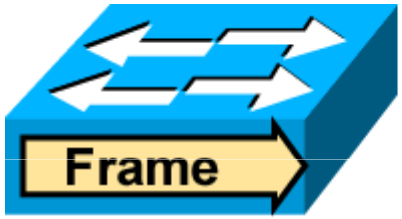
Module 07 :
Layer 2 Switching

Basic Layer 2 Switching and Bridging Functions

Transmitting Frames

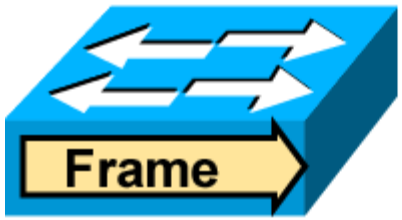
Cut-Through

- **Switch**가 목적지 주소를 확인한 후 즉시 전달하는 방법



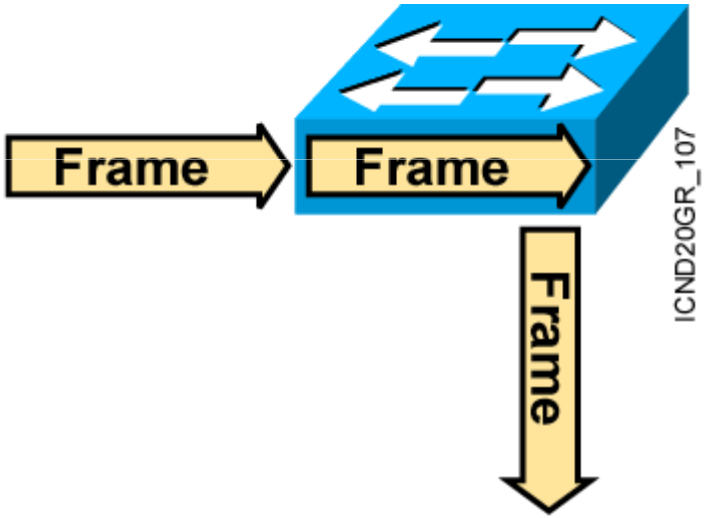
Fragment-Free

- **Switch**가 프레임에 **64 byte**까지 검사한 후 즉시 전달을 시작한다.

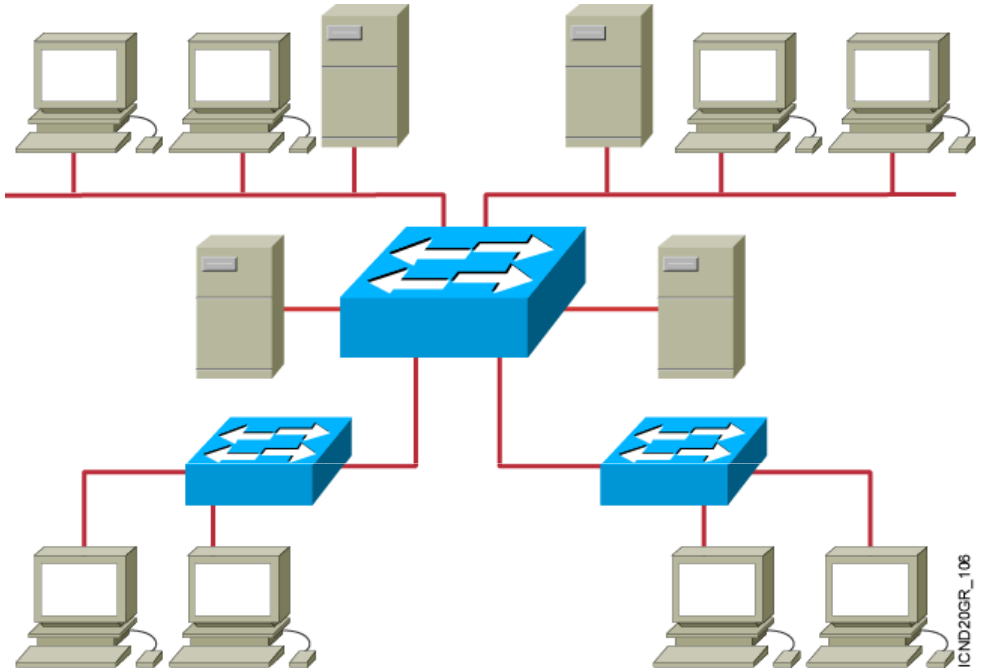


Store and Forward

프레임을 모두 전송 받아 검사 후에 전달한다.

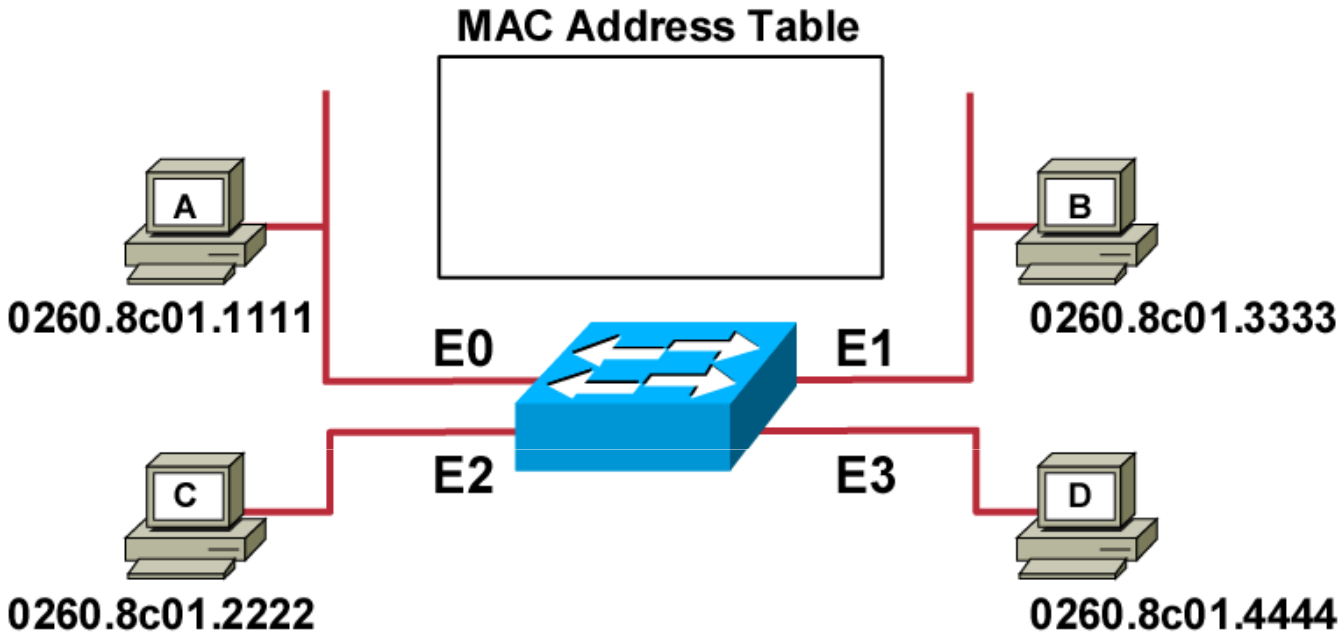


Ethernet Switches and Bridges



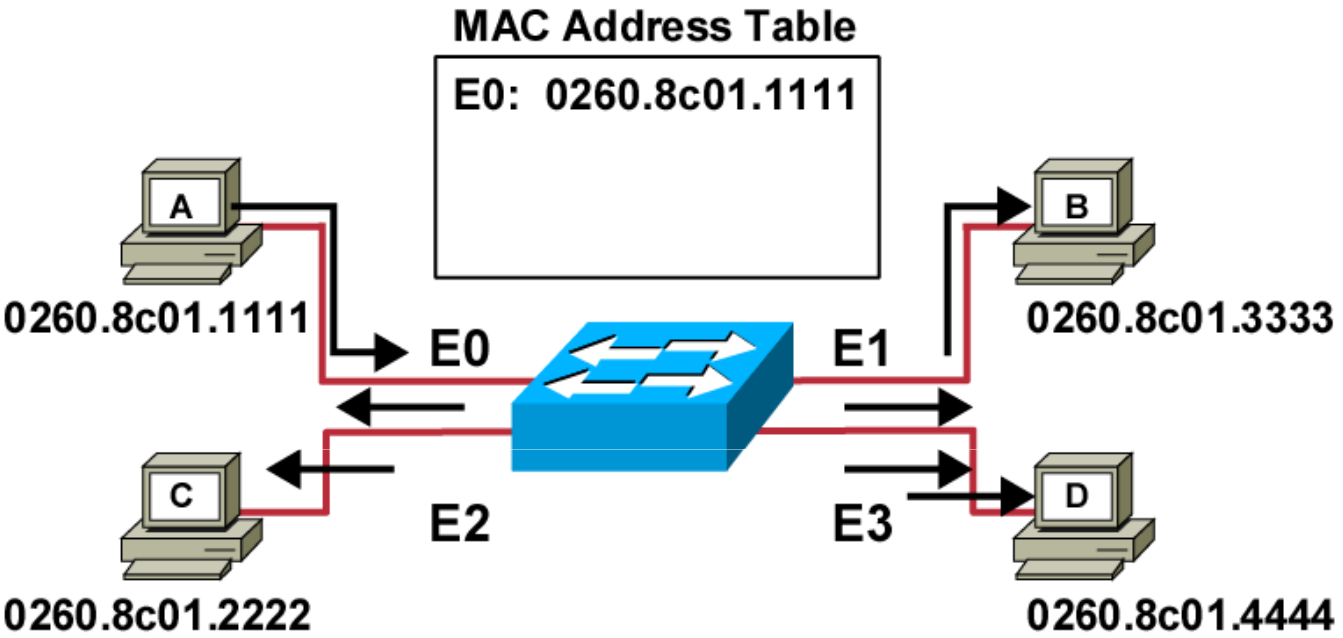
- **Address learning**
- **Forward/filter decision**
- **Loop avoidance**

MAC Address Table



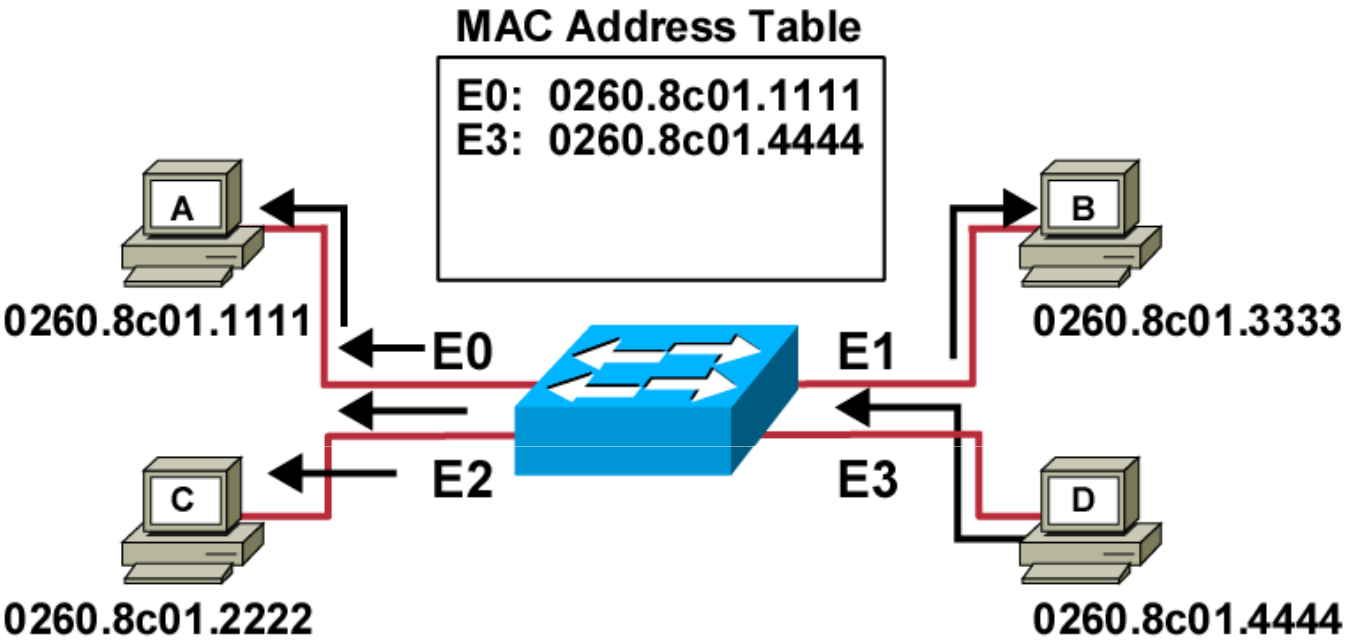
- 초기에는 **MAC Address Table**이 비어있다**.**

Learning Addresses



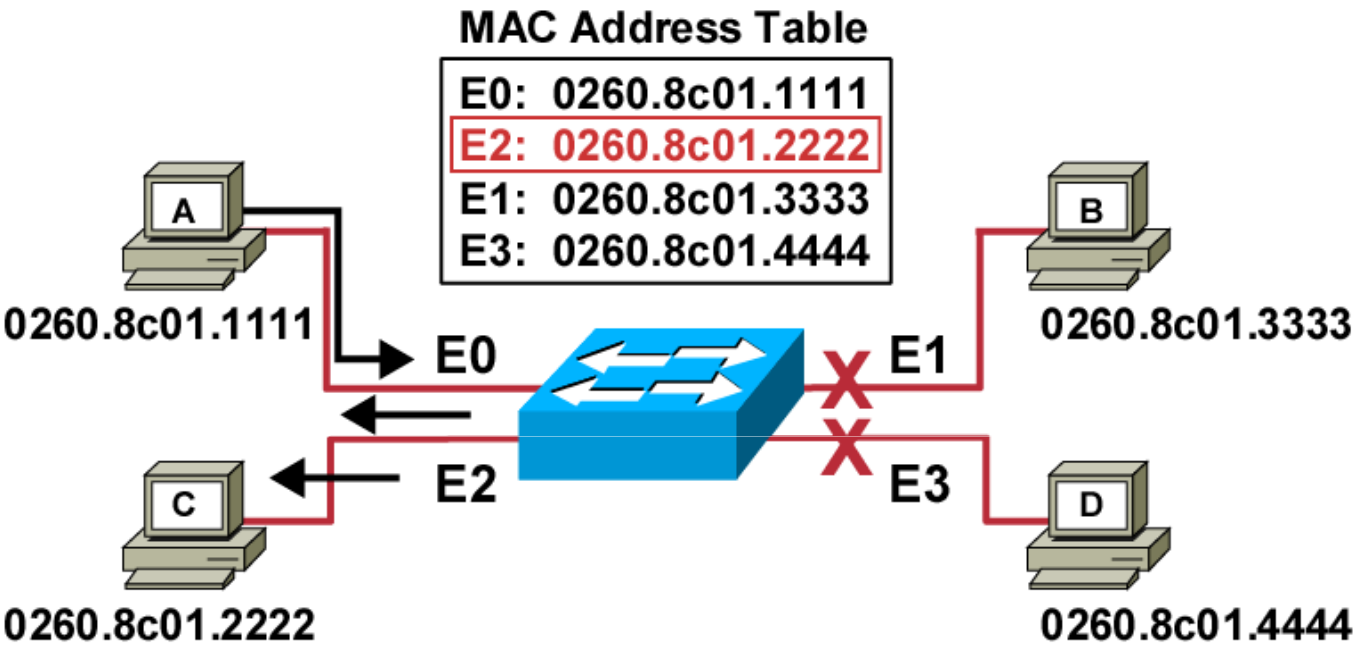
- **Host A**가 **Host B**에게 **Frame**을 전달한다.
- **Switch**는 **MAC Address Table**이 비어 있기 때문에 **Frame**을 모든 포트로 **Flooding**한다.
- **Host A**에서 온 **Frame**을 **Flooding** 하는 동안 스위치는 **e0** 에 **Host A**에 **MAC Address**를 학습한다.
- **Host A**에 대한 **MAC Address Table** 정보는 **Cache**에 저장된다. **(Aging Time 300**초**)**

Learning Addresses (Cont.)



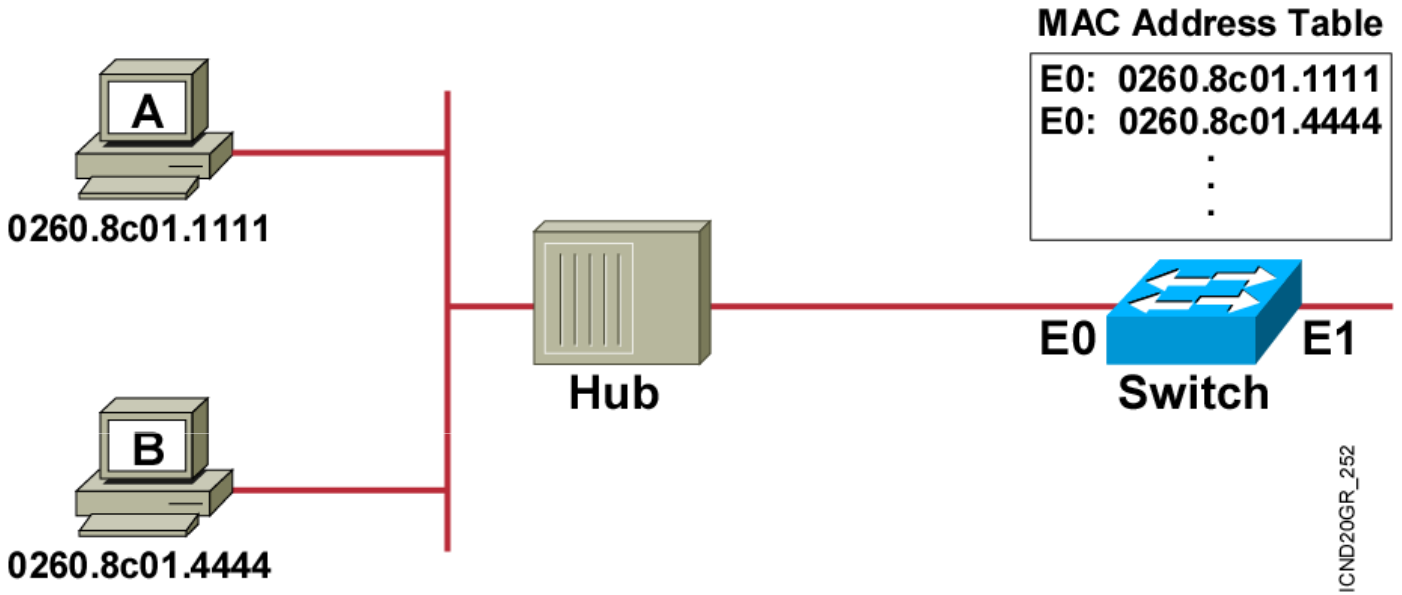
- **Host D**가 **Host C**에게 **Frame**을 전달한다.
- **Switch**는 **MAC Address Table**에 목적지 **MAC Address**에 대한 정보가 없기 때문에 **Frame**을 전달된 포트를 제외한 모든 포트로 **Flooding**한다.
- **Host D**에서 온 **Frame**을 **Flooding** 하는 동안 스위치는 **e3** 에 **Host D**에 **MAC Address**를 학습한다.
- **Host D**에 대한 **MAC Address Table** 정보는 **Cache**에 저장된다. **(Aging Time 300**초**)**

Filtering Frames



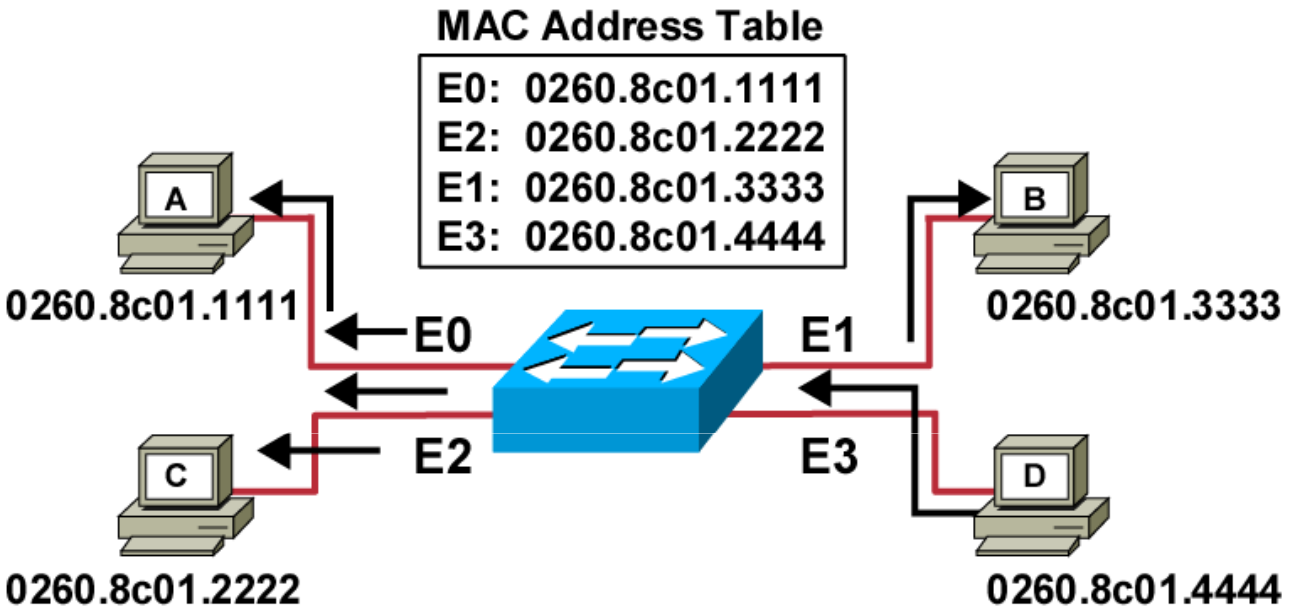
- **Host A**가 **Host C**에게 **Frame**을 전달한다.
- **Switch**는 **MAC Address Table**에 목적지 **MAC Address**에 대한 정보를 찾아 해당 하는 포트인 **E2**로 **Frame**을 전달한다.
- **E2**에 대한 **Aging Time**이 초기화 된다.

Filtering Frames (Cont.)



- **Host A**가 **Host B**에게 **Frame**을 보낸다.
- **Switch**는 **MAC Address Table**에 **Host B**에 **MAC Address**를 추가한다.

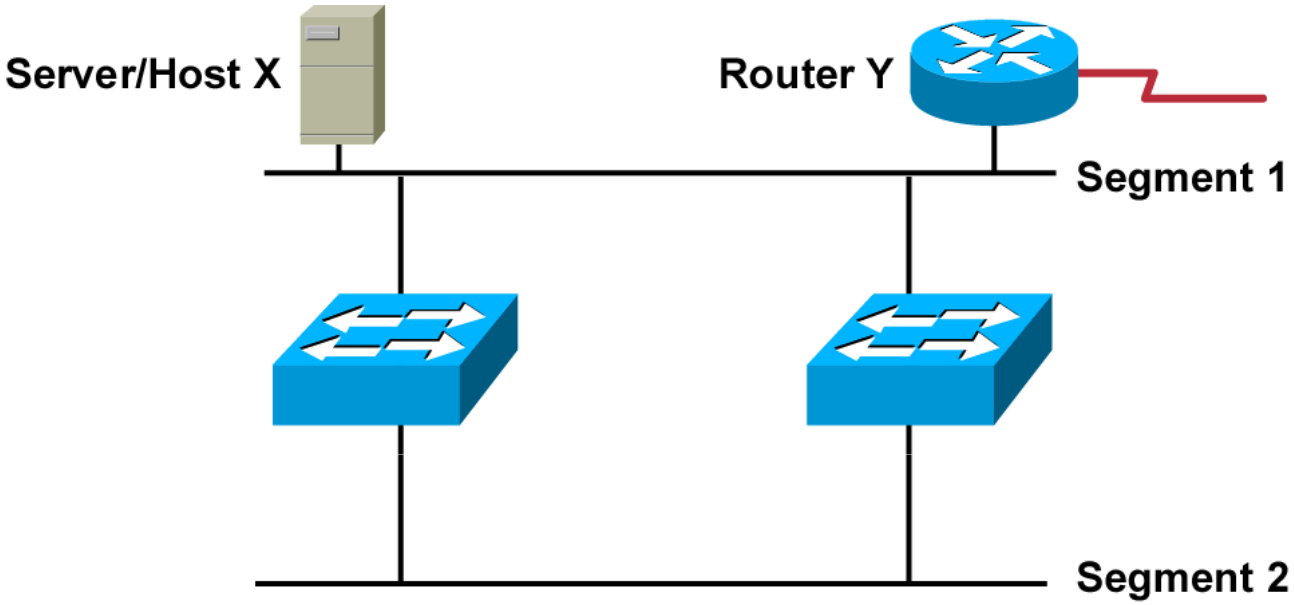
Broadcast and Multicast Frames



- **Host D**가 **Broadcast** 또는 **Multicast**를 보낸다.
- **Broadcast**나 **Multicast**는 전달된 포트를 제외한 모든 포트로 **Flooding** 된다.

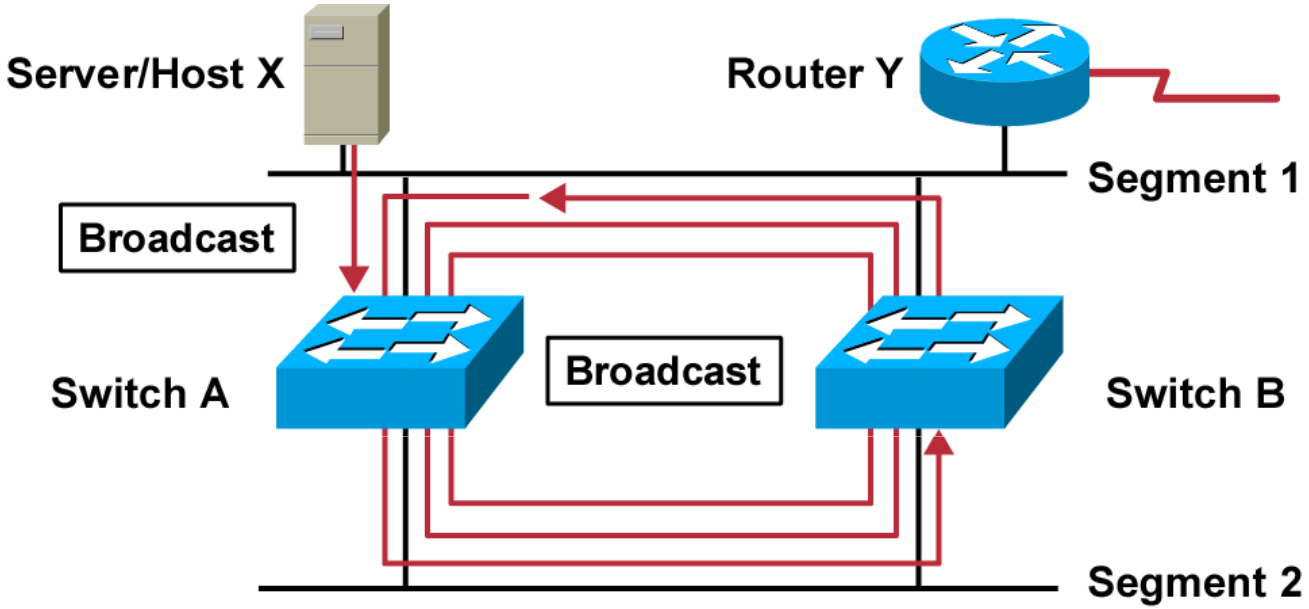
Redundant Topology Overview

Redundant Topology



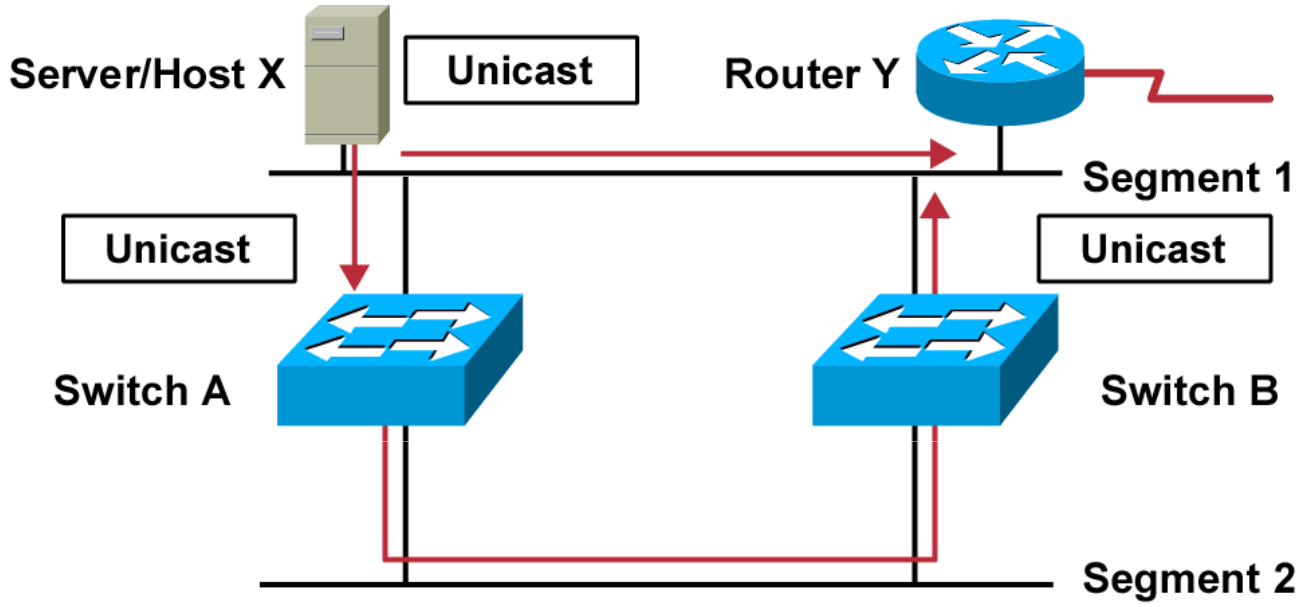
- 링크 이중화는 한 지점에서의 장애로 인해 네트워크 기능 상실을 방지한다.
- 링크 이중화는 **Broadcast Storm, Multiple frame** 복사**, MCA Address Table** 불안정성 문제가 발생한다.

Broadcast Storms



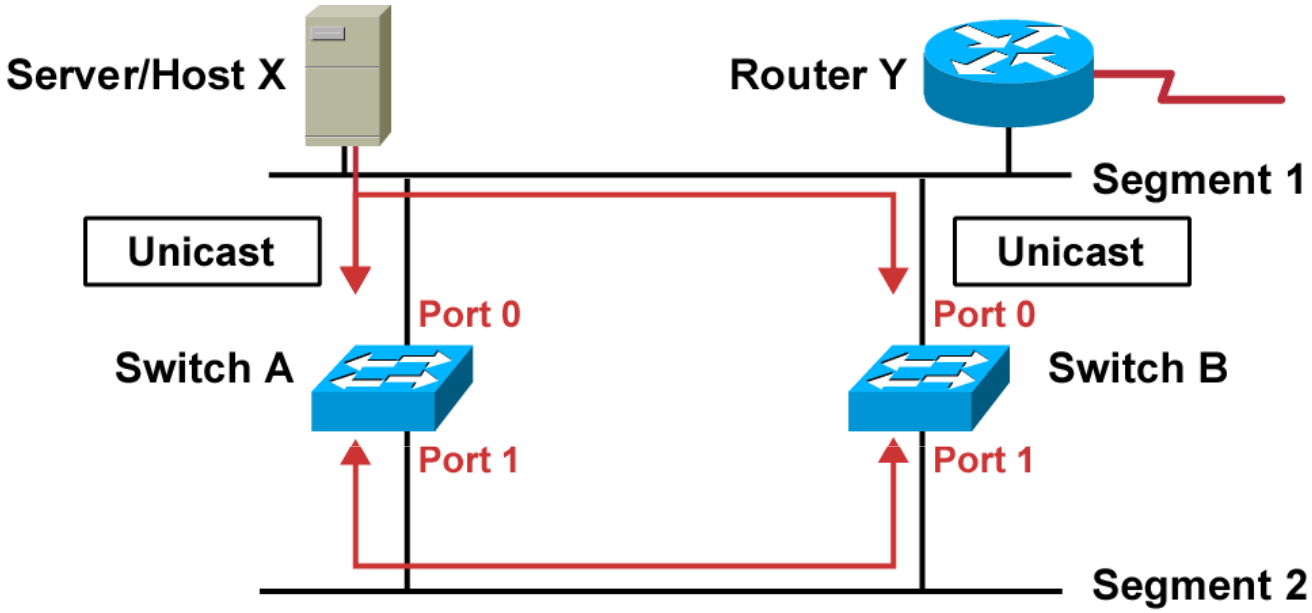
- **Host X** 가 **Broadcast**를 보낸다.
- **Switch**는 계속해서 **Broadcast traffic**을 서로에게 전파한다.

Multiple Frame Copies



- **Host X** 가 **Unicast Frame**을 **Router Y**로 보낸다.
- **Router Y**와 **Switch A**는 **Frame**을 받게 된다. **Switch A**는 **MAC Table**에 **Host X**에 대한 **MAC Address**가 없기 때문에 **Flooding**한다.
- **Switch A**로 부터 **Flooding**된 **Frame**을 **Switch B**가 받아 다시 **Flooding**한다.
- **Router Y**는 동일한 복사된 동일한 **Frame**을 다시 받게 된다.

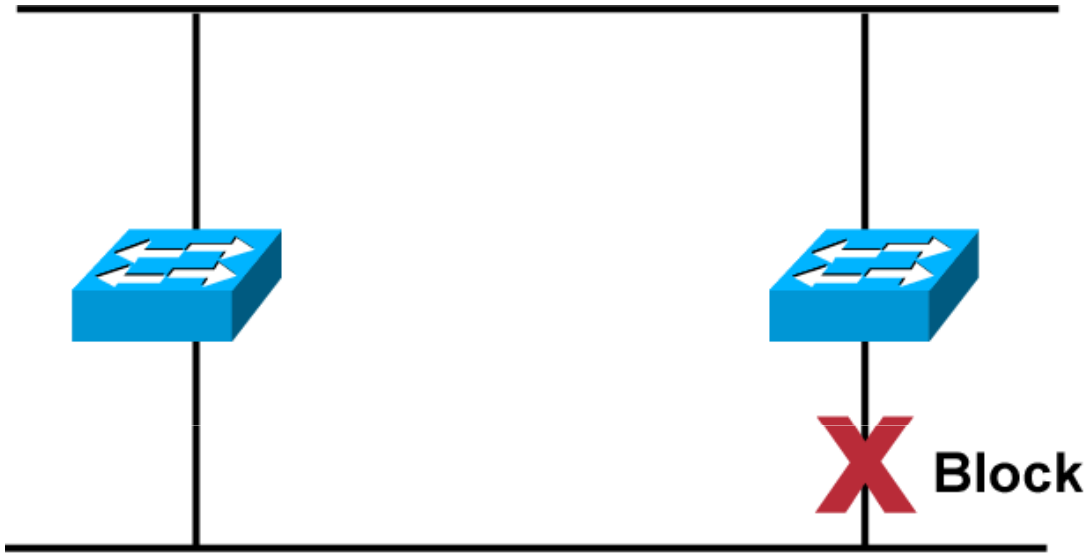
MAC Database Instability



- **Host X**가 **Router Y**에게 **Unicast Frame**을 보낸다.
- 아직 **Router Y**에 **MAC Address**를 학습한 **Switch**가 없다.
- **Switch A**와 **Switch B**는 **Port 0**에 **Host X**에 **MAC Address**를 학습한다.
- 두 **Switch**에서 **Router Y**로 가는 **Frame**이 **Flooding** 된다.
- **Switch A**와 **Switch B**가 **Port 1**에서 **Host X**에 **MAC Address**를 부정확하게 학습한다.

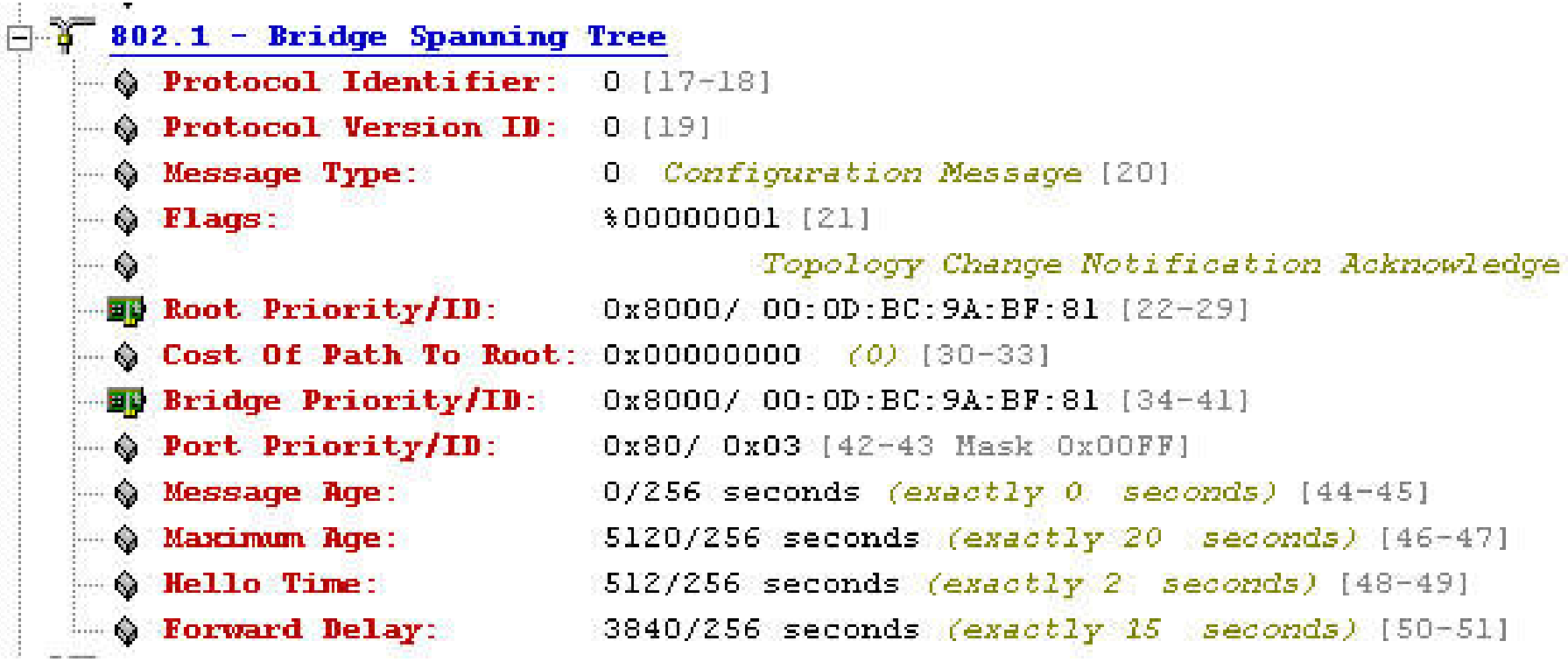
Spanning-Tree Protocol Overview

Spanning-Tree Protocol



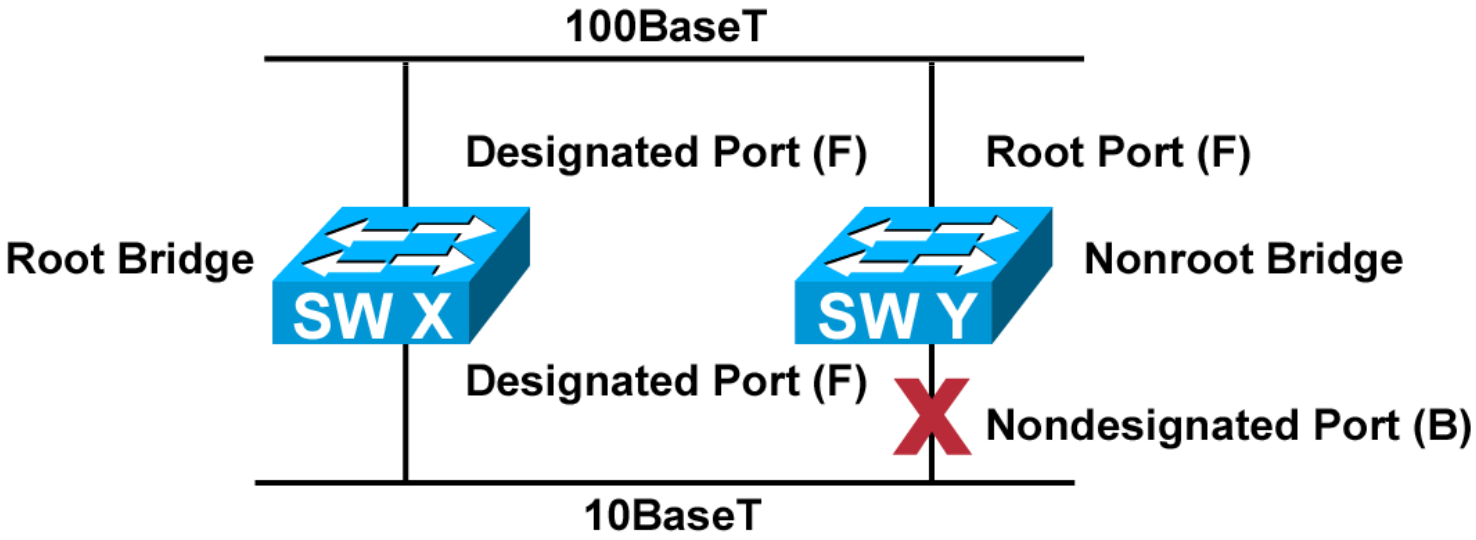
- **STP**는 **Switch**가 **Topology**내의 루프를 인식하고 하나의 **Link**를 차단하고 있는 상태에서 **Loop**를 제거한다.
- **STP**는 포트를 계속 모니터링 하다가 만약 다른 포트에 장애나 토폴로지 변경이 발생하는 경우 **Bridge**는 포트를 재설정하여 연결의 완전 손실이나 새로운 루프를 막는다.

BPDU (802.1d)

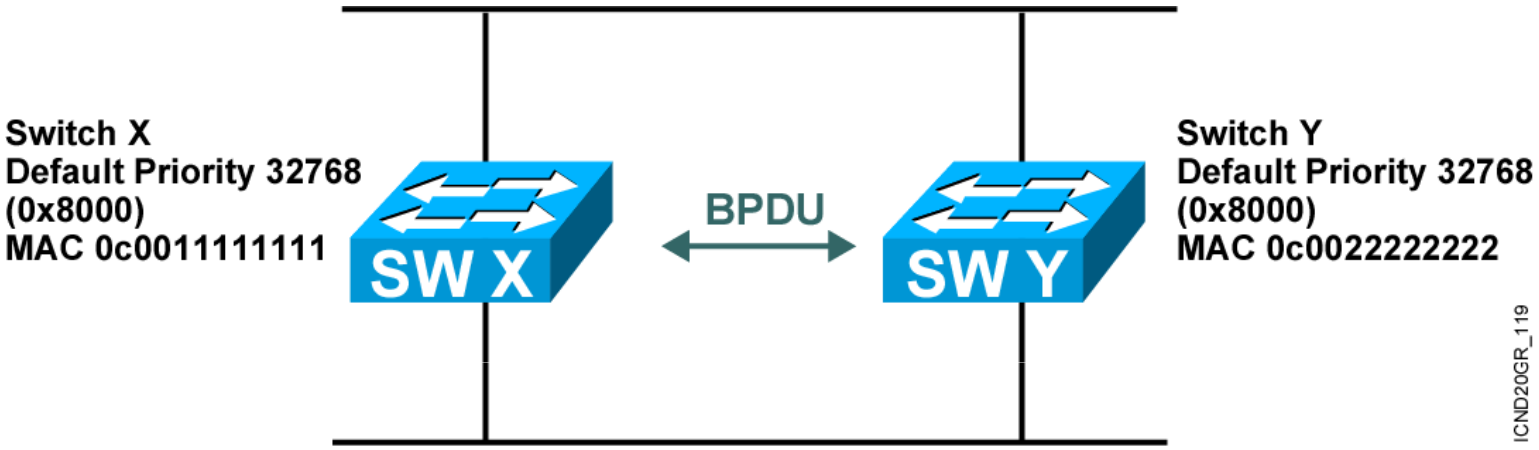

802.1 - Bridge Spanning Tree
Protocol Identifier: 0 [17-18]
Protocol Version ID: 0 [19]
Message Type: 0 Configuration Message [20]
Flags: %00000001 [21]
Topology Change Notification Acknowledge
Root Priority/ID: 0x8000/ 00:0D:BC:9A:BF:81 [22-29]
Cost Of Path To Root: 0x00000000 (0) [30-33]
Bridge Priority/ID: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

Spanning-Tree Operation

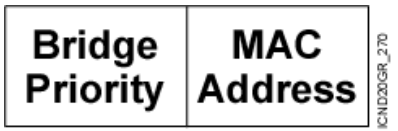
- **Network**당 하나에 **Root Bridge**를 갖는다.
- **Non-Root Bridge**당 하나의 **Root Port**를 갖는다.
- **Segment** 당 하나의 **Designated Port**를 갖는다.
- **Nondesignated Port**는 사용하지 않는다.



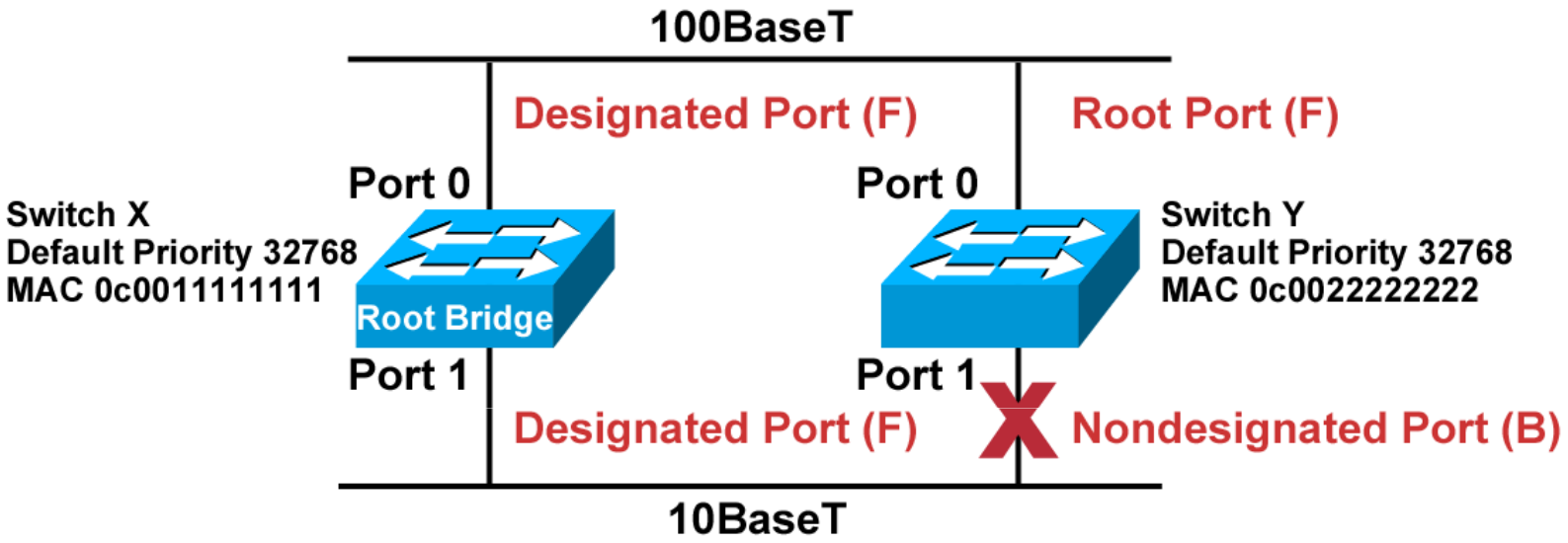
Spanning-Tree Protocol Root Bridge Selection



- **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 (Cont.)

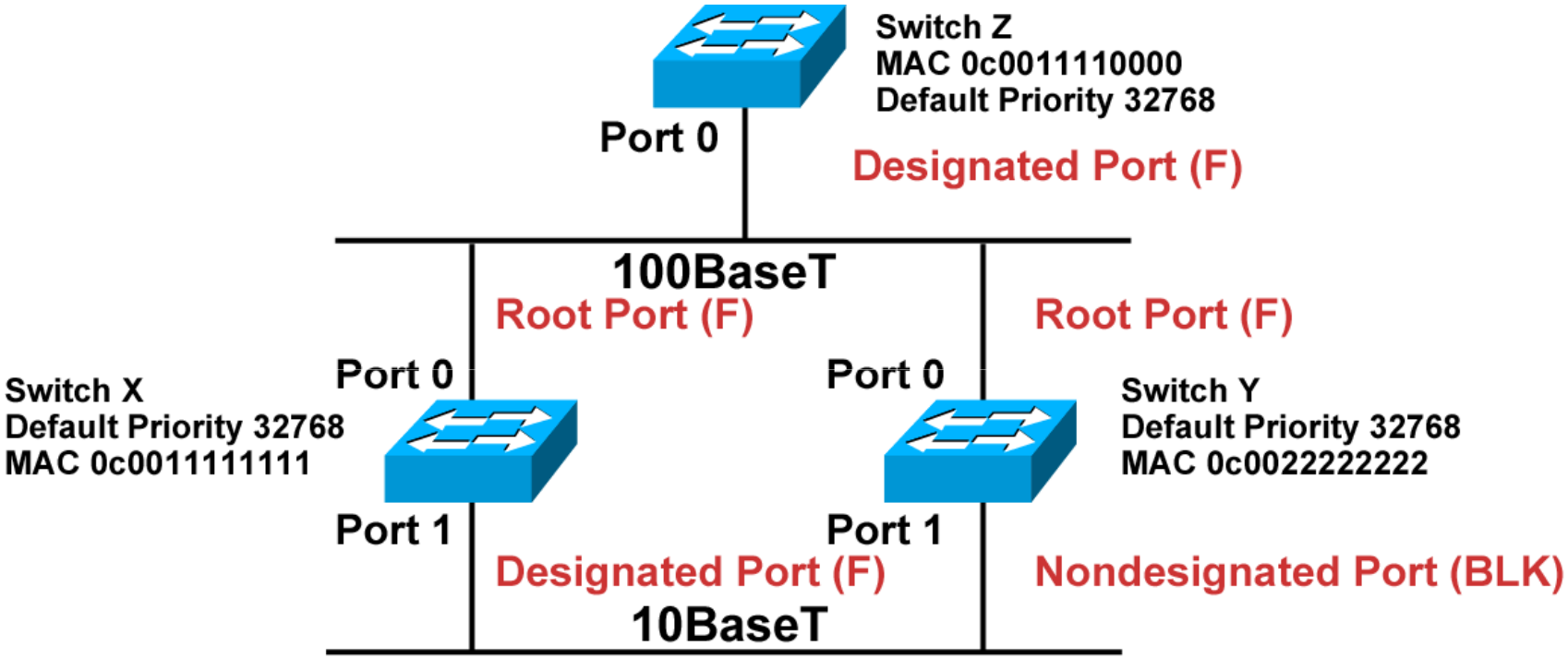


- **Switch X (Root Bridge)**는 모든 포트가 **Designated Port**가 된다.
- **Switch Y**는 **Cost**가 더 낮은 **Fastethernet Port**가 **Root Port**가 된다.
- **Switch Y**에 **ethernet Port**는 **Nondesignated Port**가 된다.

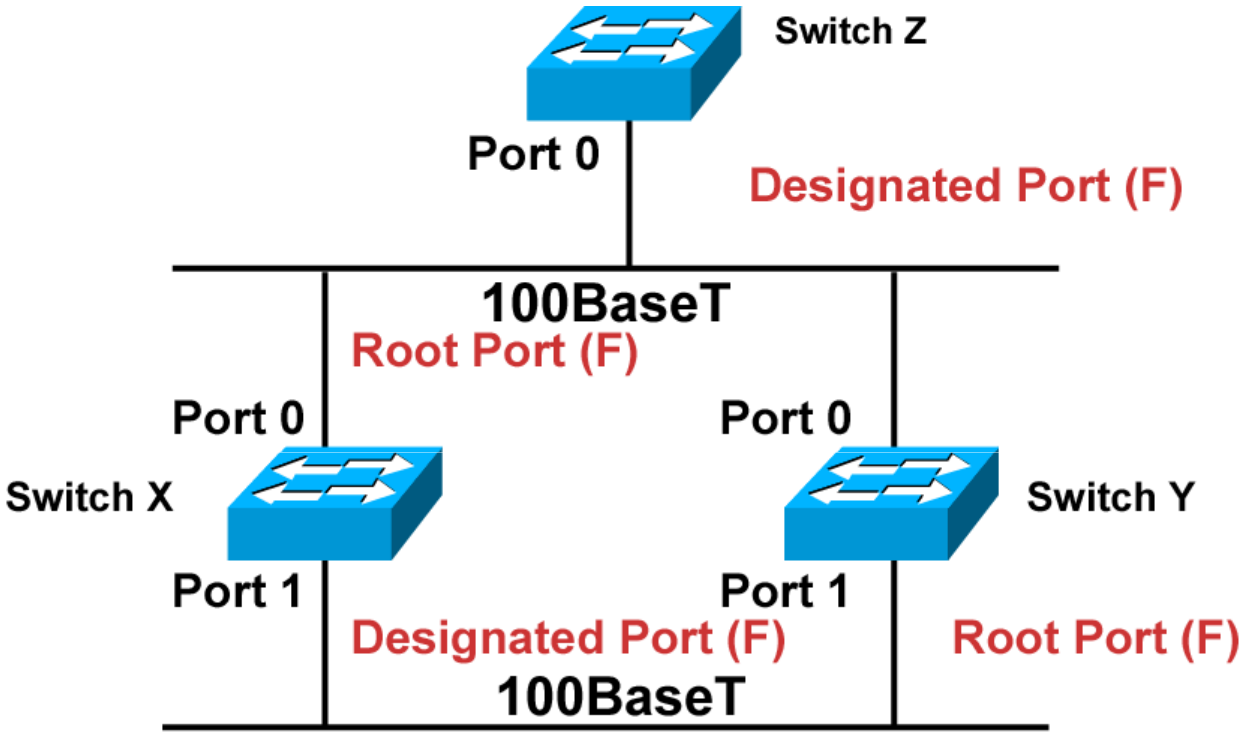
Spanning-Tree Path Cost

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

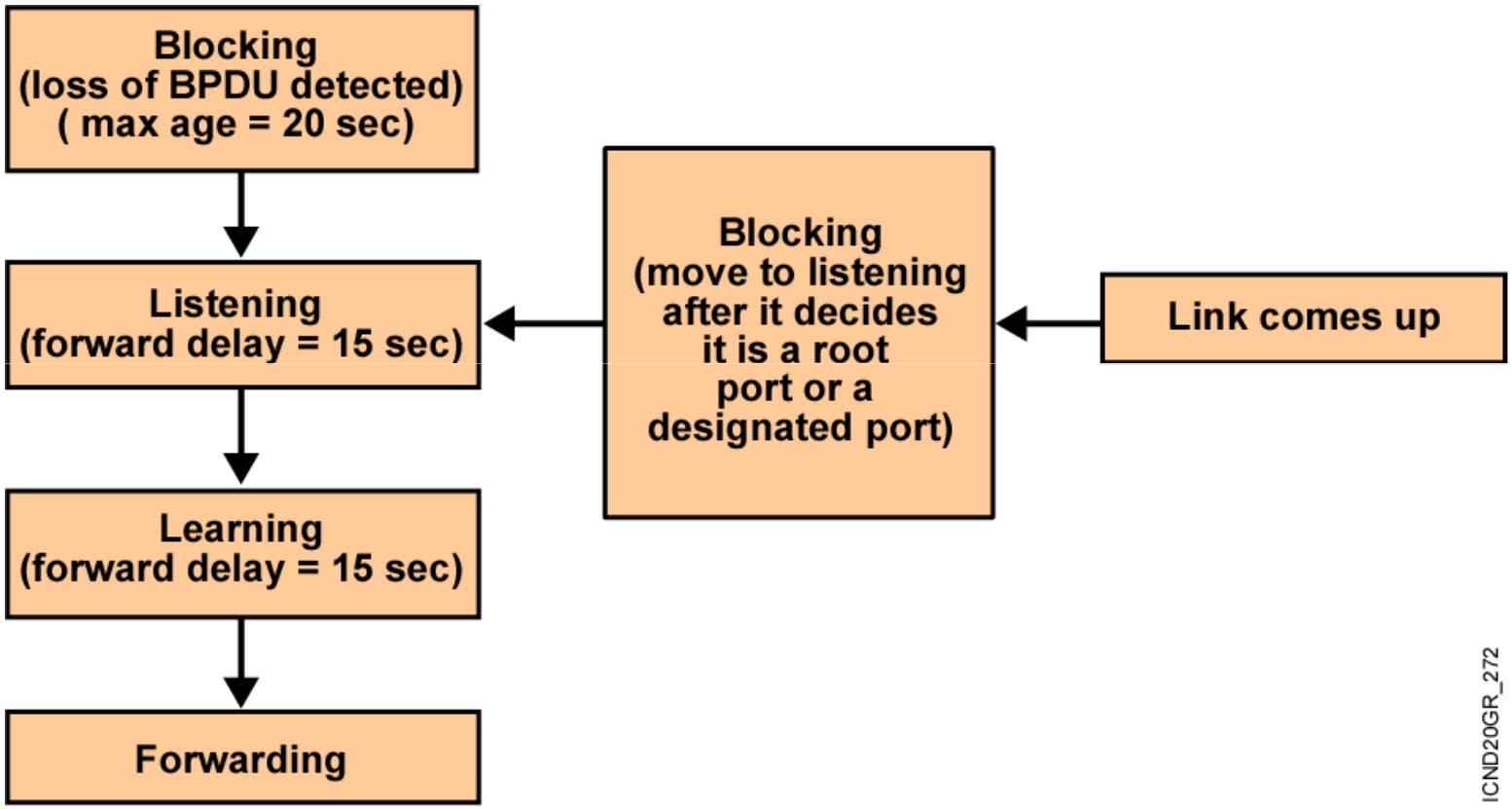


Spanning-Tree Recalculation



- 전달 포트에 대한 브리지 장애나 링크 장애로 인해 토폴로지가 변경될 때 **STP**는 **Network Topology**를 다시 조정해서 차단된 포트를 전달 상태로 변경하여 연결이 이루어지도록 한다.

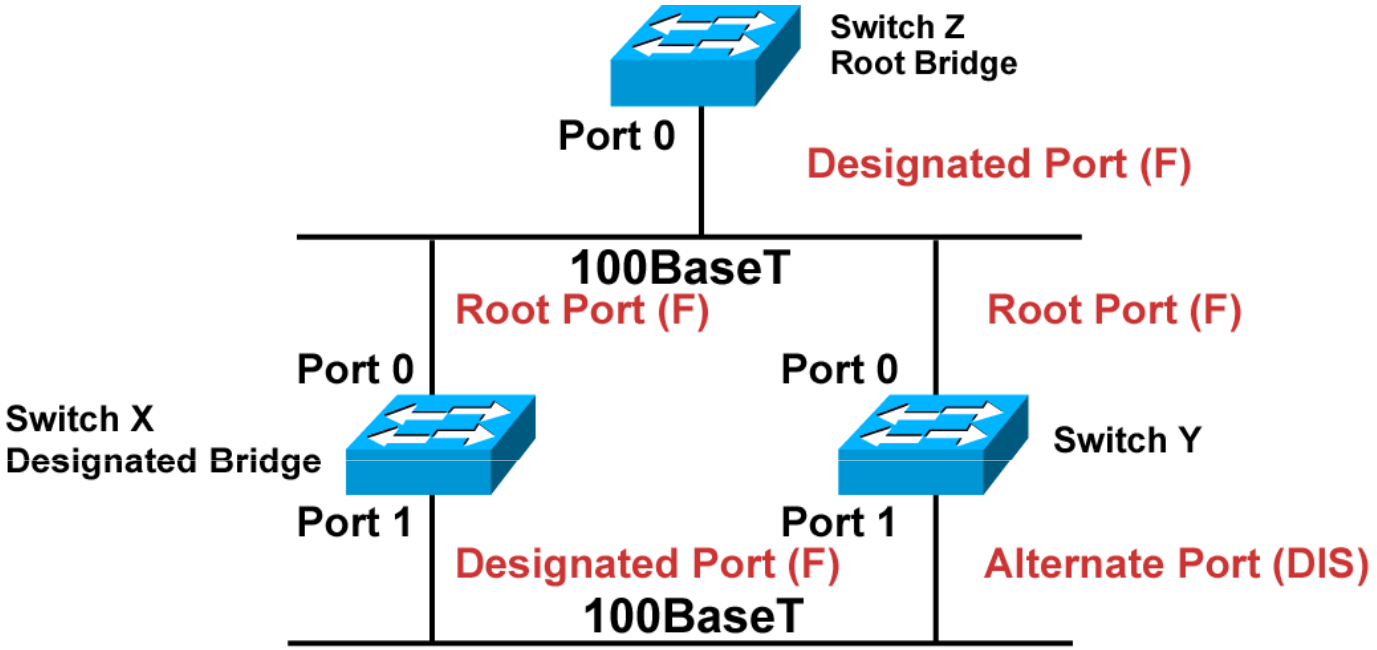
Spanning-Tree Port States



Spanning-Tree Convergence

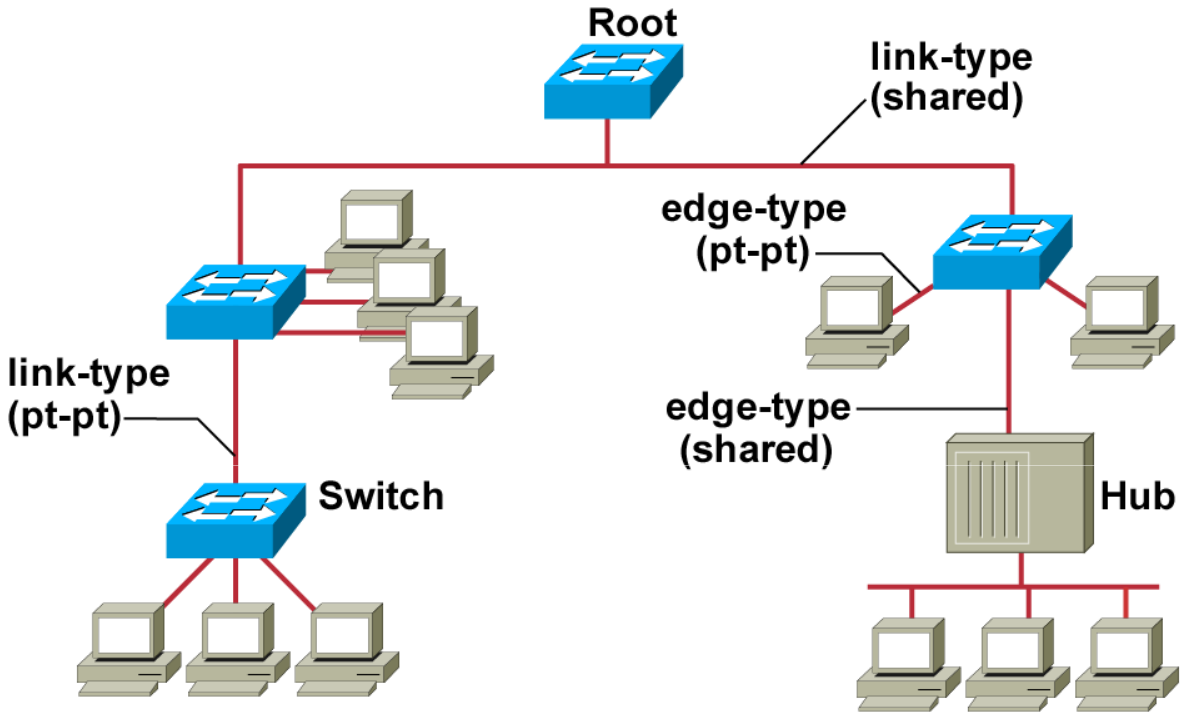
- **Convergence occurs when all the switch and bridge ports have transitioned to either the forwarding or the blocking state.**
- **When the network topology changes, switches and bridges must recompute the Spanning-Tree Protocol, which disrupts user traffic.**

Rapid Spanning-Tree Protocol



- **802.1w** 표준을 **RSTP (Rapid Spanning Tree Protocol)**라고 부른다**.**
- **RSTP**는 링크 장애 시 빠르게 포트 변경이 이루어 진다**.** 이전에 **802.1d**는 **BPDU Time**이 만료되기를 기다렸다가 포트 변경을 하지만 **802.1w**는 포트 장애나 토폴로지 변경 시 즉시 그 정보를 인접 장비에 전달하여 포트 선출을 하여 변경 즉시 토폴로지에 적용된다**.**

Rapid Transition to Forwarding



- **RSTP**에서 **Port Type**은 **Link-Type**과 **Edge-Type**으로 구분한다.
- **Link-Type**은 다시 **Shared or Pt-Pt**로 구분된다. **Shared**인 경우 **loop**발생 여지가 있는 경우이고, **Pt-PT**는 단일 **Link**로 연결되어 **Loop**가 발생하지 않는 환경을 정의한다.
- **Edge-type**도 **Shared**와 **Pt-Pt**로 분리하는데 **Shared**인 경우 **Collision Domain** 이 경우 이고, **Pt-Pt**는 서버나, 라우터와 연결되어 **Loop**가 발생되지 않는다.

Configuring a Catalyst Switch

2950 Default Configuration

- **IP address: 0.0.0.0**
- **CDP: enabled**
- **100baseT port: autonegotiate duplex mode**
- **Spanning tree: enabled**
- **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
```

- **Switch**에 **VLAN1 Interface**에 **IP Address**와 **Subnet mask**를 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
```

Showing the Switch IP Address

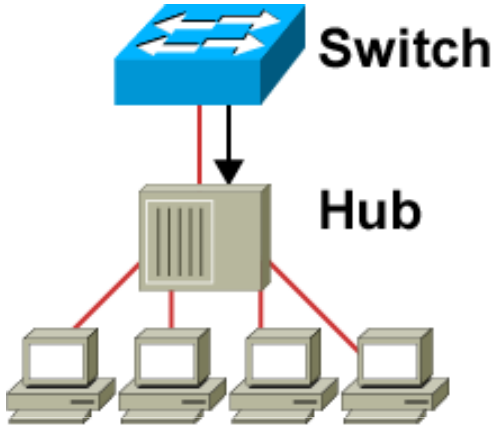
Catalyst 2950

```
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

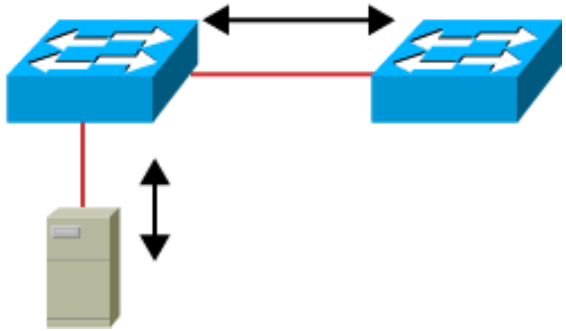
Half Duplex (CSMA/CD)

- 단방향 **Data** 흐름
- **Collision** 가능성이 더 높음
- **Hub** 연결



Full Duplex

- **Point-to-point only**
- 전용 **switched port**에 연결
- 양쪽에서의 **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, 10Mb/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

```
ASW1900(config)#mac-address-table permanent {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 2950 only

```
ASW2950(config)#mac-address-table static
mac_addr {vlan vlan_id} [interface int1 [int2 ... int15]]
```

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

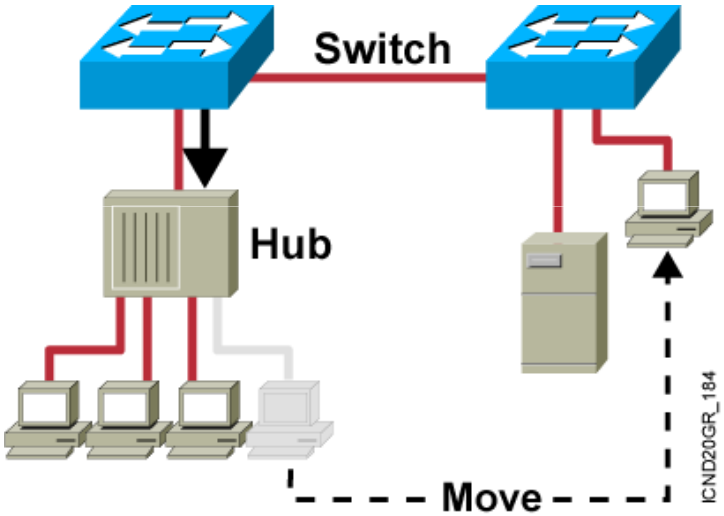
```
ASW2950#show mac-address-table secure
```

```
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**를 설정한다.
2. **Port**에 **MAC Address**를 설정한다.

Changing a MAC Address

1. **Remove MAC address restrictions. (no switchport port-security)**

Moving a MAC Address

1. 새로운 포트에 포트 보안을 설정한다.
2. 새로운 인터페이스에 대해 할당된 포트에 **MAC Address**를 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**를 하면 초기화된 상태로 부팅하게 된다.