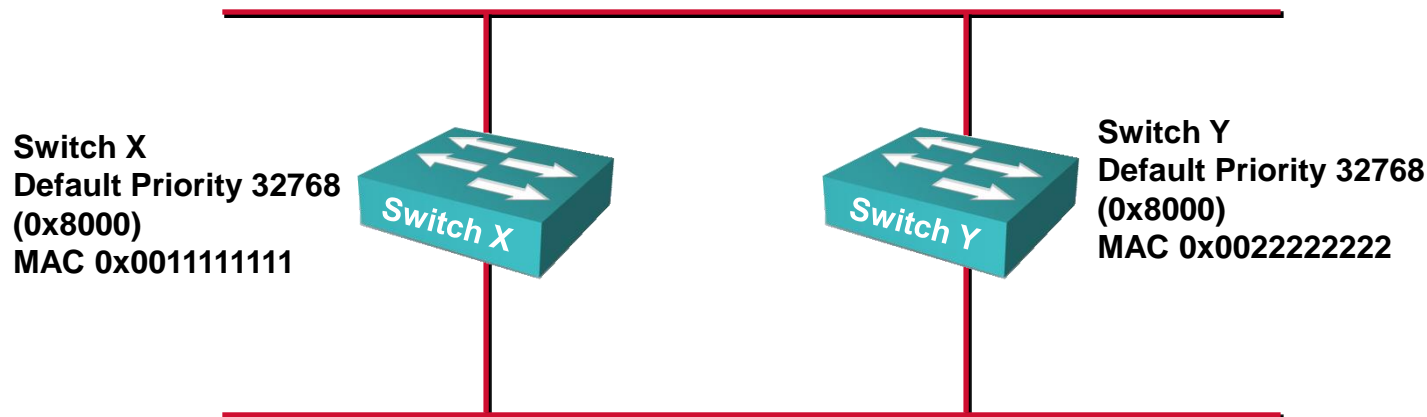
		802.1 - Bridge Spanning Tree
	Protocol Identifier:	0 [17-18]
	Protocol Version ID:	0 [19]
	Message Type:	0 <i>Configuration Message</i> [20]
	Flags:	%00000001 [21]
		<i>Topology Change Notification Acknowledge</i>
	Root Priority/ID:	0x8000/ 00:0D:BC:9A:BF:81 [22-29]
	Cost Of Path To Root:	0x00000000 (0) [30-33]
	Bridge Priority/ID:	0x8000/ 00:0D:BC:9A:BF:81 [34-41]
	Port Priority/ID:	0x80/ 0x03 [42-43 Mask 0x00FF]
	Message Age:	0/256 seconds (<i>exactly 0 seconds</i>) [44-45]
	Maximum Age:	5120/256 seconds (<i>exactly 20 seconds</i>) [46-47]
	Hello Time:	512/256 seconds (<i>exactly 2 seconds</i>) [48-49]
	Forward Delay:	3840/256 seconds (<i>exactly 15 seconds</i>) [50-51]

Spanning-Tree Operation



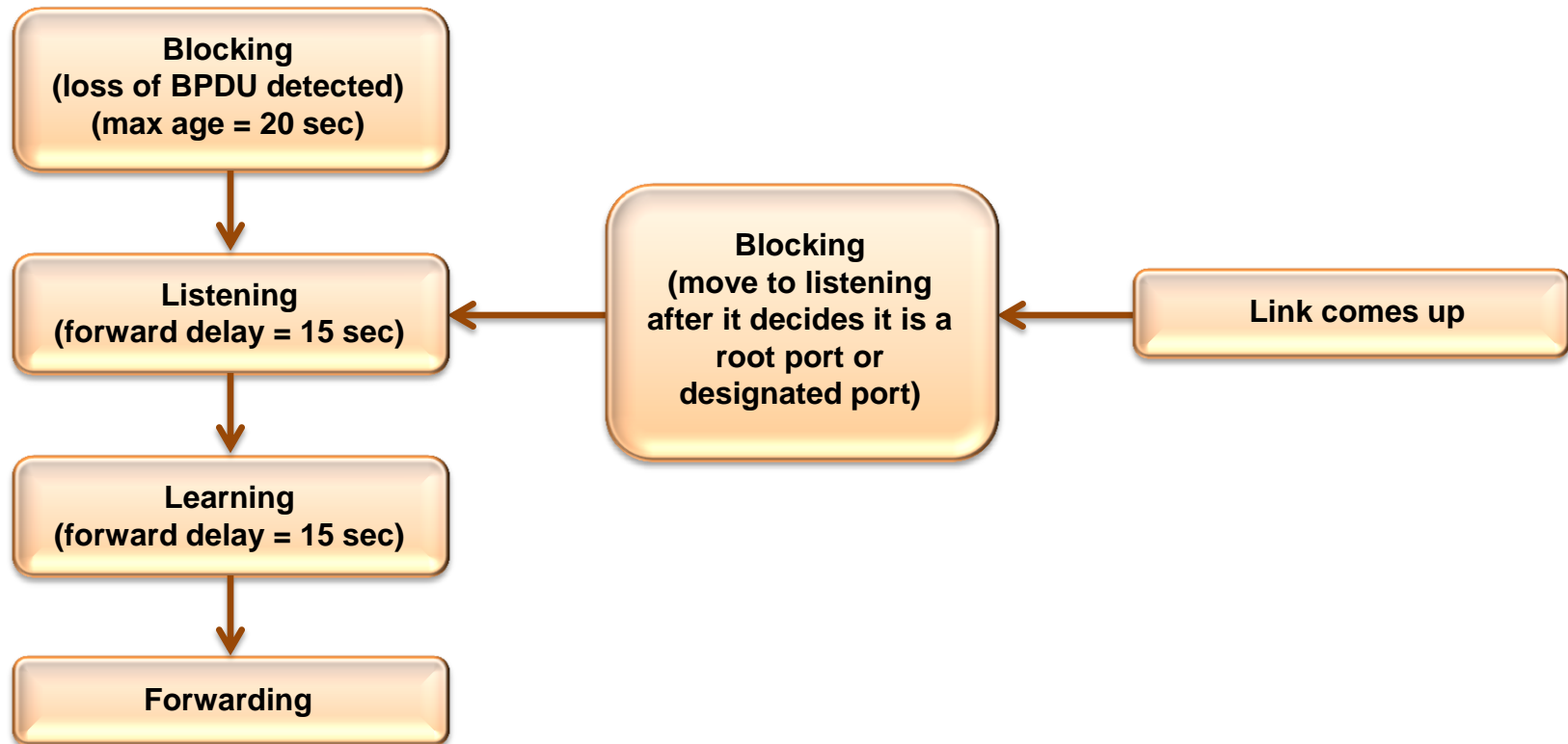
- Network당 하나의 Root Bridge를 가진다
- Non-Root Bridge당 하나의 Root Port를 가진다
- Segment당 하나의 Designated Port를 가진다
- Nondesignated Port는 사용하지 않는다

Spanning-Tree Protocol Root Bridge Selection

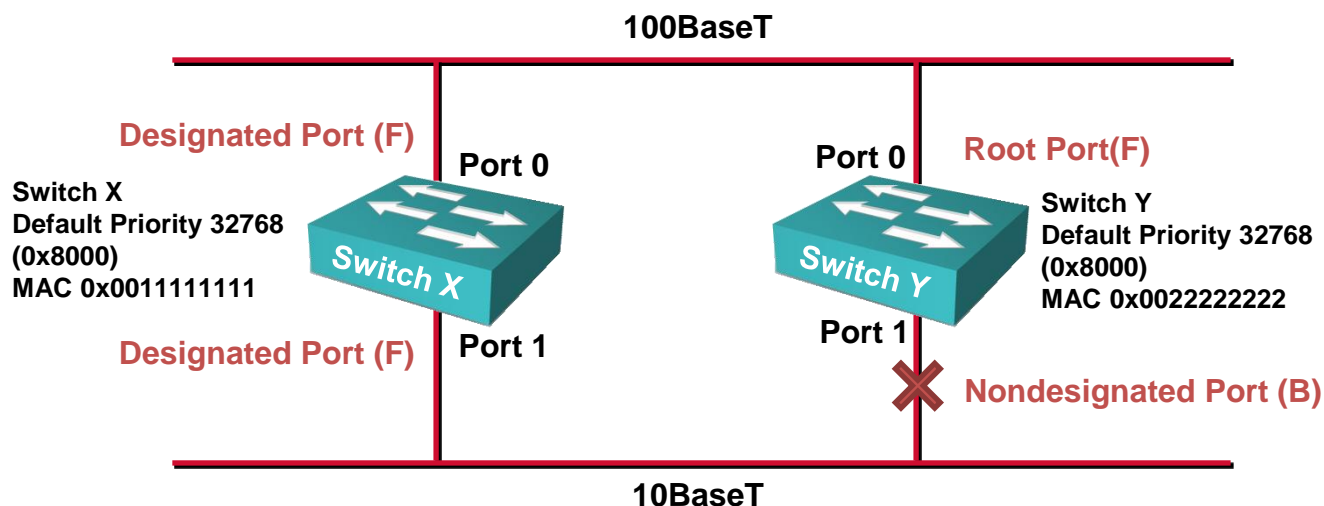


- BPDU = Bridge Protocol Data Unit(Default = 매 2초마다 전송함)
- Root Bridge = Lowest Bridge ID를 갖는 Bridge
- Bridge ID = Bridge Priority + MAC Address

Spanning-Tree Port States



Spanning-Tree Port States (Cont.)

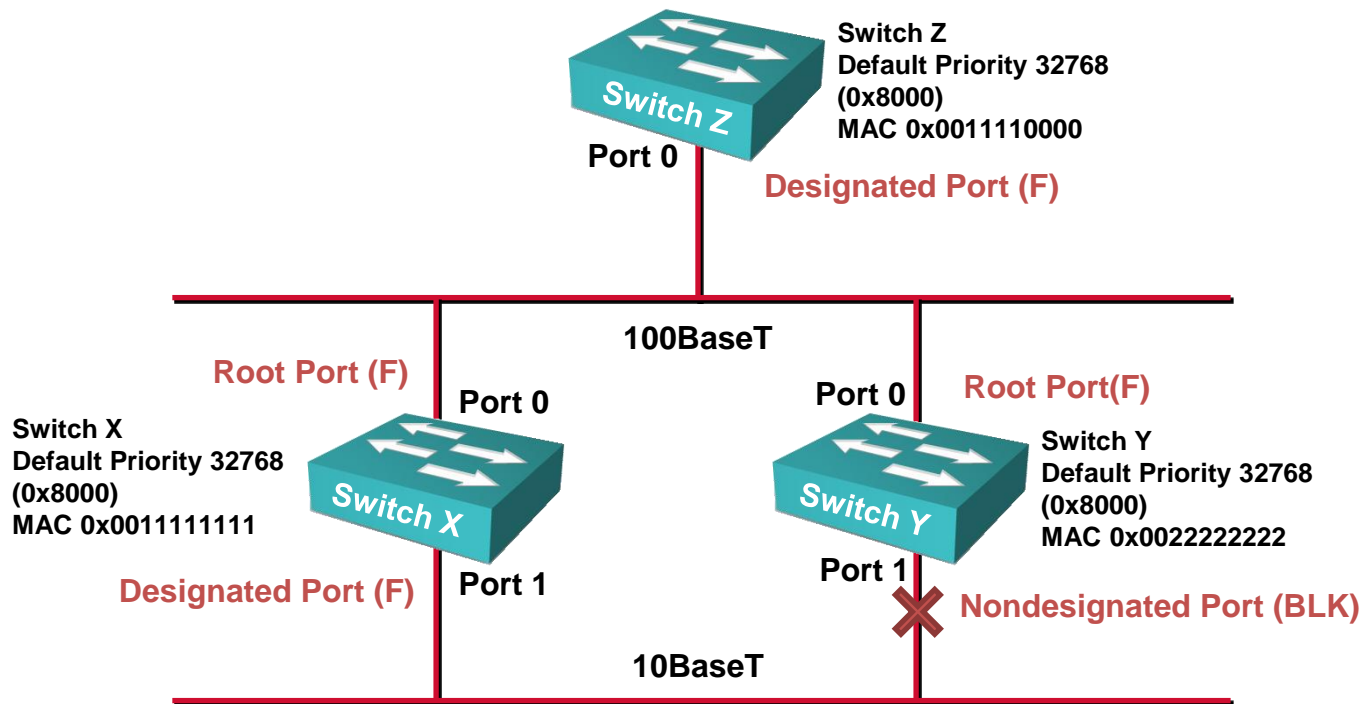


- Switch X(Root Bridge)는 모든 포트가 Designated Port가 된다
- Switch Y는 cost가 더 낮은 Fastethernet port가 Root Port가 된다
- Switch Y에 ethernet port는 Nondesignated Port가 된다

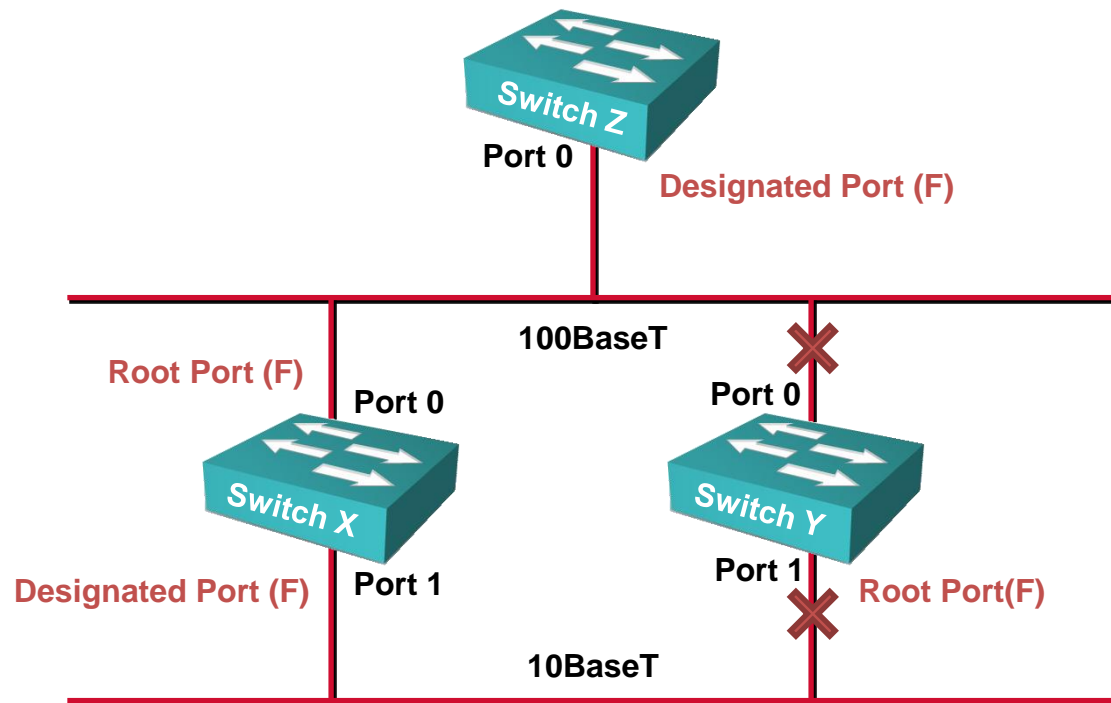
Spanning-Tree Path Cost

Link Speed	Cost (Revised IEEE Spec)	Cost (Previous IEEE Spec)
10 Gbps	2	1
1 Gbps	4	1
100 Mbps	19	10
10 Mbps	100	100

Spanning-Tree Example



Spanning-Tree Recalculation

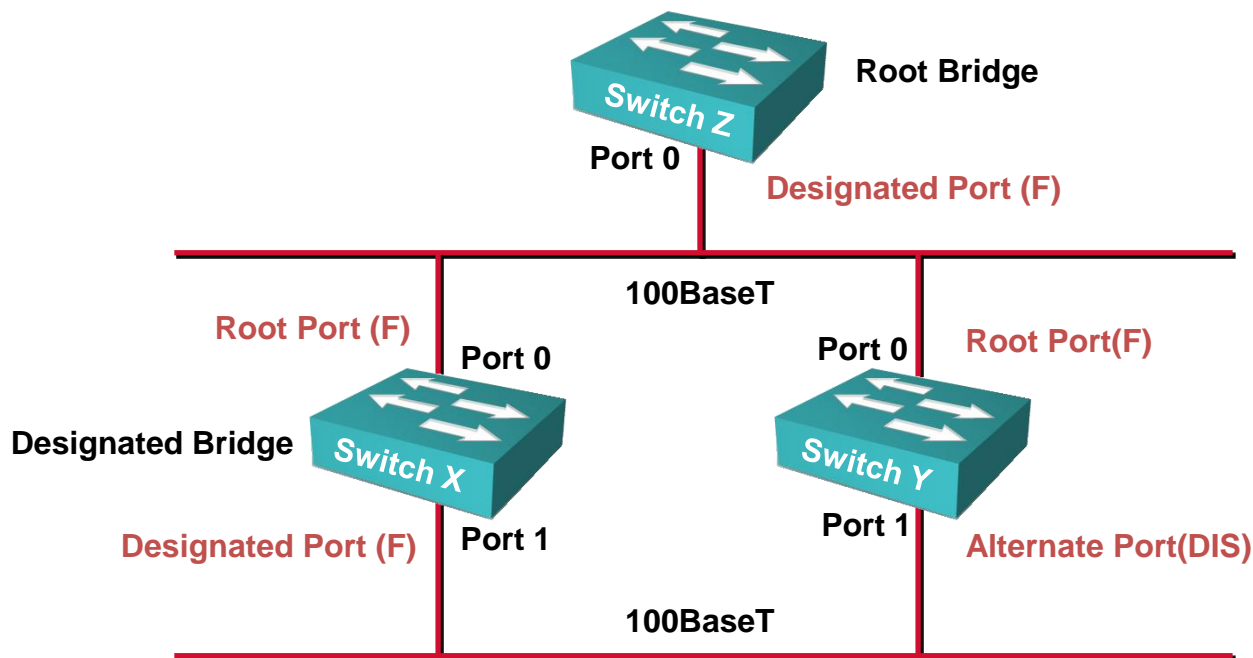


- 전달 포트에 대한 브리지 장애나 링크 장애로 인해 토폴로지가 변경될 때 STP는 Network Topology를 다시 조정해서 차단된 포트를 전달 상태로 변경하여 연결이 이루어 지도록 한다

Spanning-Tree Convergence

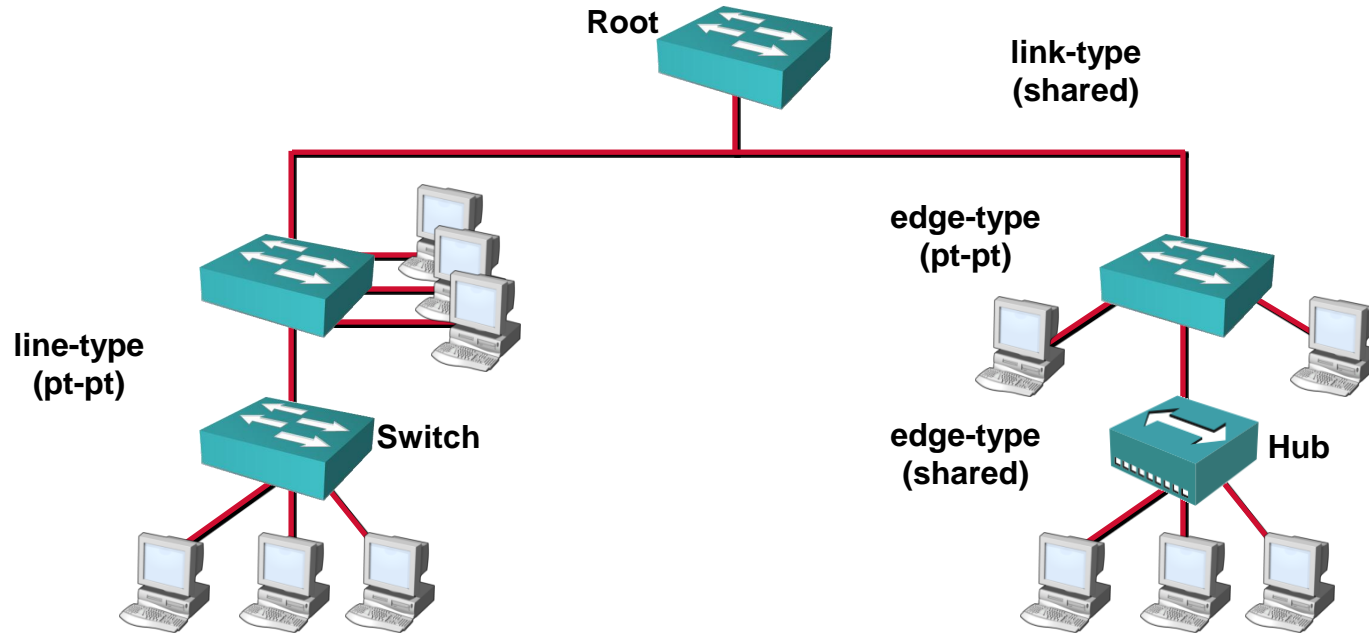
- Switch나 Bridge port가 forwarding이나 blocking 상태로 변할 때 Convergence가 발생한다
- Network Topology가 변경되었을 때, Switch나 Bridge는 Spanning-Tree Protocol을 다시 계산 한다

Rapid Spanning-Tree Protocol



- 802.1w 표준을 RSTP(Rapid Spanning Tree Protocol)라고 부른다
- RSTP는 링크 장애 시 빠르게 포트 변경이 이루어 진다 이전에 802.1d는 BPDU Time이 완료되기를 기다렸다가 포트를 변경하지만 802.1w는 포트 장애나 토폴로지 변경 시 즉시 그 정보를 인접 장비에 전달하여 포트 선출을 하여 변경 즉시 토폴로지에 적용된다

Rapid Transition to Forwarding



- RSTP에서 Port Type은 Link-Type과 Edge-Type으로 구분한다
- Link-Type은 다시 Shared or Pt-Pt로 구분된다. Shared인 경우 loop발생 여지가 있는 경우이고, Pt-Pt는 단일 Line로 연결되어 loop가 발생하지 않는 환경을 정의 한다
- Edge-Type도 Shared와 Pt-Pt로 분리하는데 Shared는 Collision Domain인 경우이고, Pt-Pt는 서버나, 라우터와 연결되어 loop가 발생되지 않는다



Configuration a Catalyst Switch

2950 Default configuration

- **IP Address : 0.0.0.0**
- **CDP : enabled**
- **100BaseT Port : auto negotiate duplex mode**
- **Spanning tree : enable**
- **Console password : none**

Port Names on Catalyst 2950 Switches

```
ASW2950#show run
```

```
Building configuration...  
Current configuration:
```

```
!  
!  
interface FastEthernet0/1  
!  
interface FastEthernet0/2
```

```
ASW2950#show spanning-tree
```

```
VLAN 0001  
Spanning tree enabled protocol ieee  
Root ID Priority      32769  
      Address      000b.5f2a.5a00  
      This bridge is the root  
      Hello Time    2 sec MAX Age 20 sec Forward  
Delay 15 sec
```

```
ASW2950#show vlan
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4, Fa0/5, Fa0/6, Fa0/7, Fa0/8, Fa0/9, Fa0/10, Fa0/11, Fa0/12, Fa0/13, Fa0/14, Fa0/15, Fa0/16, Fa0/17, Fa0/18, Fa0/19, Fa0/20, Fa0/21, Fa0/22, Fa0/23, Fa0/24

Configuring the Switch IP Address

▪ Catalyst 2950

```
ASW2950(config-if)#ip address {ip_address} {mask}
```

```
ASW2950(config)#interface vlan 1  
ASW2950(config-if)#ip address 10.5.5.11 255.255.255.0
```

- Switch에 VLAN1 Interface에 IP Address와 Subnet mask를 설정한다

Configuring the Switch Default Gateway

```
ASW2950(config)#ip default-gateway {ip_address}
```

- Catalyst 2950 Switch에 Default Gateway 설정

```
ASW2950(config)#ip default-gateway 10.5.5.3  
ASW2950(config)#
```

Showing the Switch IP Address

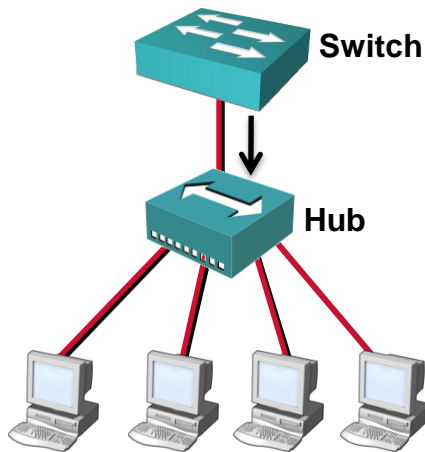
▪ Catalyst 2950

```
ASW2950#show interface vlan 1
Vlan1 is up, line protocol is up
  Hardware is Cat5k Virtual Ethernet, address is 0010.f6a9.9800 (bia 0010.f6a9.9800)
  Internet address is 172.16.80.79/24
  Broadcast address is 255.255.255.255
  . . .
ASW2950#
```

Duplex Overview

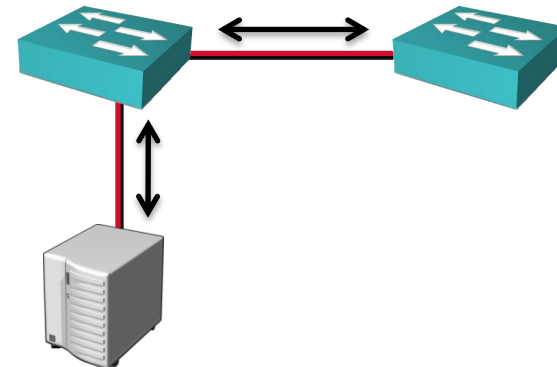
▪ Half Duplex (CSMA/CD)

- 단 방향 Data 흐름
- Collision 가능성이 더 높음
- Hub 연결



▪ Full Duplex

- Point-to-Point only
- 전용 switched port에 연결
- 양쪽에서 full-duplex 지원 필수
- Collision-free
- Collision 감지 회선 비활성



Setting Speed and Duplex Options

▪ Catalyst 2950

```
ASW2950(config)#interface fe0/1  
ASW2950(config-if)#duplex {auto | full | half}
```

Showing Duplex Options

```
ASW2950#show interfaces fastethernet0/3
```

```
FastEthernet0/3 is up, line protocol is down
  Hardware is Fast Ethernet, address is 0000.0000.0003 (bia 0000.0000.0003)
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Half-duplex, 100Mb/s
  input flow-control is off, output flow-control is off
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    0 packets input, 0 bytes, 0 no buffer
    Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    0 input packets with dribble condition detected
    0 packets output, 0 bytes, 0 underruns
    0 output errors, 0 collisions, 2 interface resets
    0 babbles, 0 late collision, 0 deferred
    0 lost carrier, 0 no carrier
    0 output buffer failures, 0 output buffers swapped out
```

Managing the MAC Address Table

■ Catalyst 2950

```
ASW2950#show mac-address-table
Dynamic Address Count:          1
Secure Address Count:          0
Static Address (User-defined) Count: 0
System Self Address Count:     25
Total MAC addresses:           26
Maximum MAC addresses:         8192
Non-static Address Table:
Destination Address  Address Type  VLAN  Destination Port
-----
0050.0f02.3372      Dynamic      1     FastEthernet0/2
```

Setting a Permanent MAC Address

▪ Catalyst 1900 and 2950

```
ASW2950(config)#mac-address-table static {mac-address type module/port}
```

```
ASW1900(config)#mac-address-table permanent 2222.2222.2222 ethernet 0/3
```

```
ASW1900#show mac-address-table
```

```
Number of permanent addresses : 1
```

```
Number of restricted static addresses : 0
```

```
Number of dynamic addresses : 4
```

Address	Dest	Interface	Type	Source Interface	List
00E0.1E5D.AE2F	Ethernet	0/2	Dynamic	All	
2222.2222.2222	Ethernet	0/3	Permanent	All	
00D0.588F.B604	FastEthernet	0/26	Dynamic	All	
00E0.1E5D.AE2B	FastEthernet	0/26	Dynamic	All	
00D0.5892.38C4	FastEthernet	0/27	Dynamic	All	

▪ Catalyst 1900 only

```
ASW2950(config)#mac-address-table static mac_addr {vlan vlan_id} [interface int 1 [int2 ... int 15]]
```

Setting a Restricted Static MAC Address on the Catalyst 2950

```
ASW2950(config)#mac-address-table secure hw-addr interface [vlan vlan_id]
```

```
ASW2950#mac-address-table secure 0003.3333.3333 fa 0/1 vlan 1
```

```
ASW2950#show mac-address-table
```

```
Dynamic Address Count:          1
Secure Address Count:           1
Static Address (User-defined) Count: 1
System Self Address Count:      25
Total MAC addresses:            28
Maximum MAC addresses:          8192
```

```
Non-static Address Table:
```

Destination Address	Address Type	VLAN	Destination Port
0050.0f02.3372	Dynamic	1	FastEthernet0/2
0003.3333.3333	Secure	1	FastEthernet0/1

```
Static Address Table:
```

Destination Address	VLAN	Input Port	Output Ports
2222.2222.2222	1	ALL	Fa0/1

Configuring Port Security

▪ Catalyst 2950

```
ASW2950(config-if)#port security max-mac-count count
```

```
ASW2950(config)#interface fa0/1  
ASW2950(config-if)#port security  
ASW2950(config-if)#port security max-mac-count 10
```

Verifying Port Security on the Catalyst 2950

```
ASW2950#show mac-address-table secure
```

```
wg_sw_2950#show mac-address-table secure
```

```
Non-static Address Table:
```

Destination Address	Address Type	VLAN	Destination Port
-----	-----	----	-----
0003.3333.3333	Secure	1	FastEthernet0/1

```
ASW2950(config-if)#port security action {shutdown | trap}
```

```
ASW2950#show port-security
```

Executing Adds, Moves, and Changes for MAC Addresses

▪ Adding a MAC Address

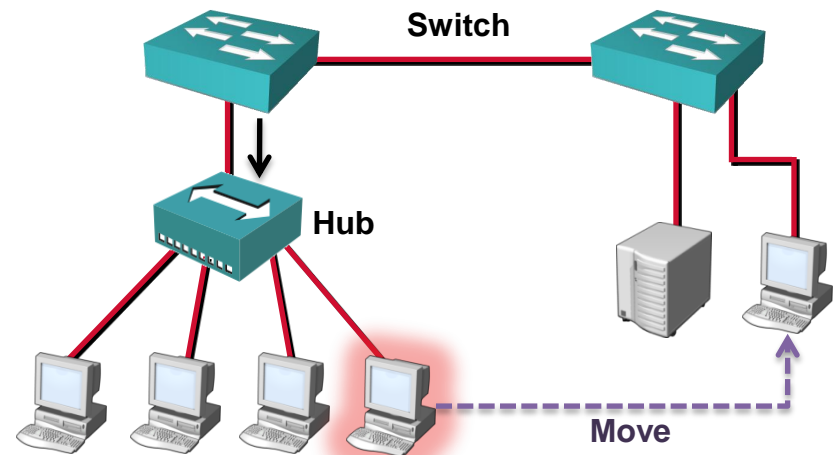
1. Port Security ■ 설정한다
2. Port에 MAC Address ■ 설정한다

▪ Changing a MAC Address

1. Remove MAC Address restrictions

▪ Moving a MAC Address

1. 새로운 포트에 포트 보안을 설정한다
2. 새로운 인터페이스에 대해 할당된 포트에 MAC Address ■ 설정한다
3. 새로 설정된 포트에 장비를 연결한다
4. 원래의 포트에서 포트 보안과 MAC Address 할당을 제거한다



Clearing NVRAM

▪ Catalyst 2950

```
ASW2950#erase startup-config
```

- Startup-config 파일을 제거하면 모든 구성정보가 제거된다
- Reload ■ 하면 초기화된 상태로 부팅하게 된다