



Data link Layer

Data link Layer Protocols

Ethernet

- **Dix Ethernet (1977)**

- DEC(digital equipment corporation)

- Intel

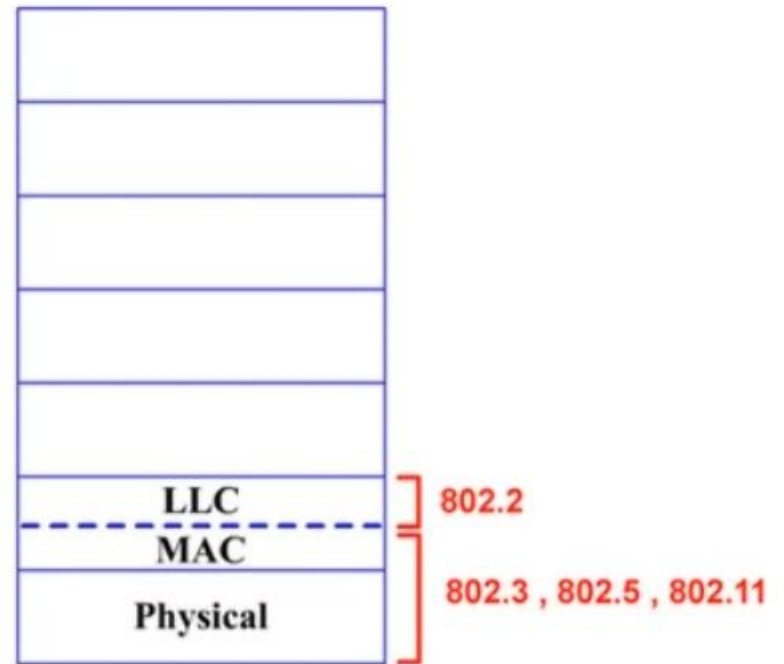
- Xerox

- **IEEE 802.3**

Data link Layer Protocols

Data-link Layer Sub layers

- Logical Link Control (LLC)
- Media Access Control (MAC)

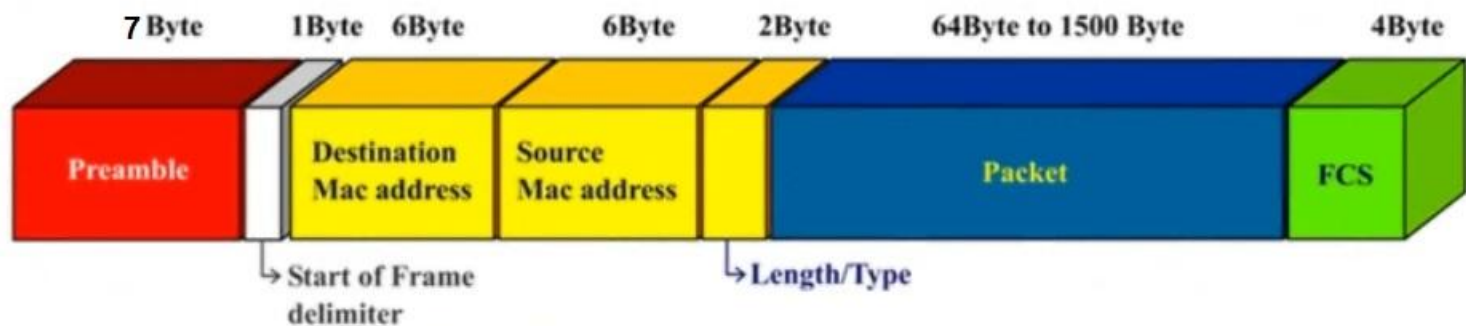


Data link Layer Protocols

Most common types of Ethernet

Common Name	Speed	Alternative Name	Name of IEEE Standard	Cable Type, Maximum Length
Ethernet	10 Mbps	10BASE-T	IEEE 802.3	Copper, 100 m
Fast Ethernet	100 Mbps	100BASE-TX	IEEE 802.3u	Copper, 100 m
Gigabit Ethernet	1000 Mbps	1000BASE-LX, 1000BASE-SX	IEEE 802.3z	Fiber, 550 m (SX) 5 km (LX)
Gigabit Ethernet	1000 Mbps	1000BASE-T	IEEE 802.3ab	100 m

Data link Layer Protocols



- **Preamble:** 8 bytes of ones and zeros to synchronize the clock
- **Start of frame delimiter:** 6 bits of zeros then 2 bits of ones
- **Destination mac address**
- **Source mac address**
- **Type / length**
- **FCS (Frame Check Sequence):** CRC (Cycle redundancy check)

Data link Layer Protocols

Logical Link Control (LLC)

IEEE 802.3 (Original)

Preamble 7	SFD 1	Destination 6	Source 6	Length 2	Data and Pad 46 – 1500	FCS 4
---------------	----------	------------------	-------------	-------------	---------------------------	----------

Destination Address 6	Source Address 6	Length 2	802.2 Header 46-1500	DATA 46-1500	FCS 4
-----------------------------	------------------------	-------------	----------------------------	-----------------	----------

IEEE 802.3 (Revised 1997)

Preamble 7	SFD 1	Destination 6	Source 6	Length/ Type 2	Data and Pad 46 – 1500	FCS 4
---------------	----------	------------------	-------------	-------------------	---------------------------	----------

Type/Length < hex 0600 (decimal 1536) then it is the **Length**.

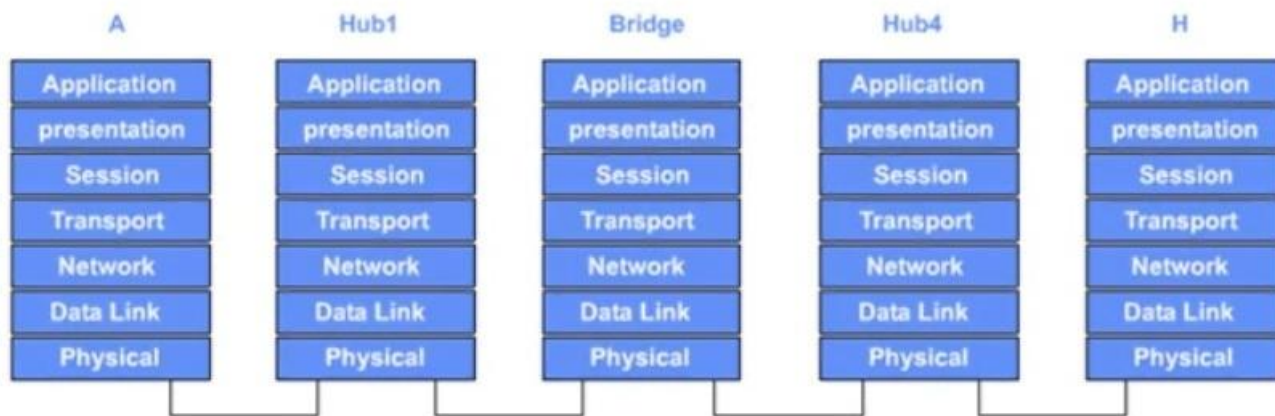
Type/Length > hex 0600 (decimal 1536) then it is the **Type**.

Data link Layer Protocols

Media Access Control (MAC)

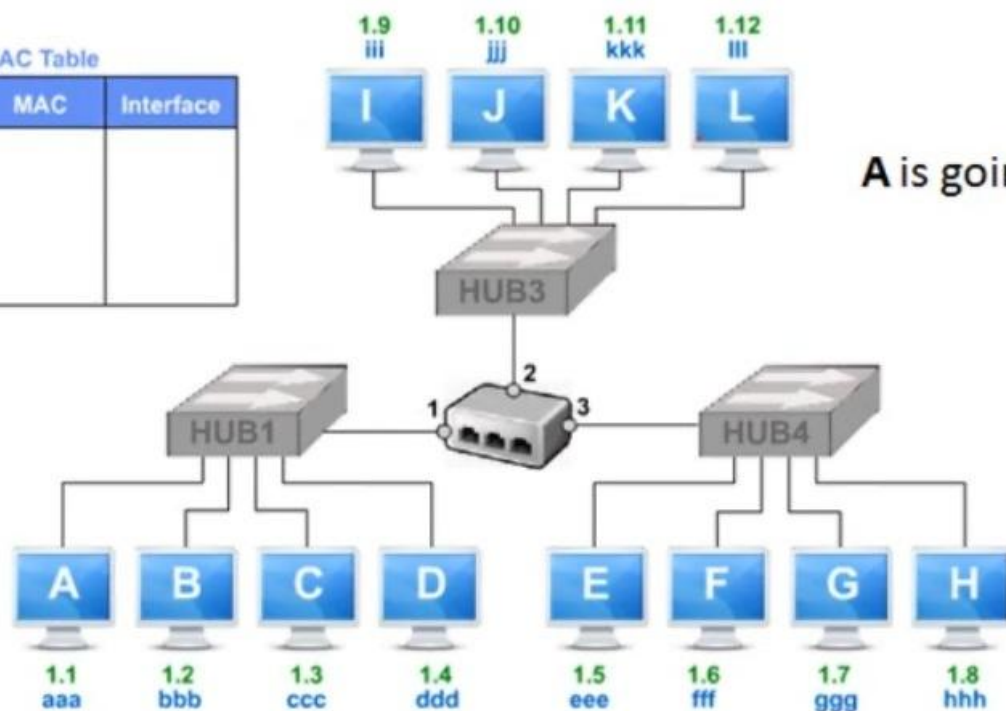
CSMA/CD (Carrier sense multiple access with collision detection)
prevent collisions and also defines how to act when a collision does occur.

Bridge operation



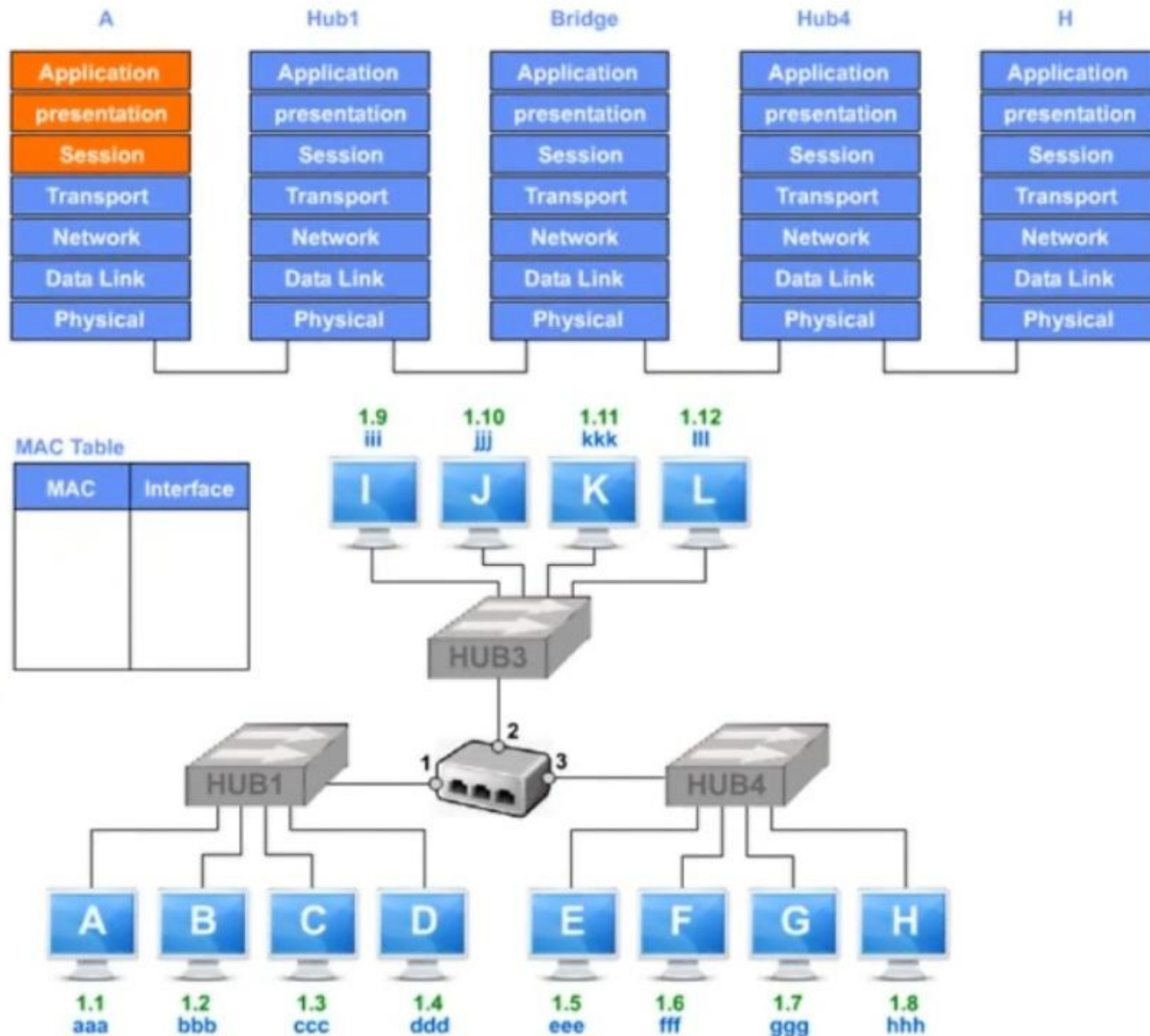
MAC Table

MAC	Interface

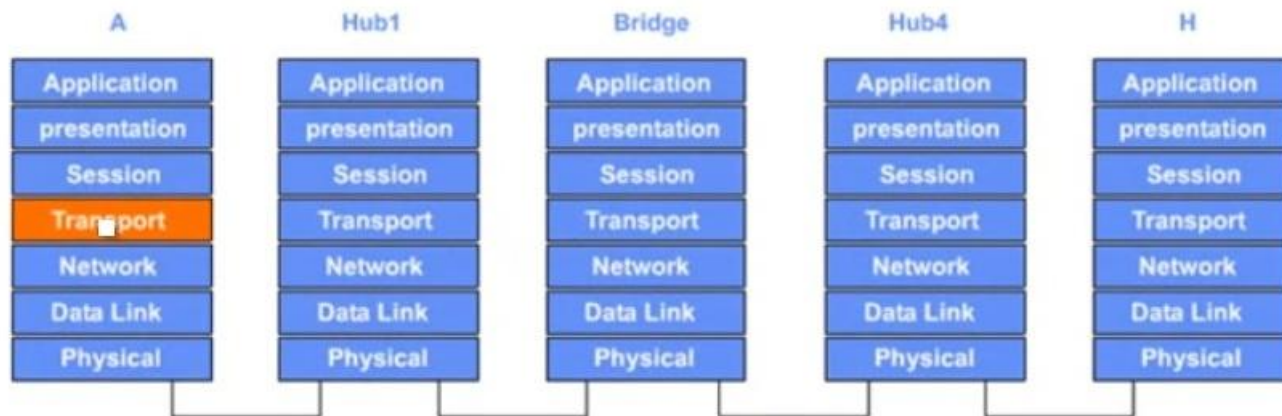


A is going to transmit data to H.

Bridge operation

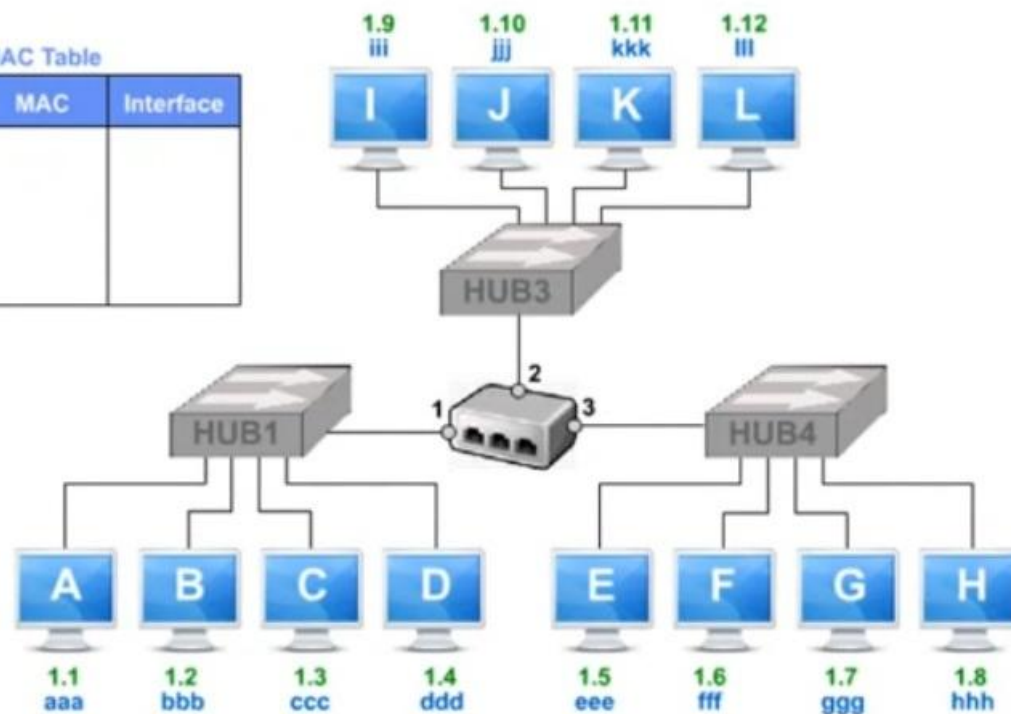


Bridge operation

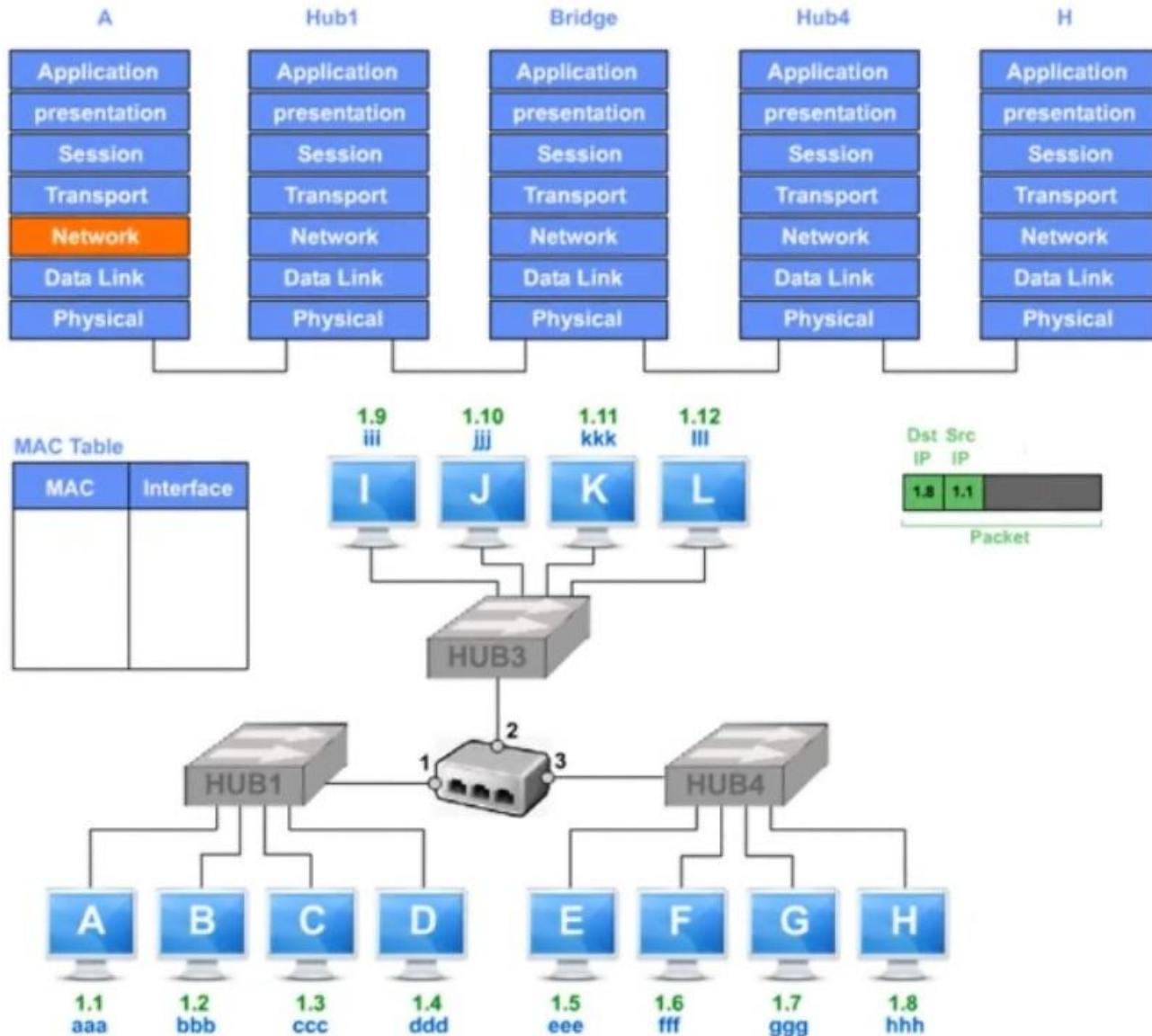


MAC Table

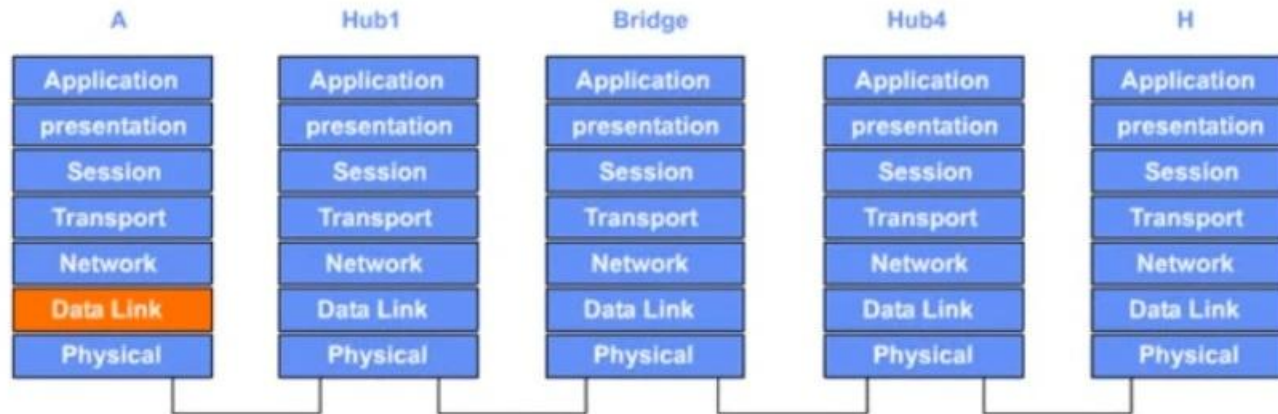
MAC	Interface



Bridge operation

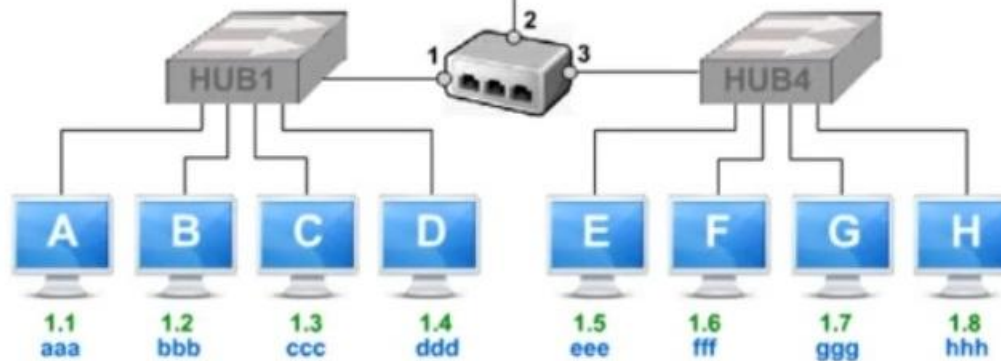


Bridge operation

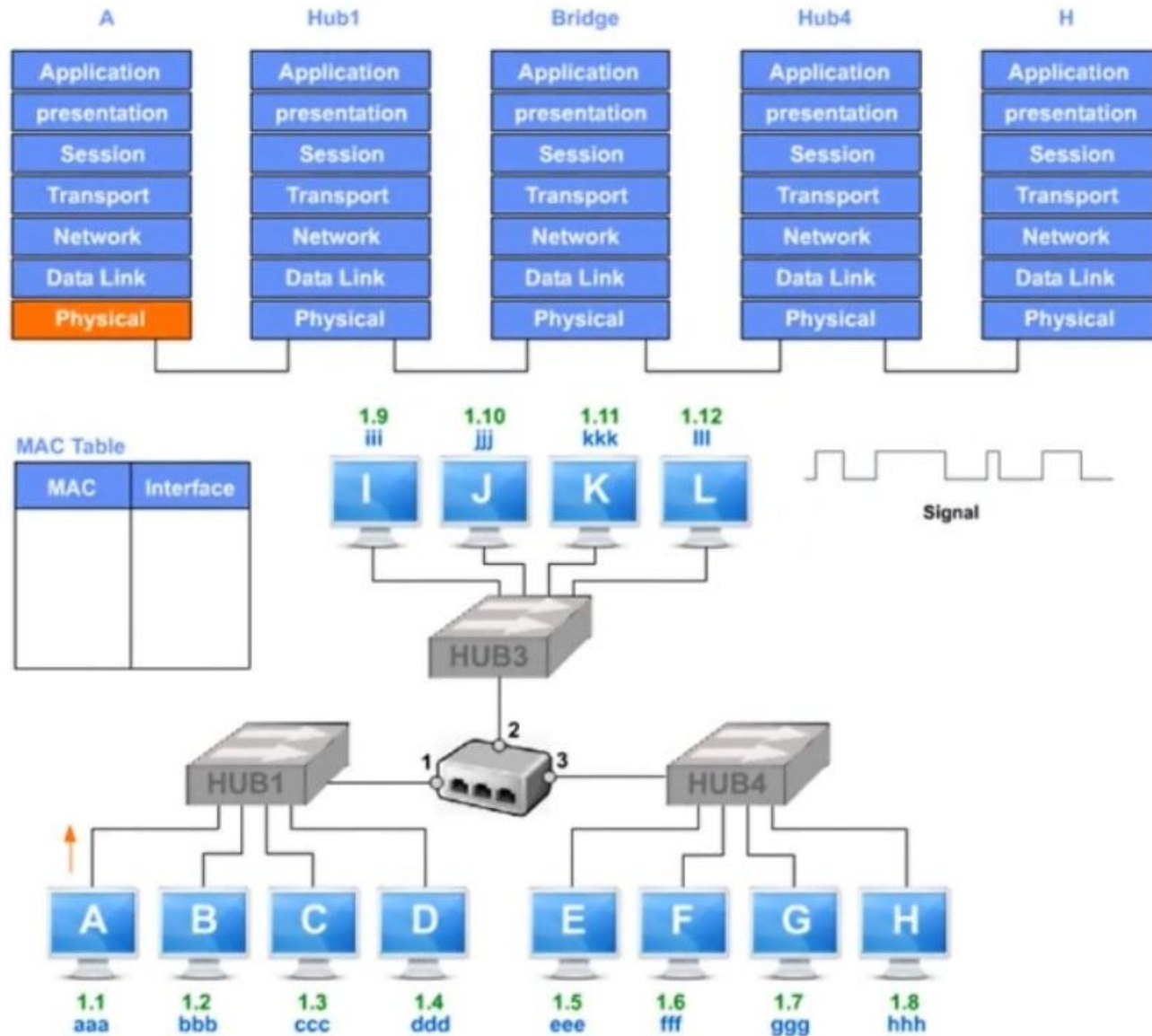


MAC Table

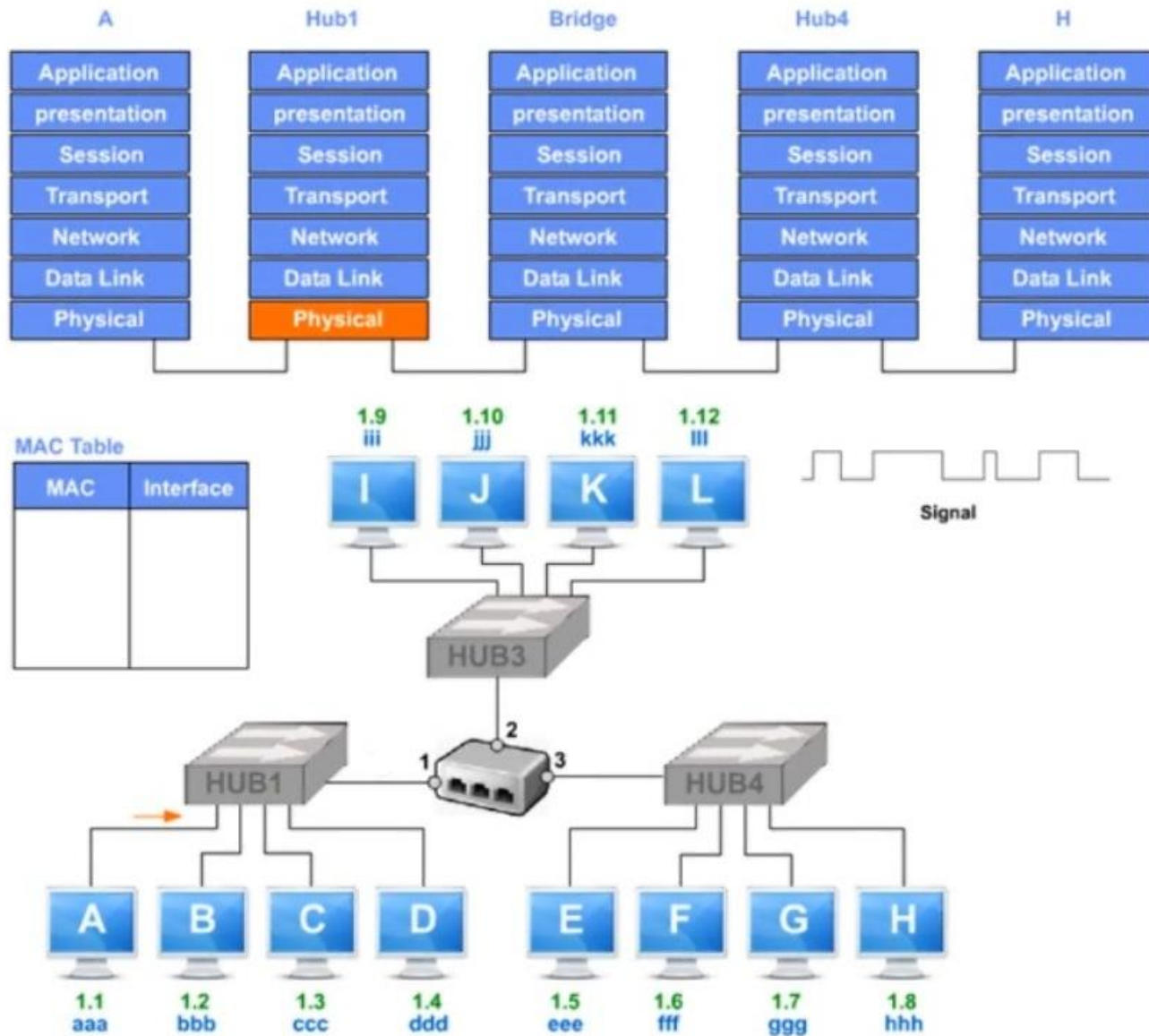
MAC	Interface



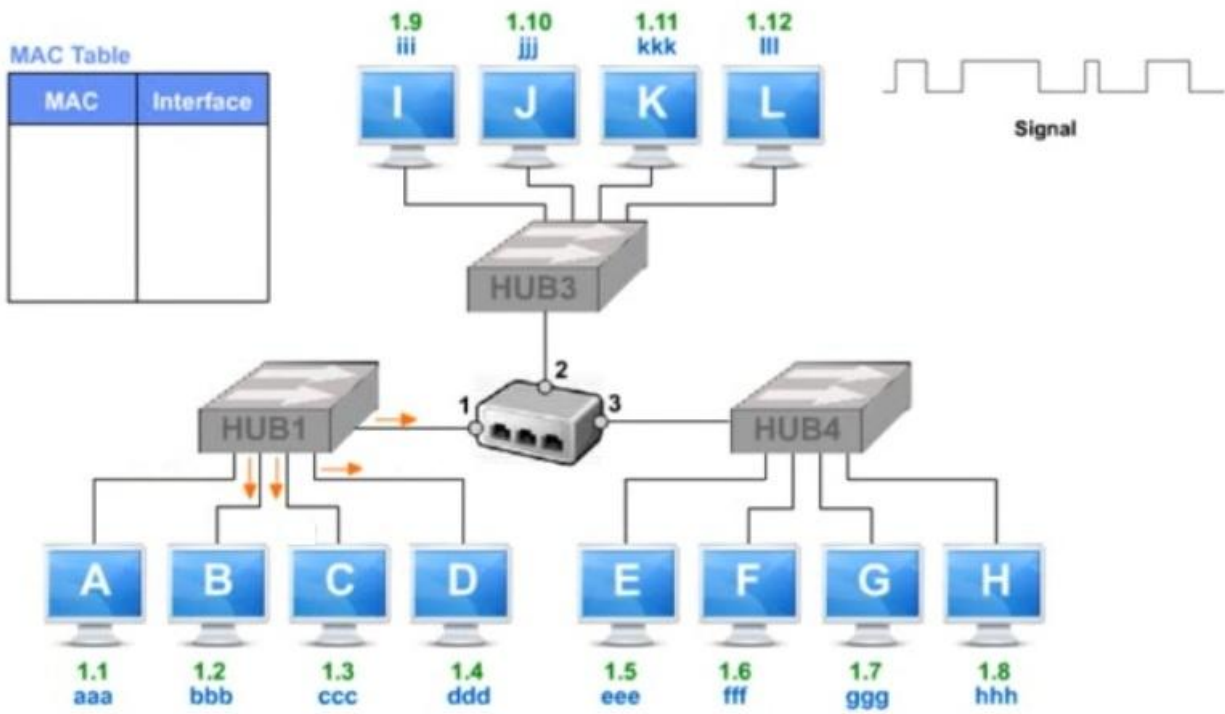
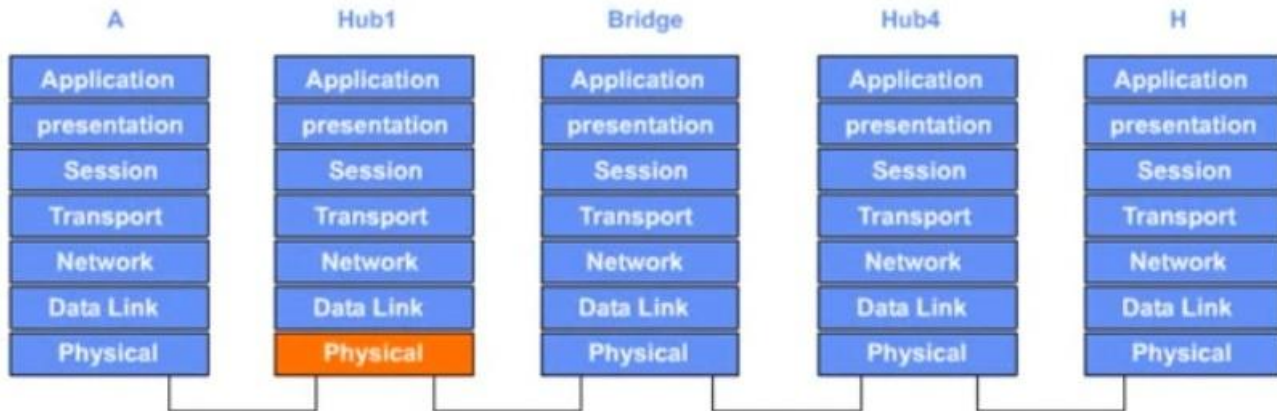
Bridge operation



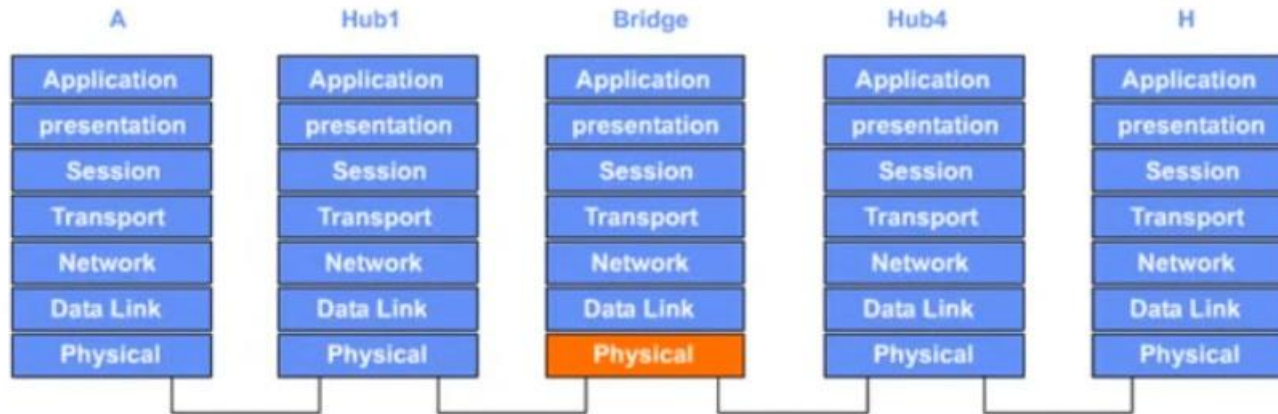
Bridge operation



Bridge operation

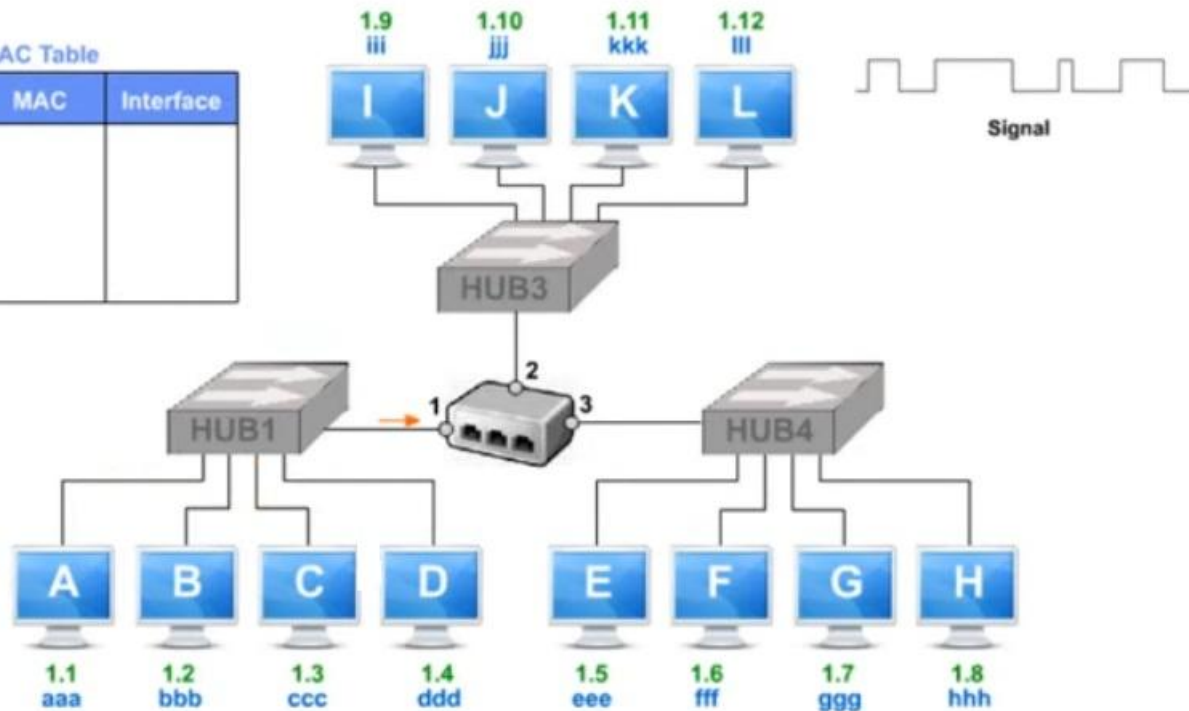


Bridge operation

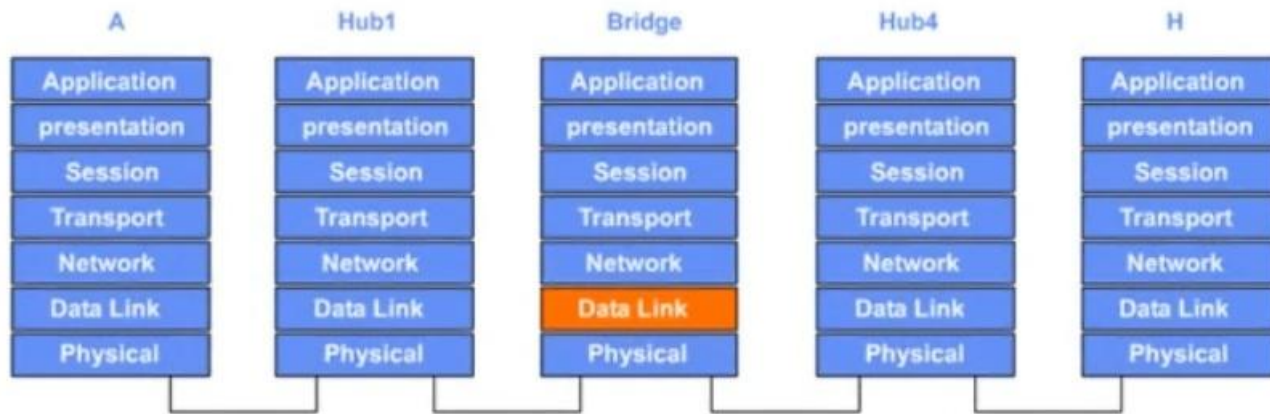


MAC Table

MAC	Interface

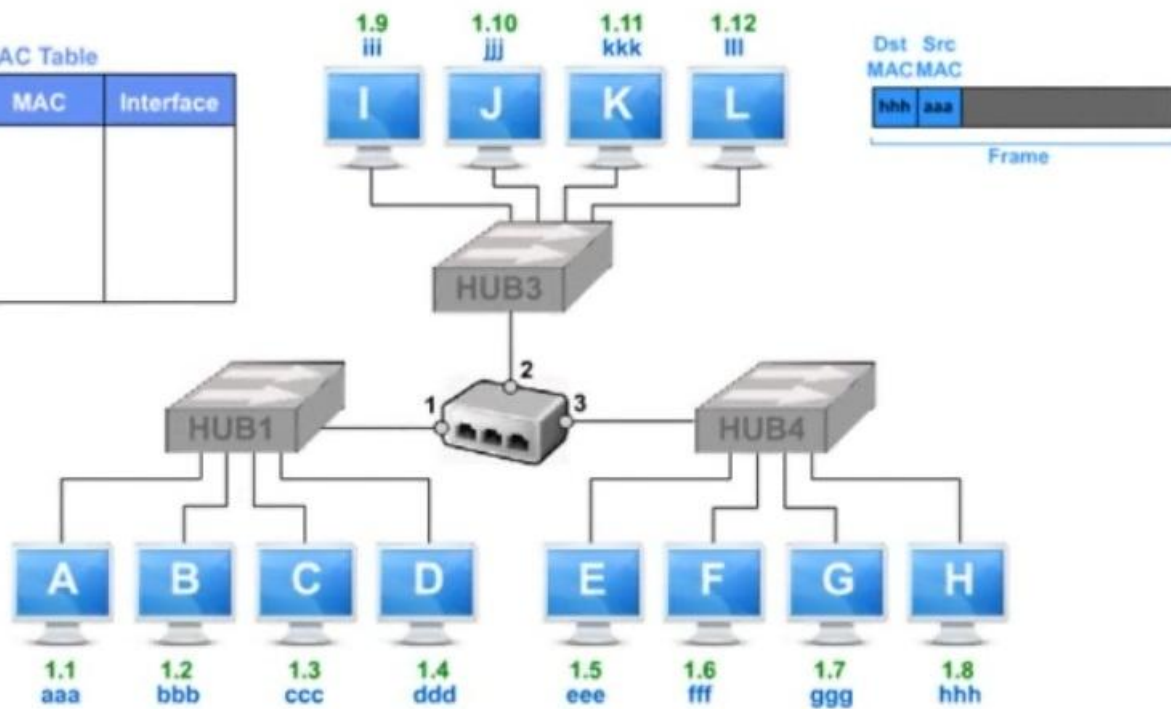


Bridge operation

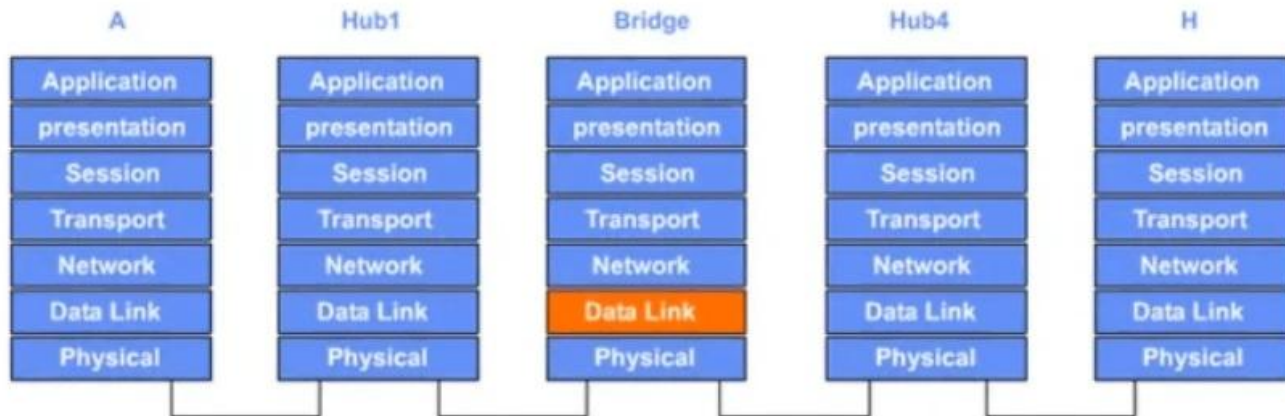


MAC Table

MAC	Interface

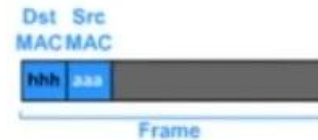
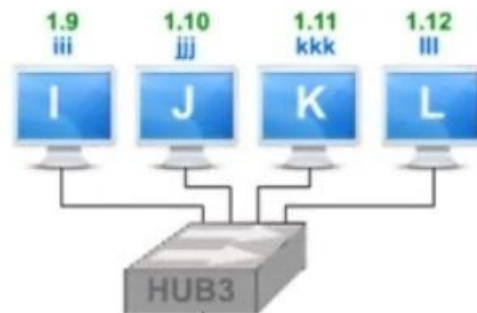


Bridge operation

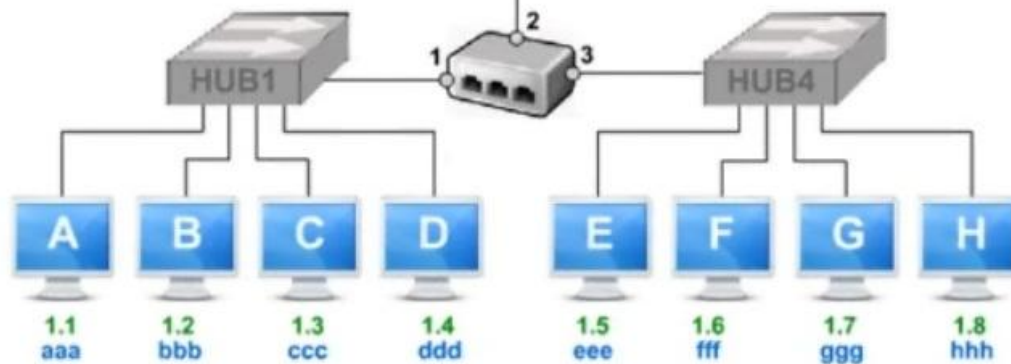


MAC Table

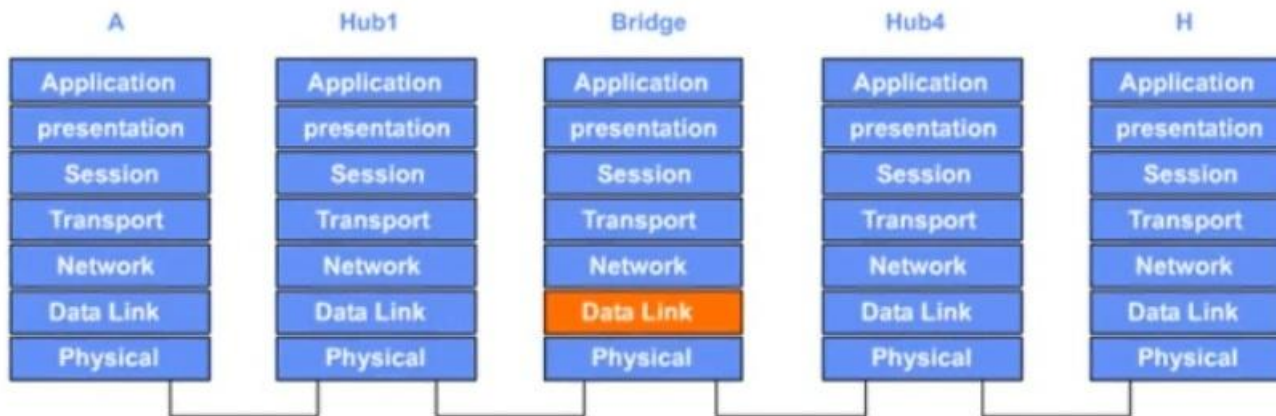
MAC	Interface
aaa	1



1. Learning (Src MAC)

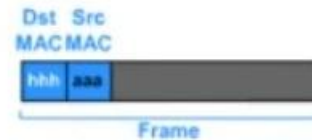


Bridge operation



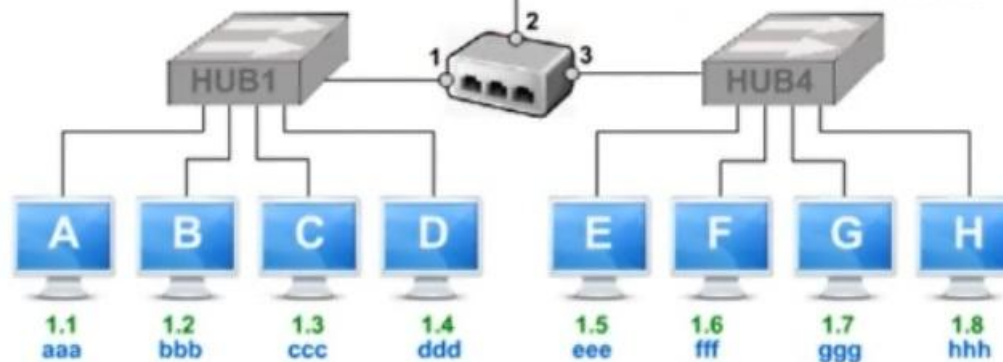
MAC Table

MAC	Interface
aaa	1

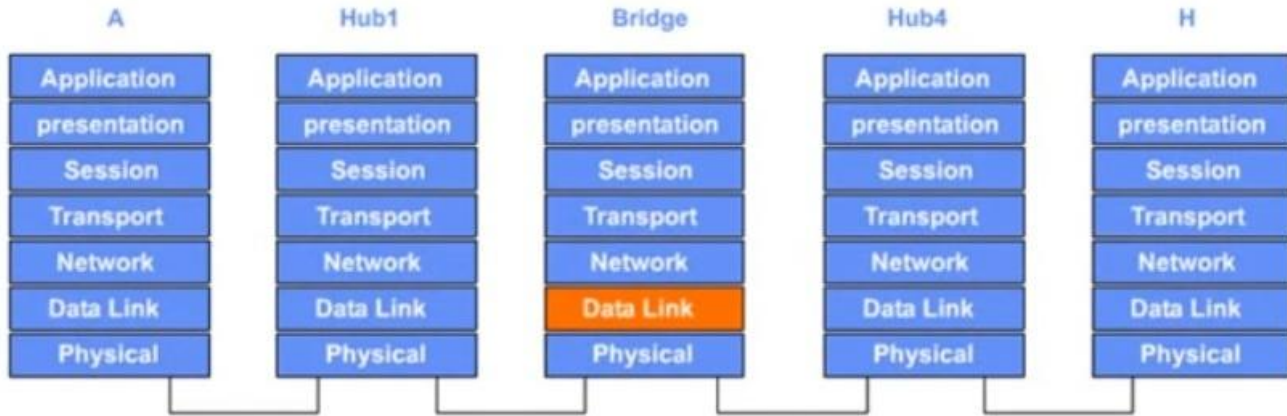


2. Forwarding (Dst MAC)

Unicast
Unknown Unicast
Broadcast

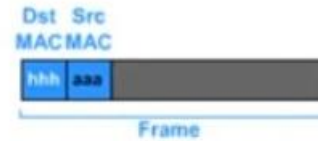


Bridge operation



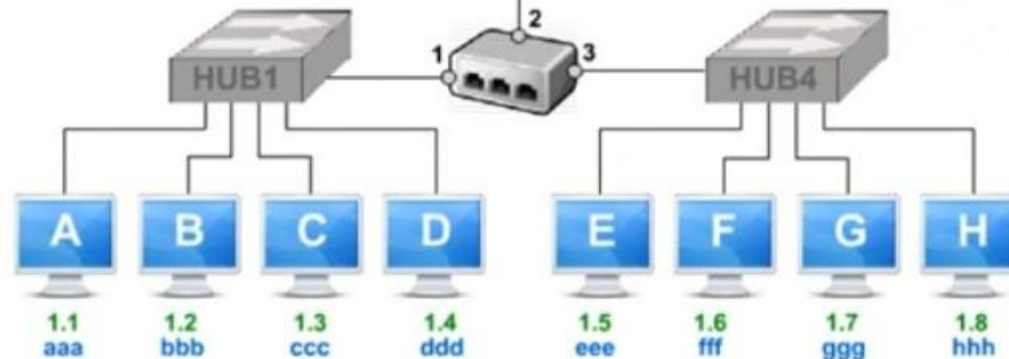
MAC Table

MAC	Interface
aaa	1

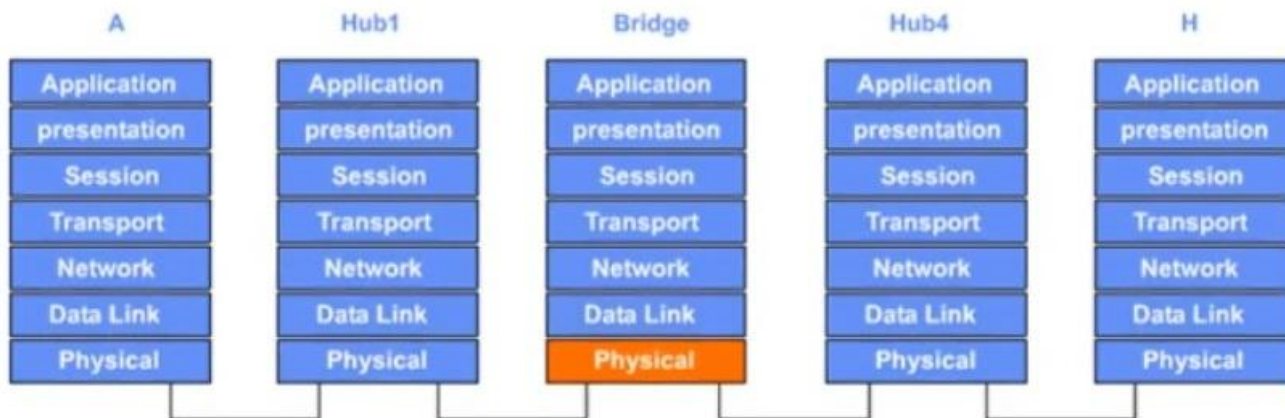


2. Forwarding (Dst MAC)

- Unicast
- Unknown Unicast**
- Broadcast

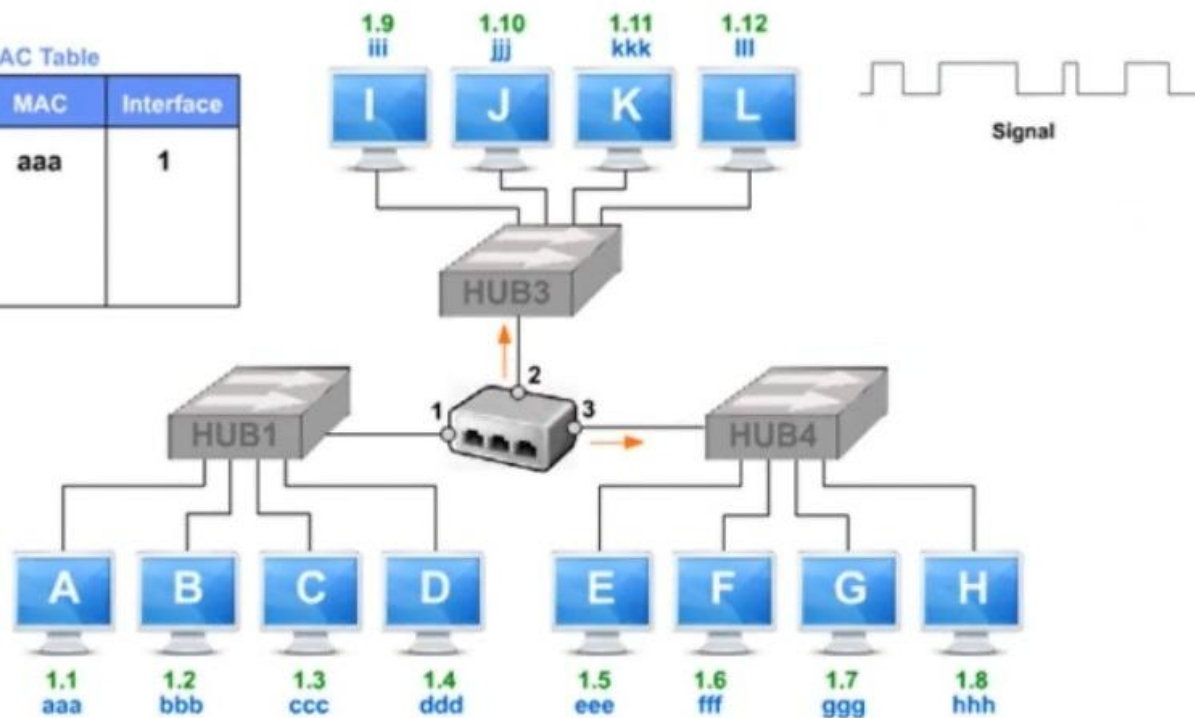


Bridge operation

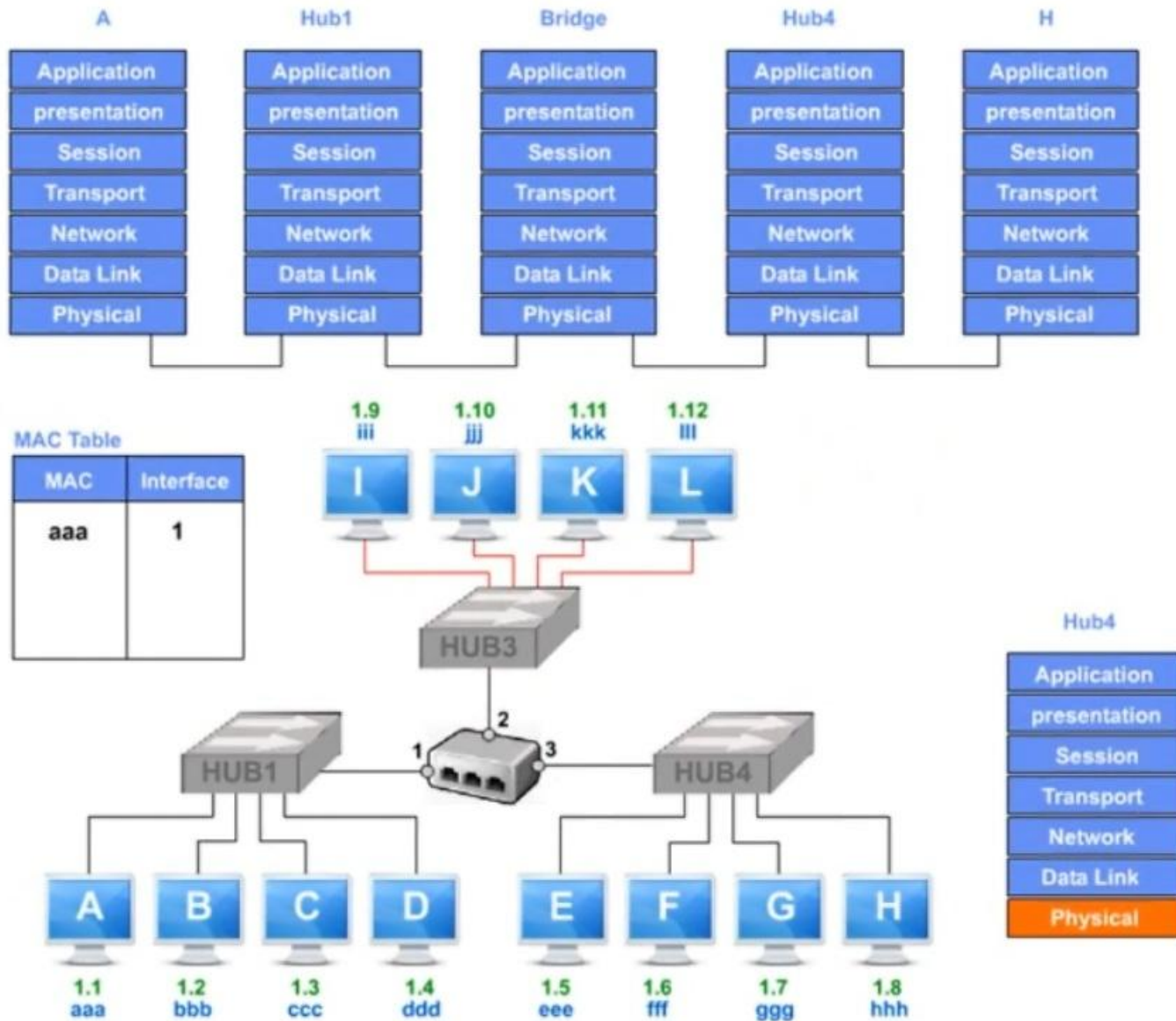


MAC Table

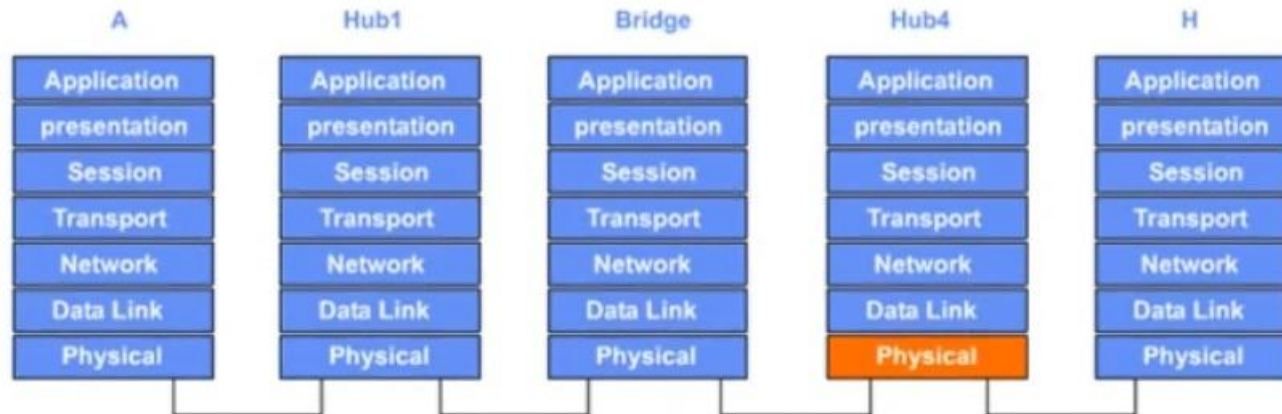
MAC	Interface
aaa	1



Bridge operation

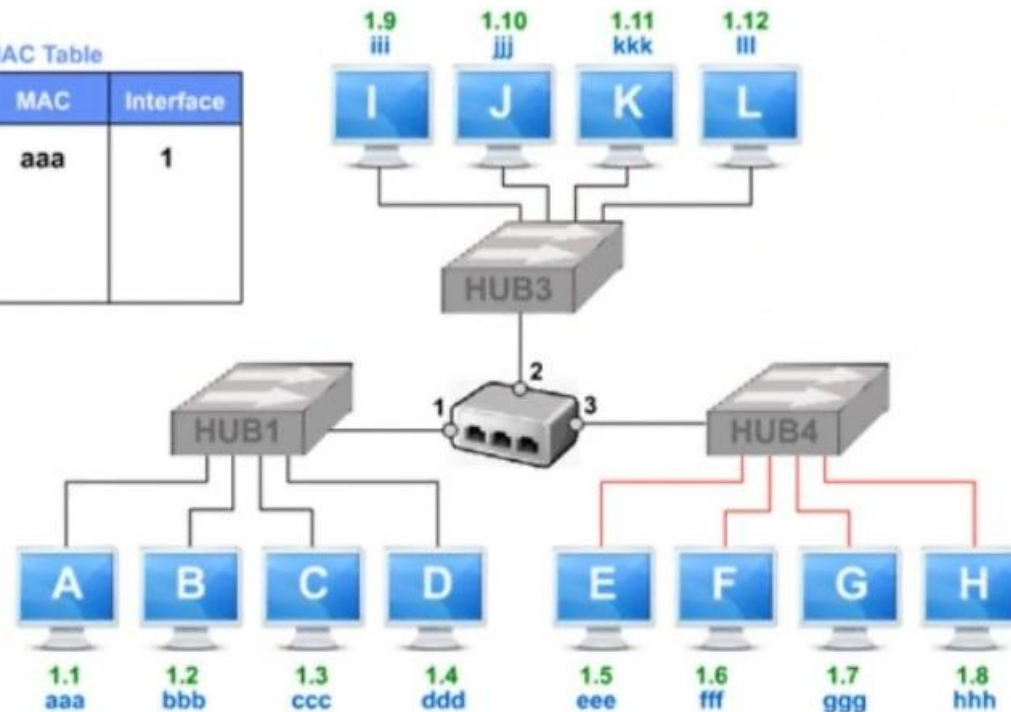


Bridge operation

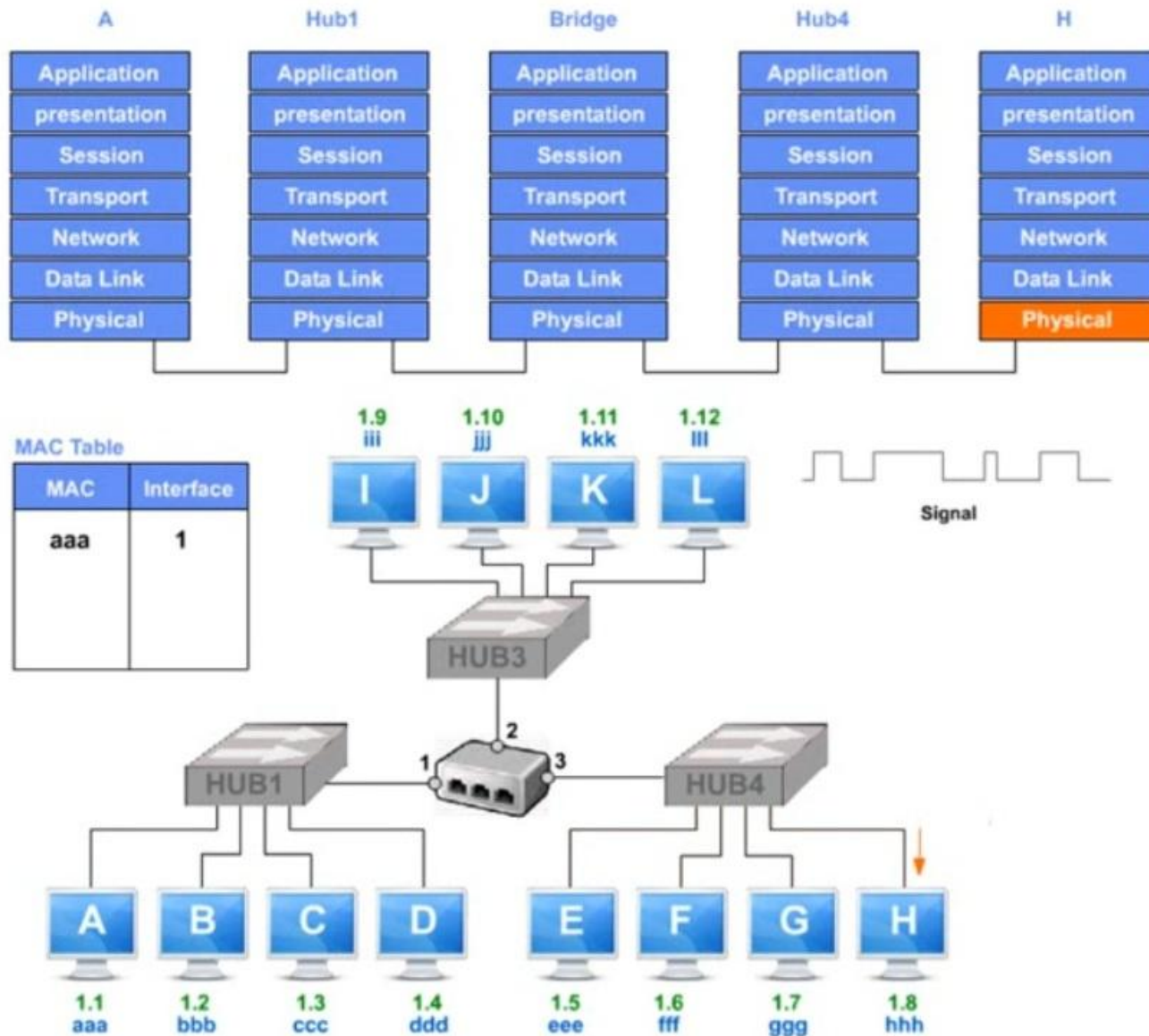


MAC Table

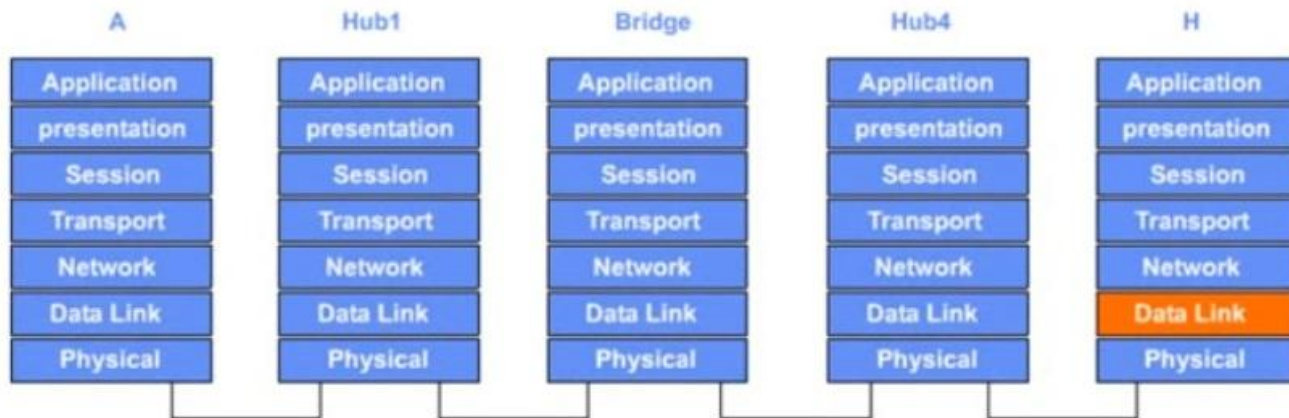
MAC	Interface
aaa	1



Bridge operation

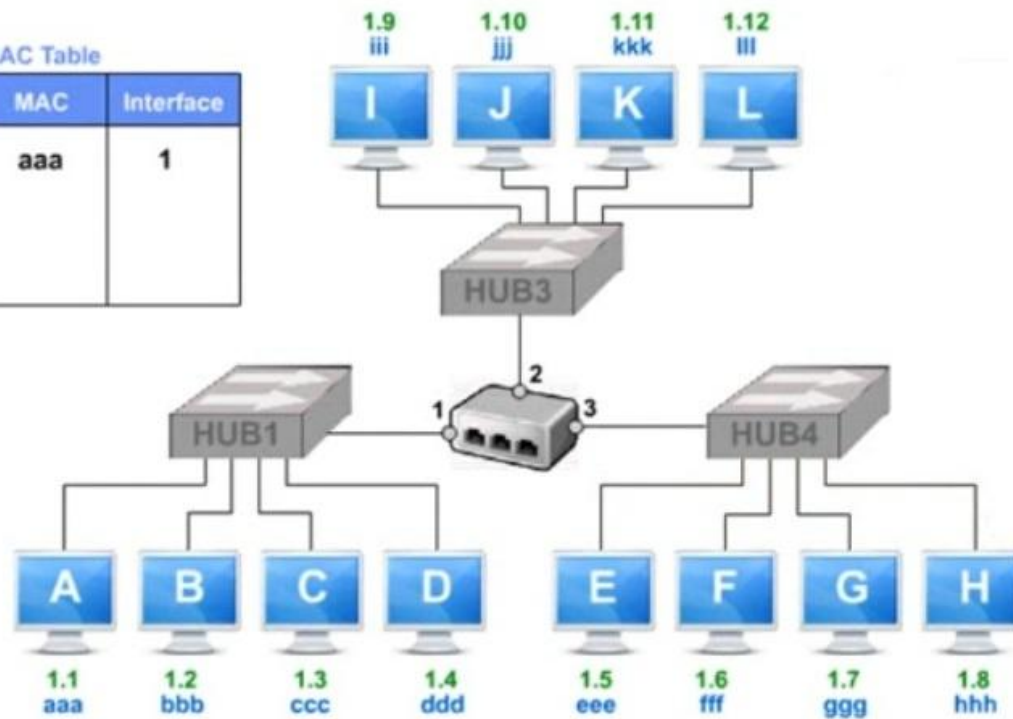


Bridge operation

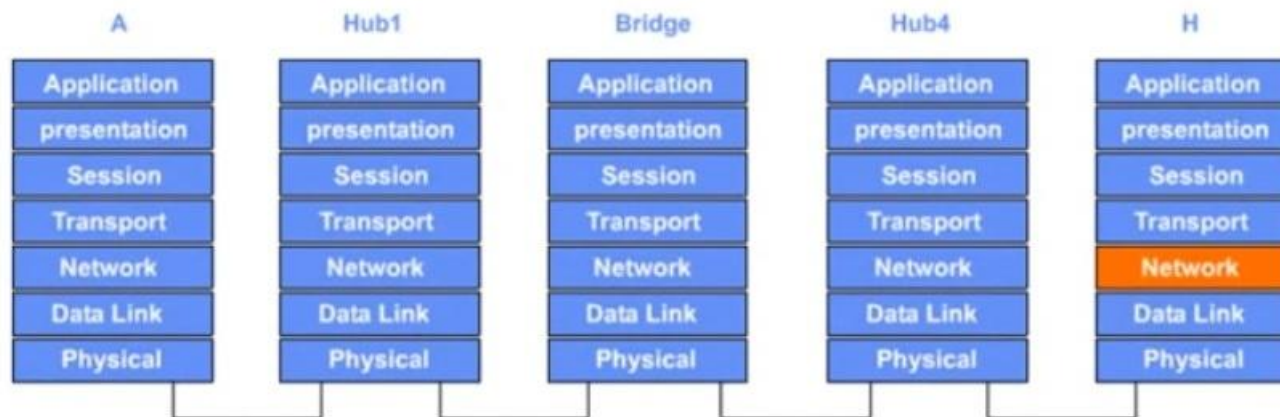


MAC Table

MAC	Interface
aaa	1

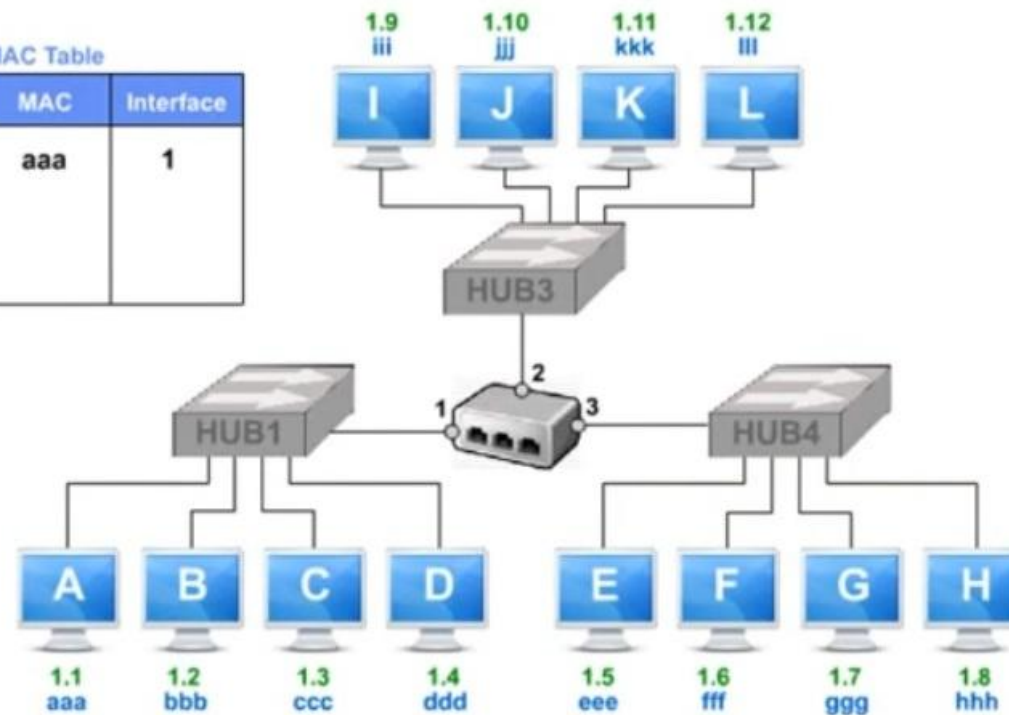


Bridge operation

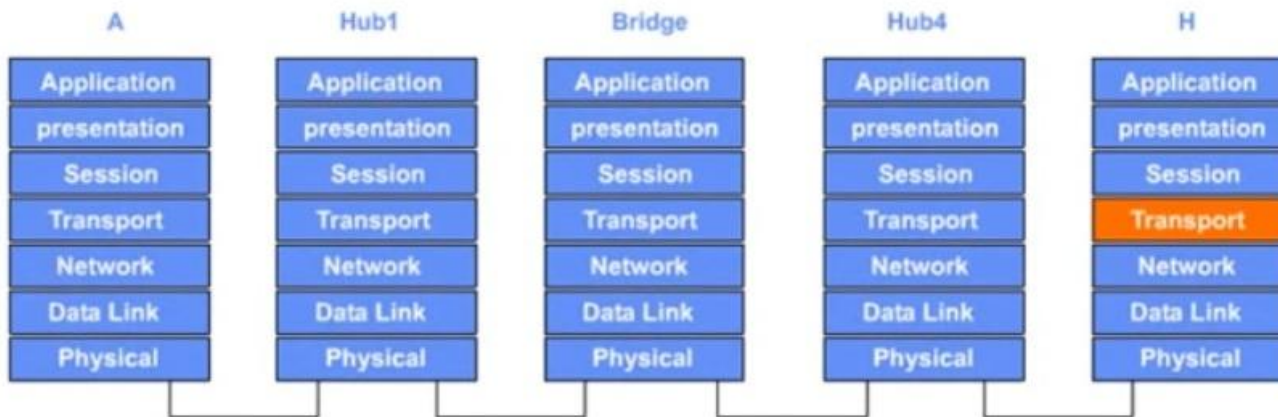


MAC Table

MAC	Interface
aaa	1

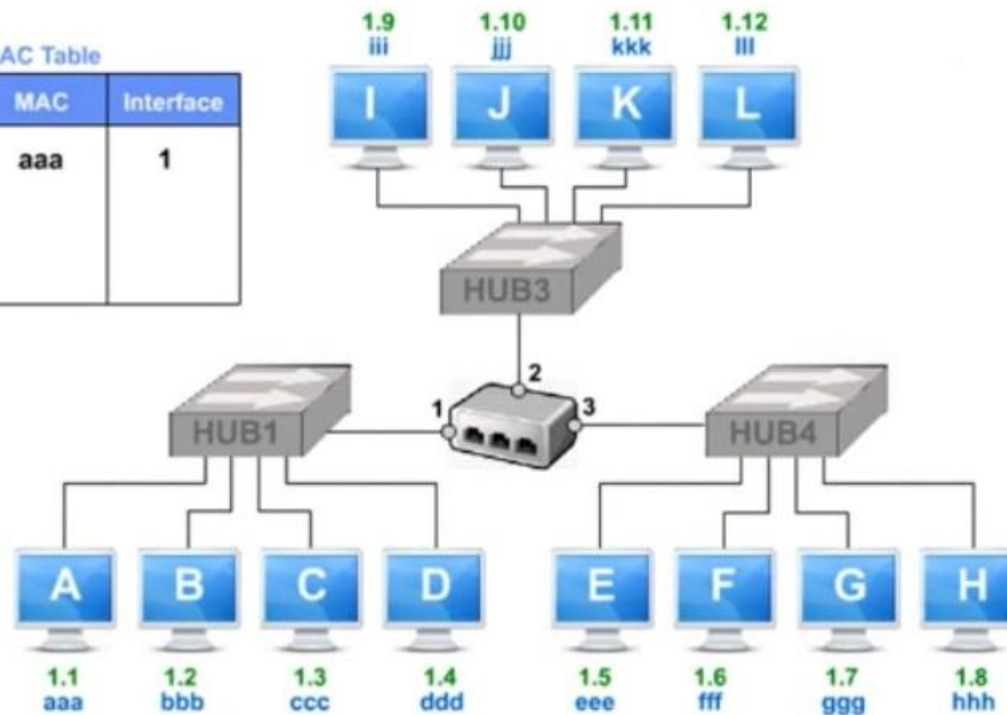


Bridge operation

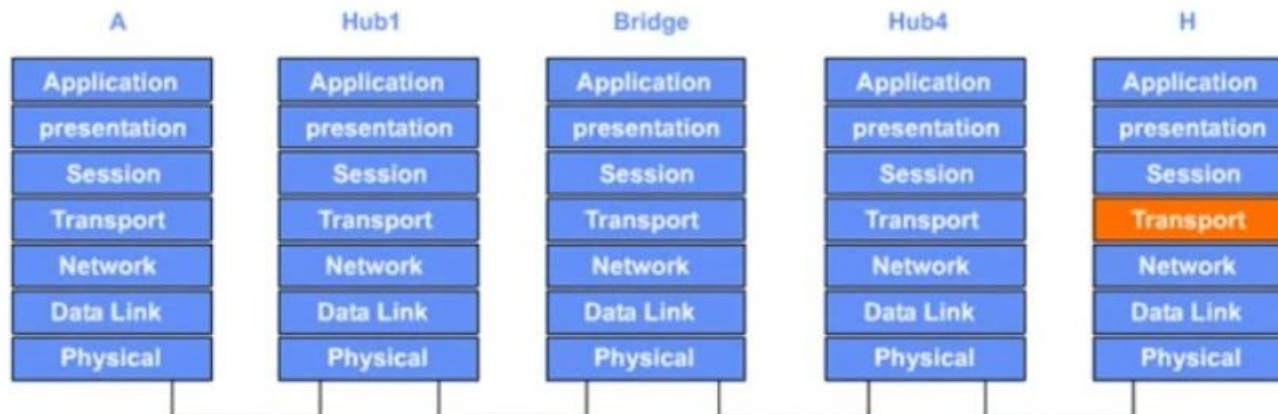


MAC Table

MAC	Interface
aaa	1

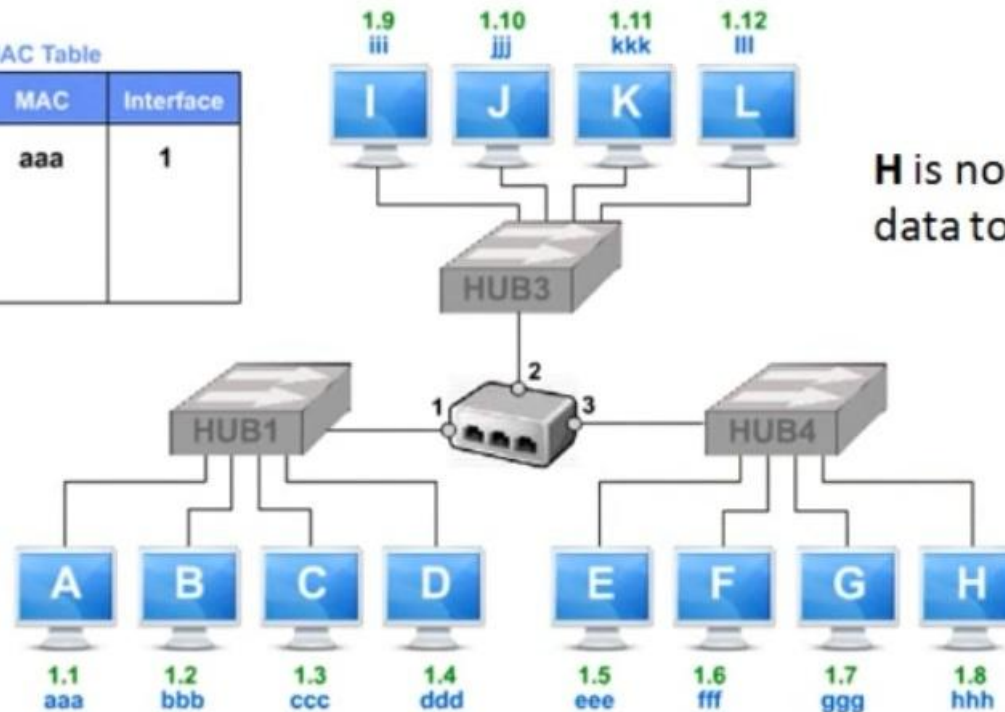


Bridge operation



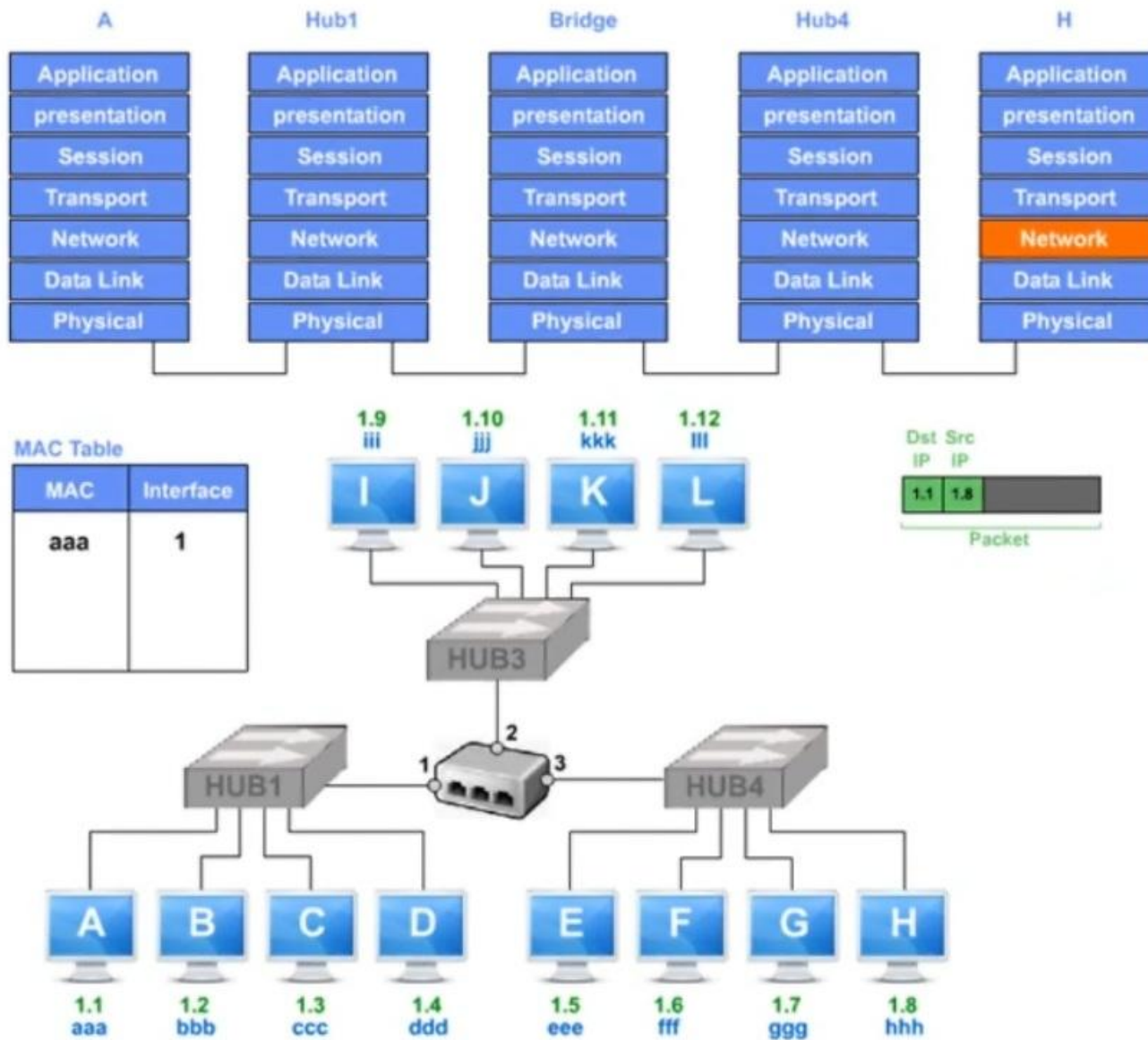
MAC Table

MAC	Interface
aaa	1

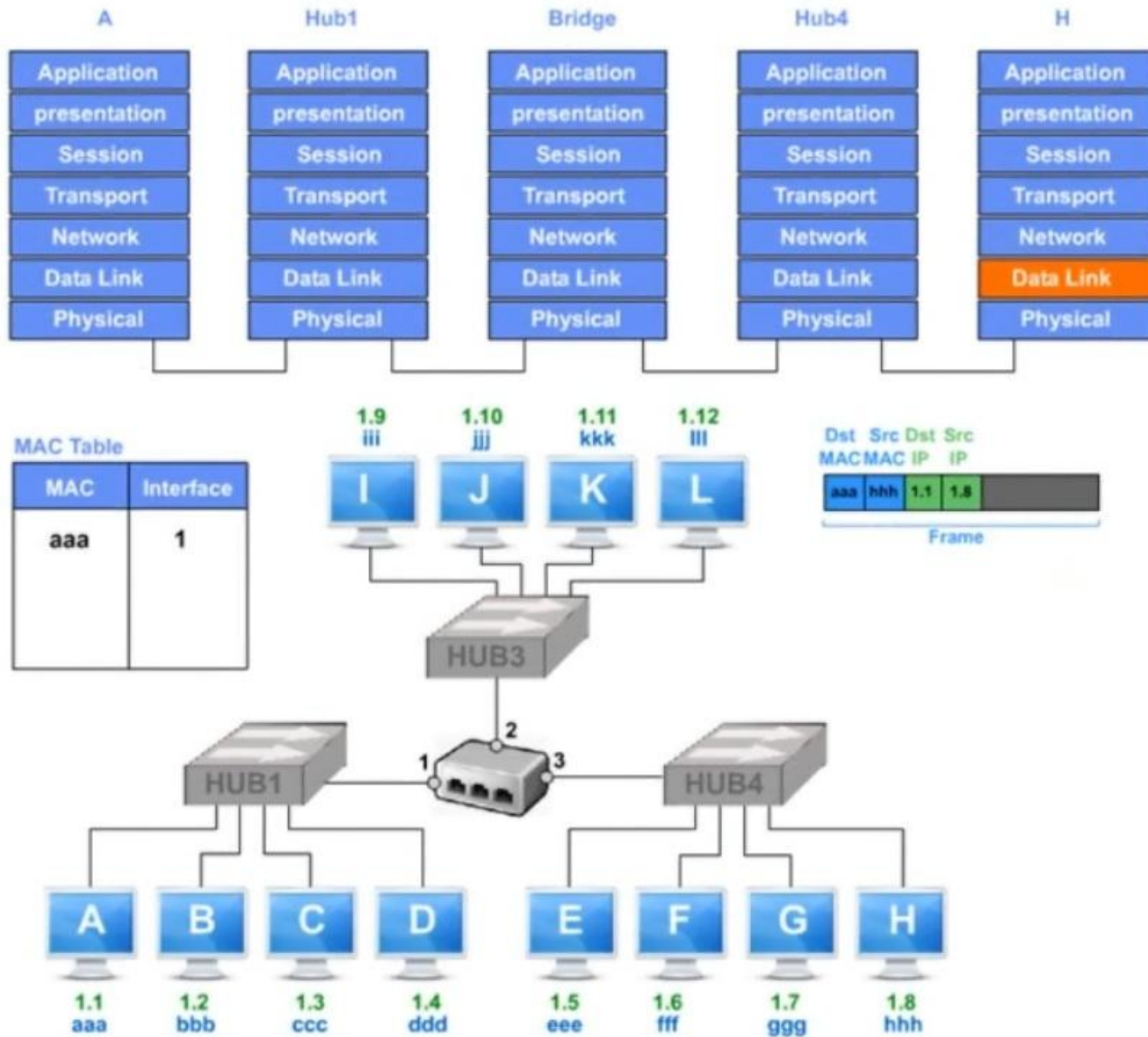


H is now going to transmit data to **A**.

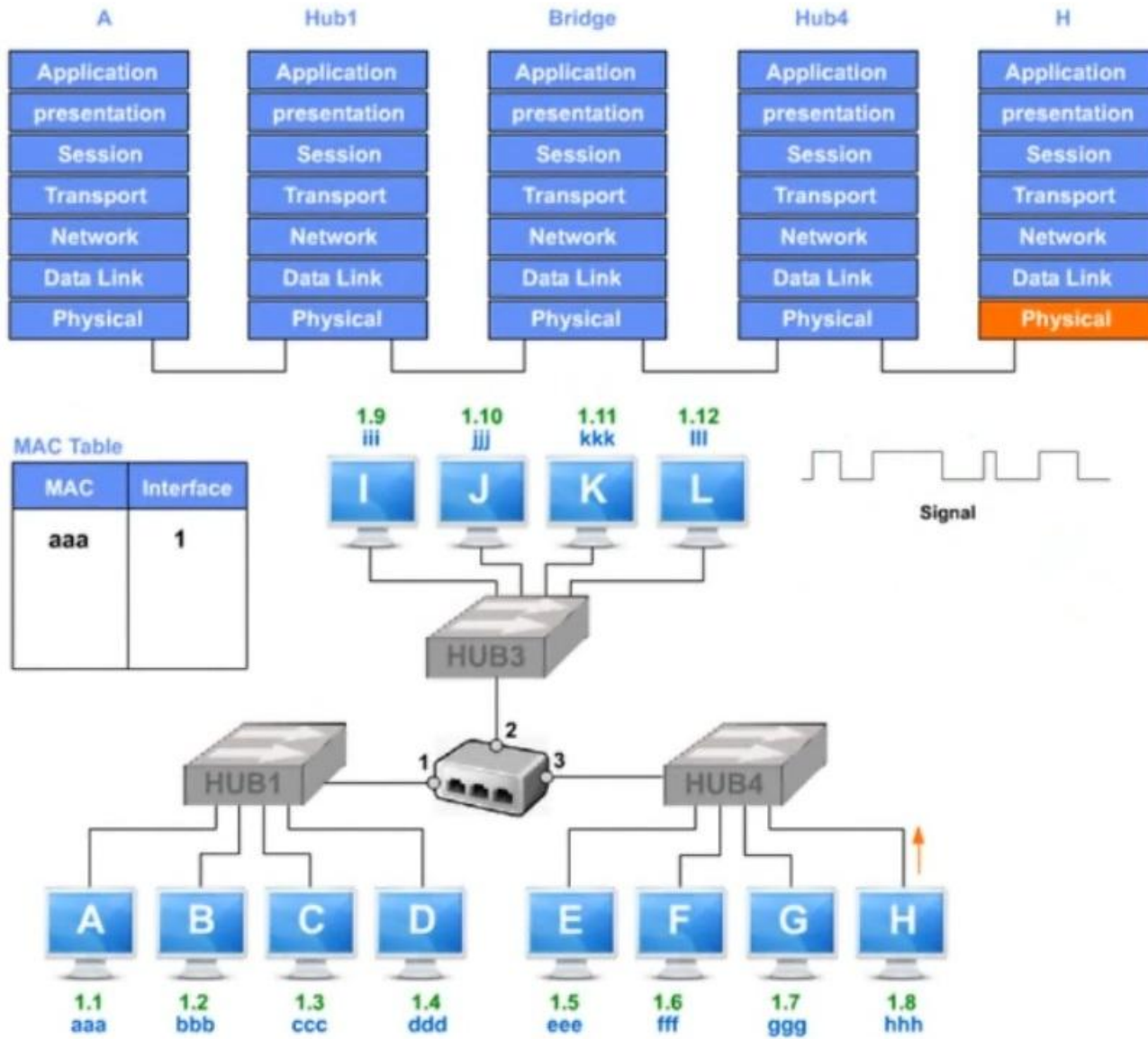
Bridge operation



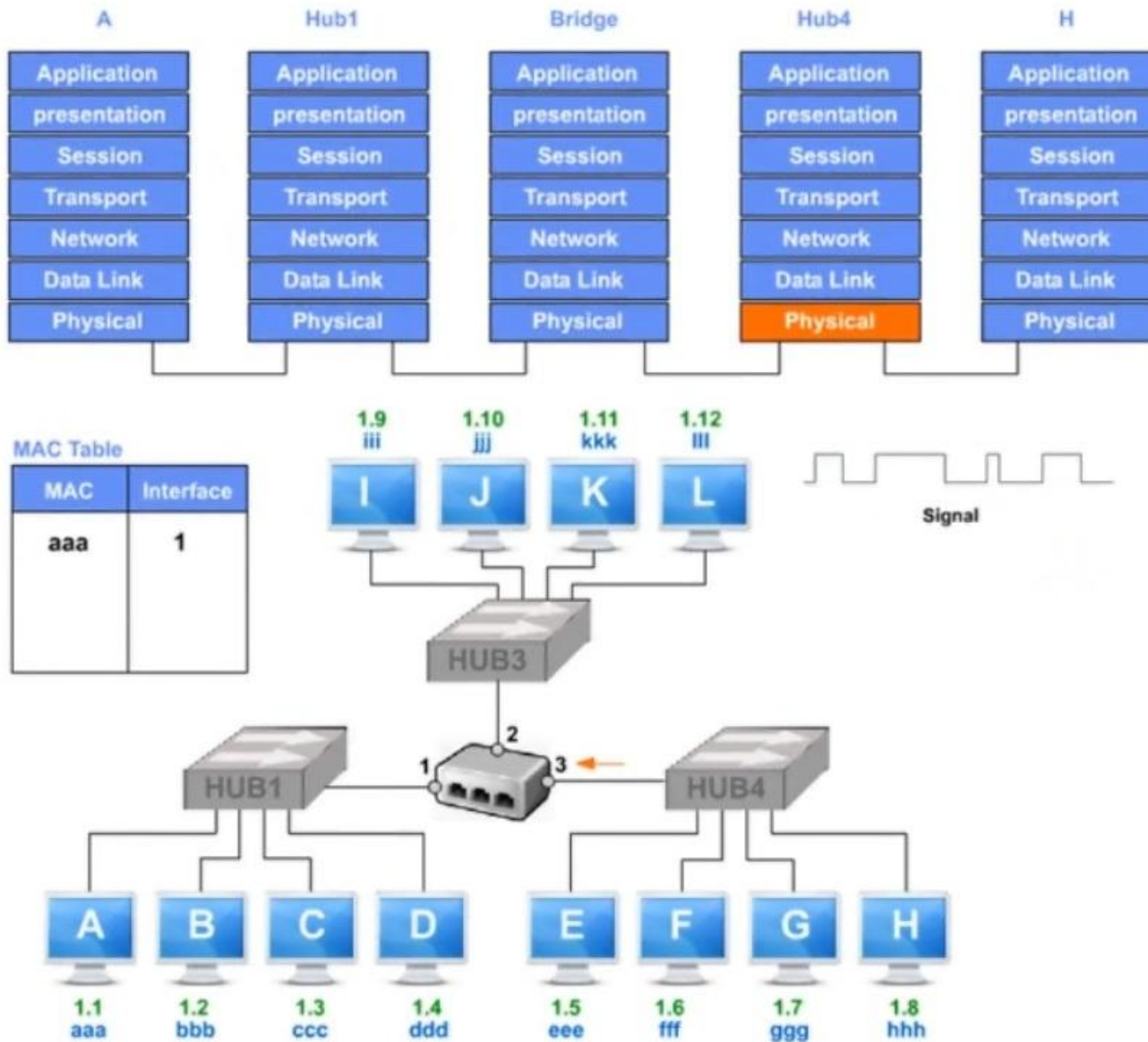
Bridge operation



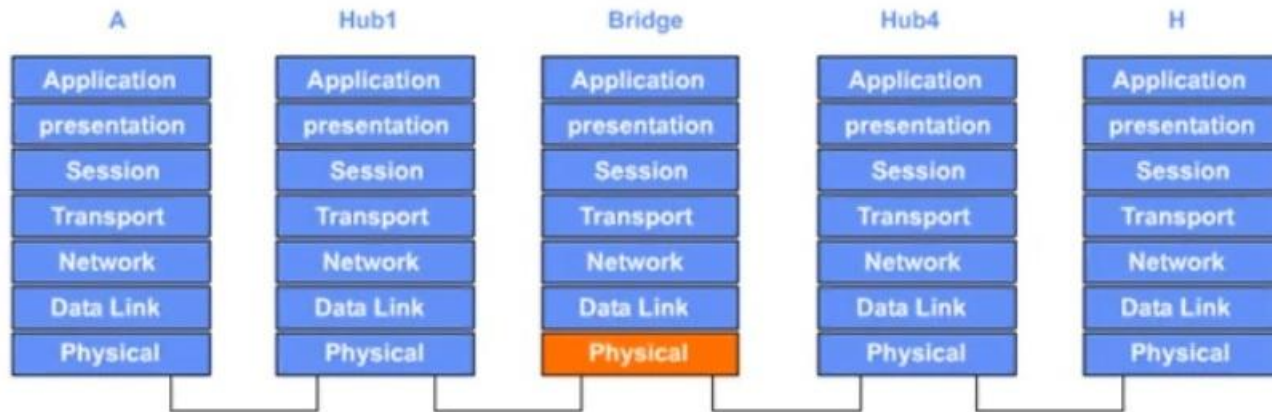
Bridge operation



Bridge operation

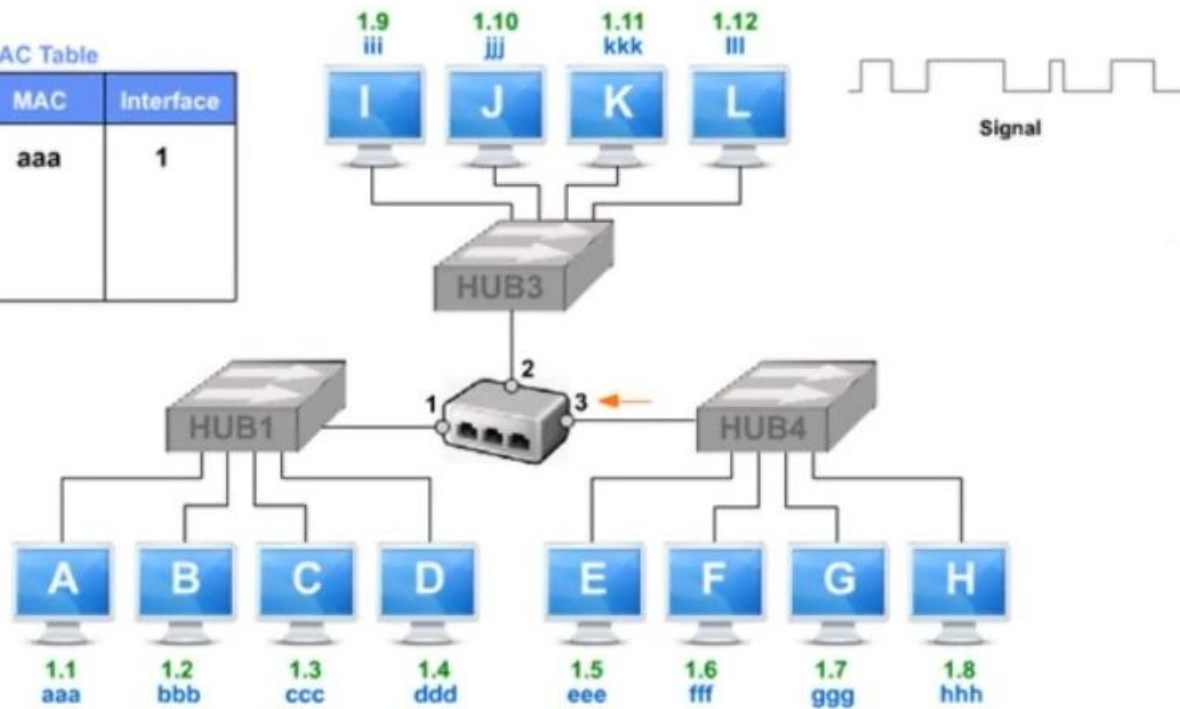


Bridge operation

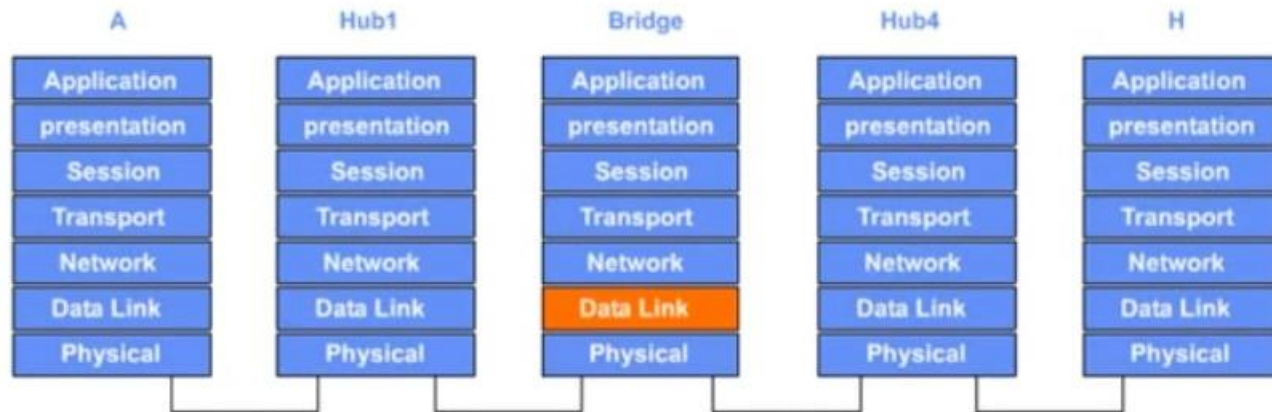


MAC Table

MAC	Interface
aaa	1

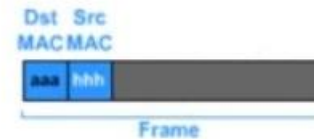
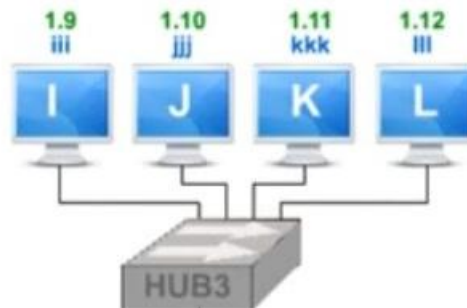


Bridge operation

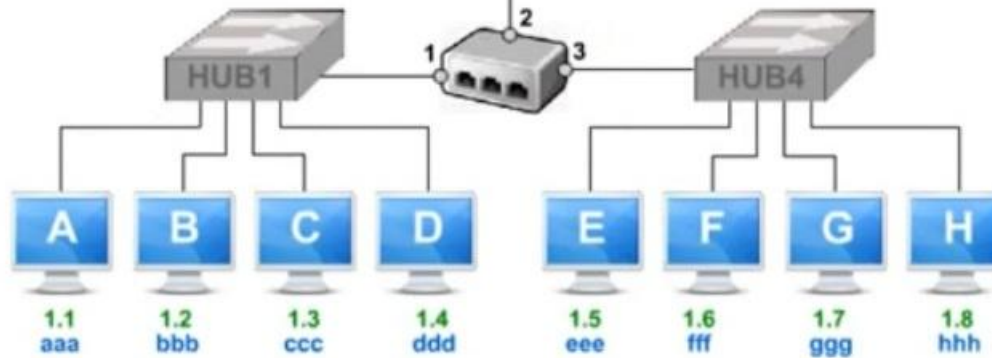


MAC Table

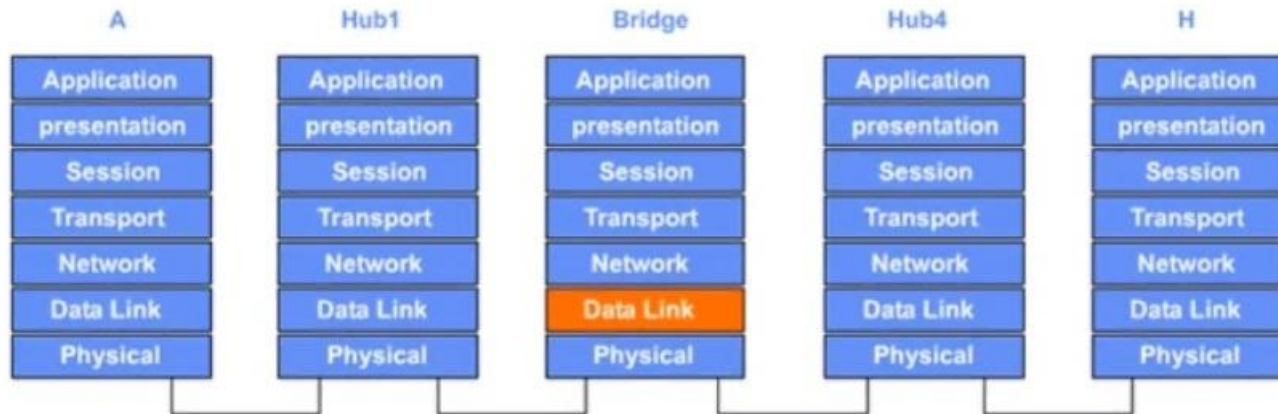
MAC	Interface
aaa	1
hhh	3



1. Learning (Src MAC)

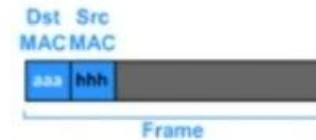


Bridge operation



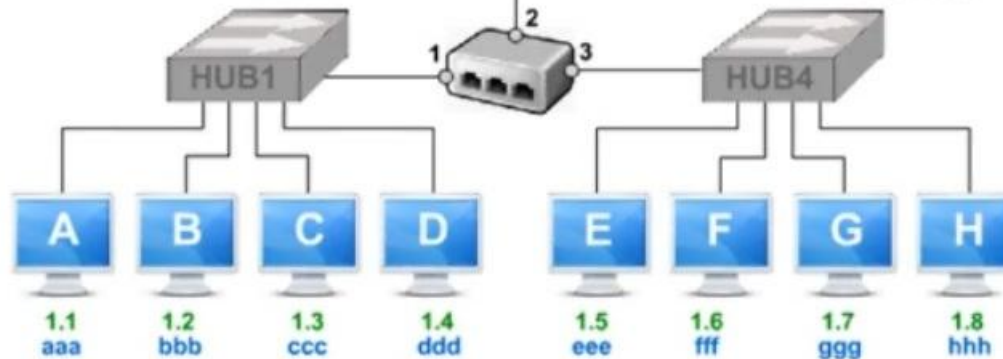
MAC Table

MAC	Interface
aaa	1
hhh	3

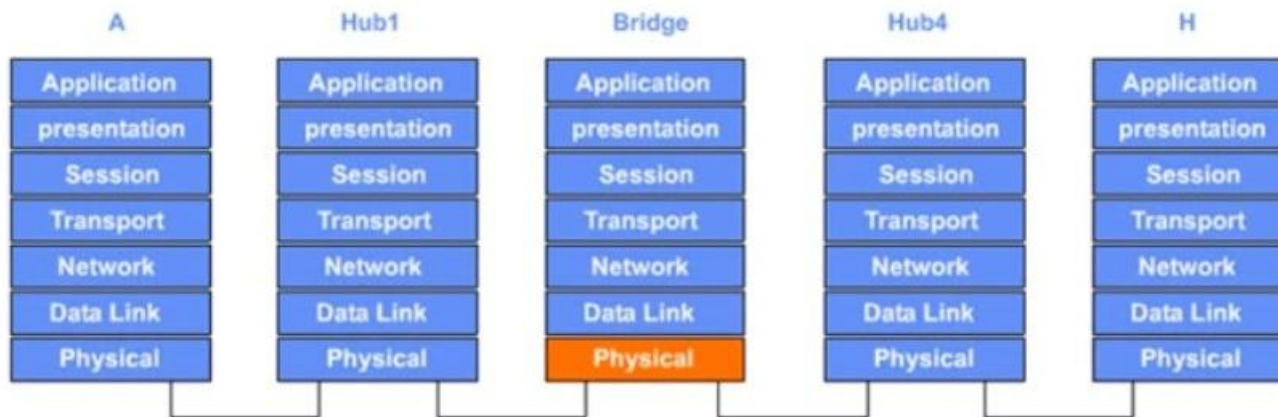


2. Forwarding (Dst MAC)

- Unicast
- Unknown Unicast
- Broadcast

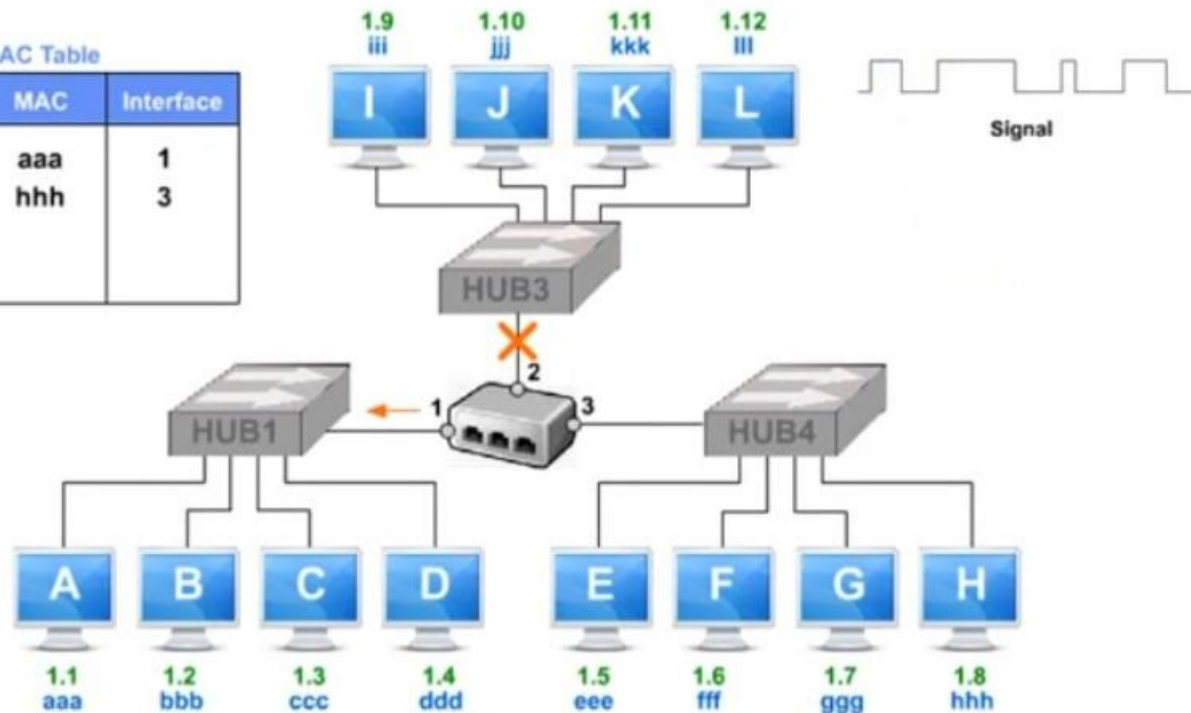


Bridge operation

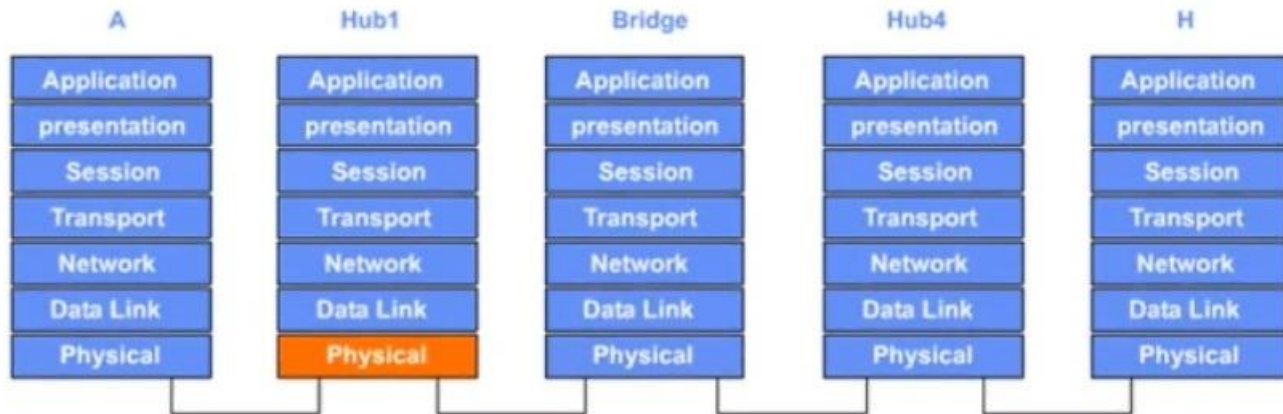


MAC Table

MAC	Interface
aaa	1
hhh	3

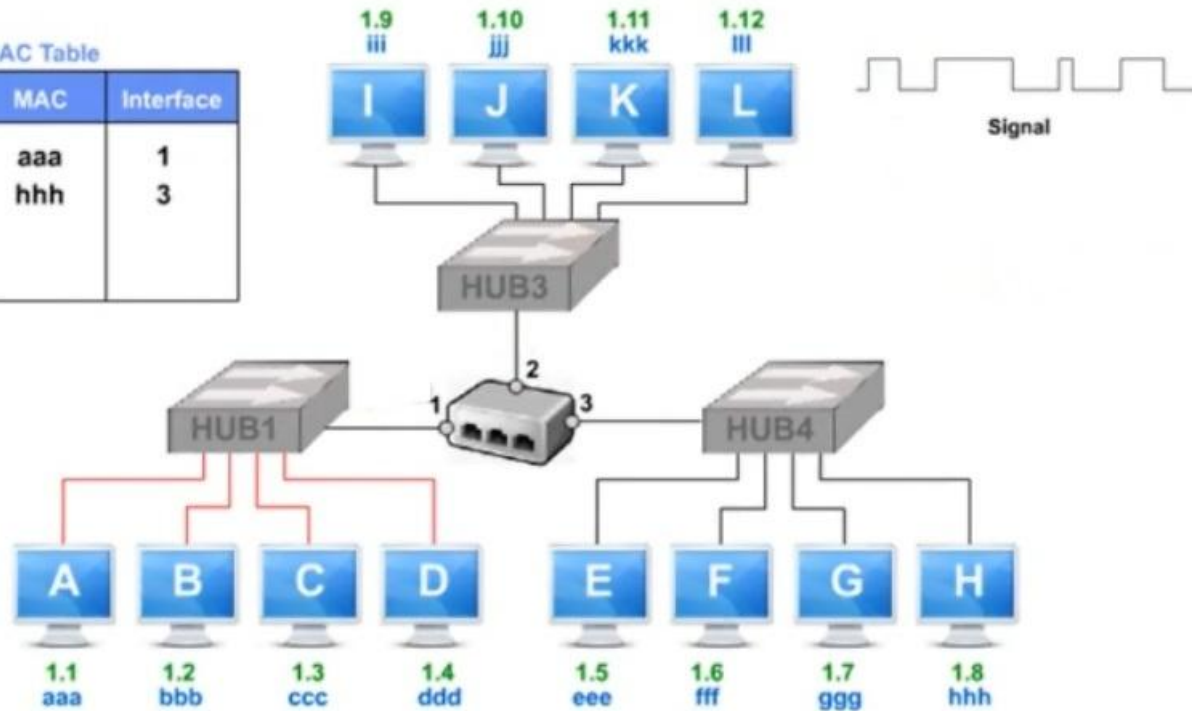


Bridge operation

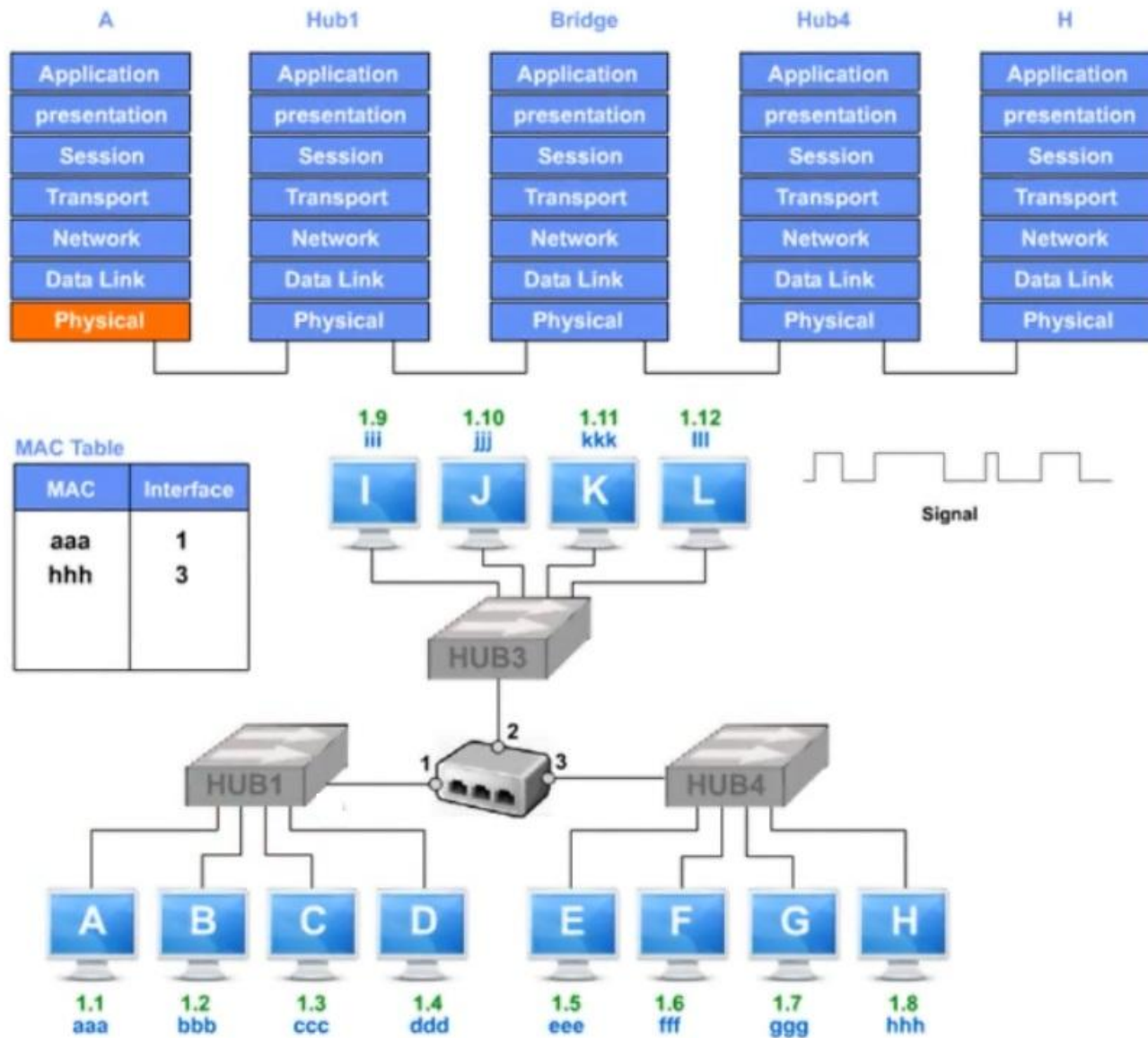


MAC Table

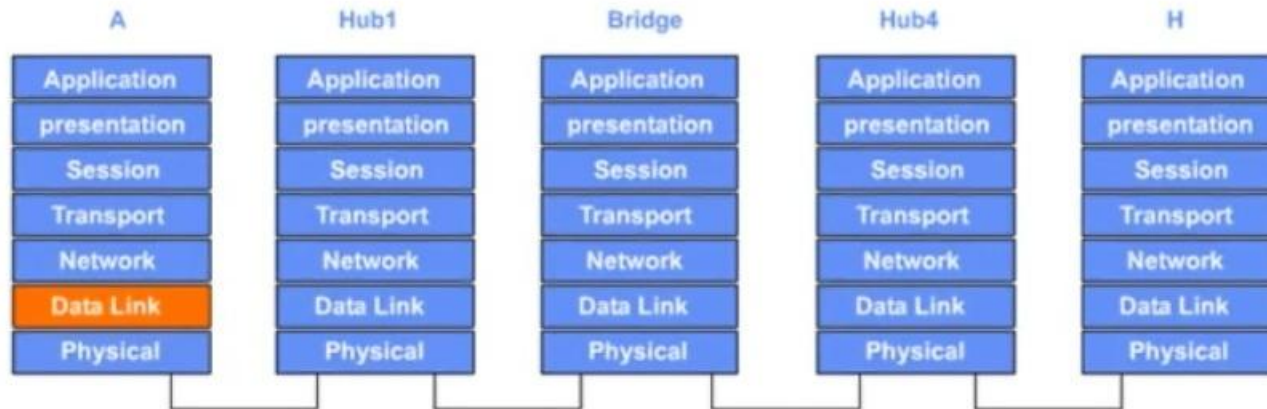
MAC	Interface
aaa	1
hhh	3



Bridge operation

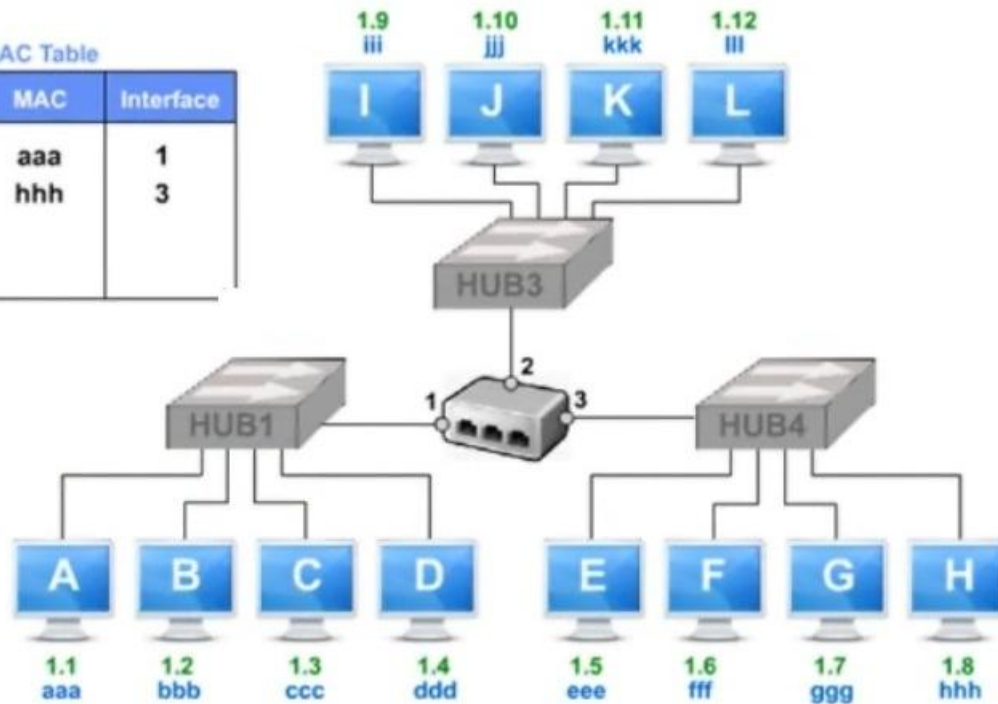


Bridge operation

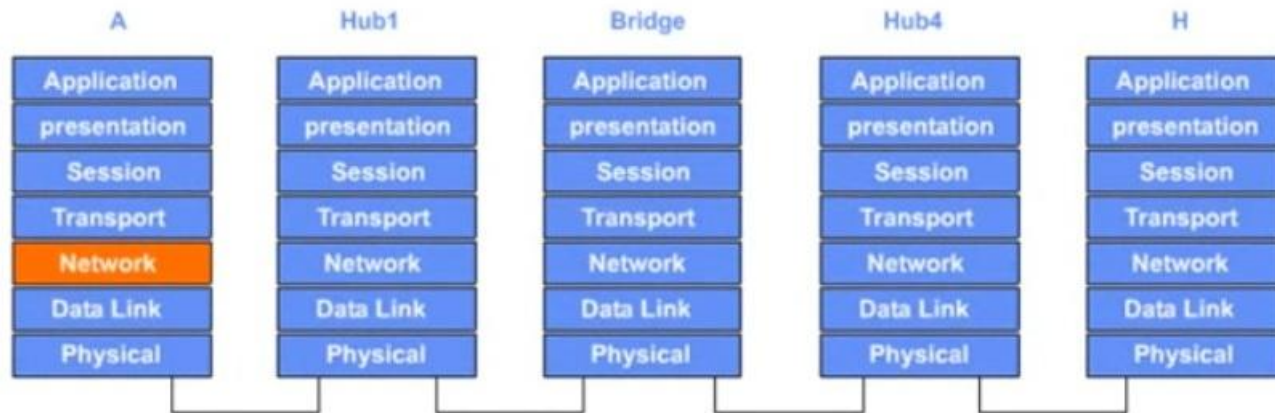


MAC Table

MAC	Interface
aaa	1
hhh	3

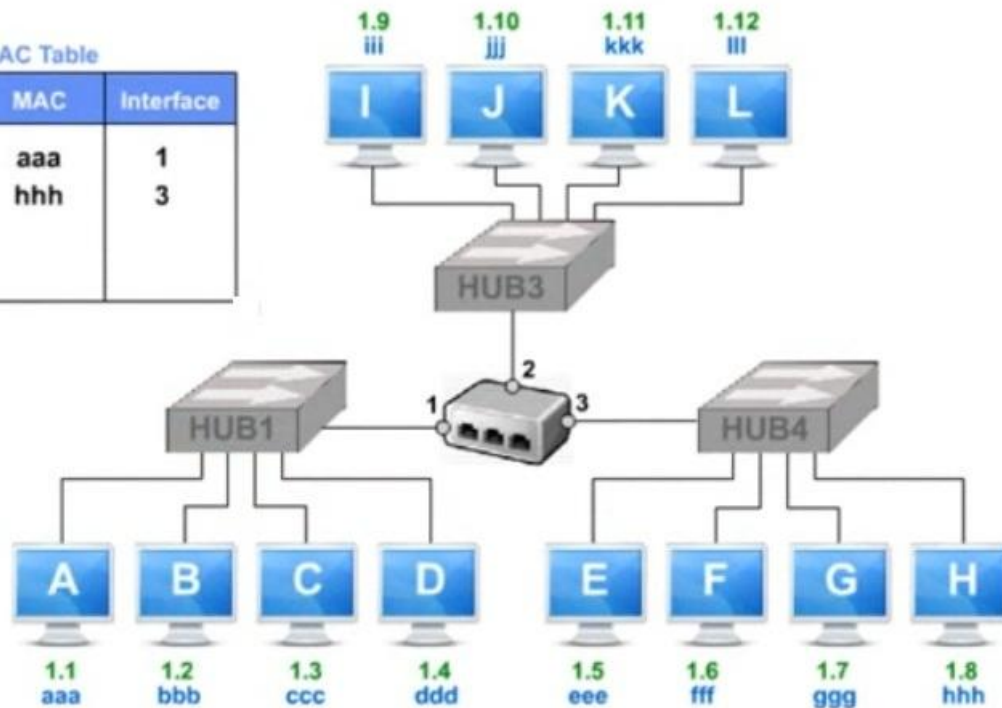


Bridge operation

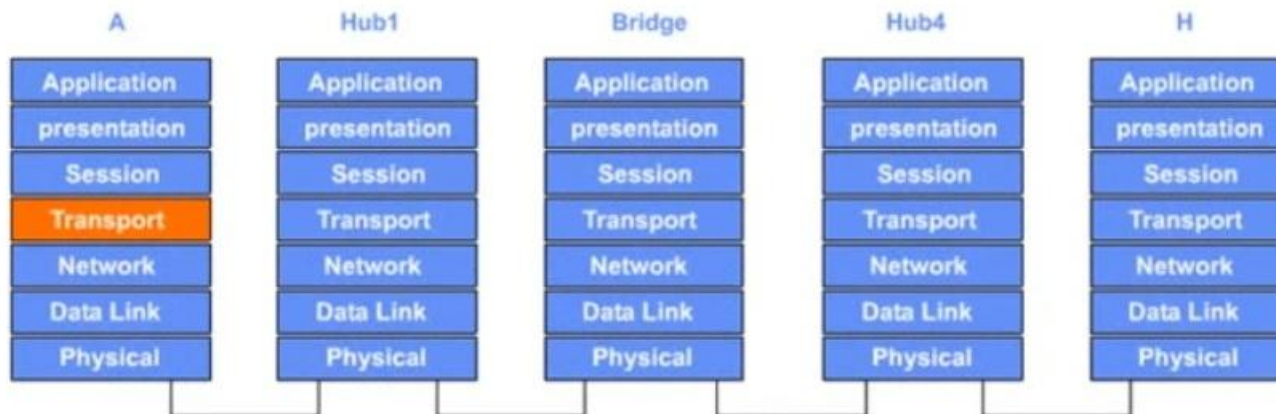


MAC Table

MAC	Interface
aaa	1
hhh	3

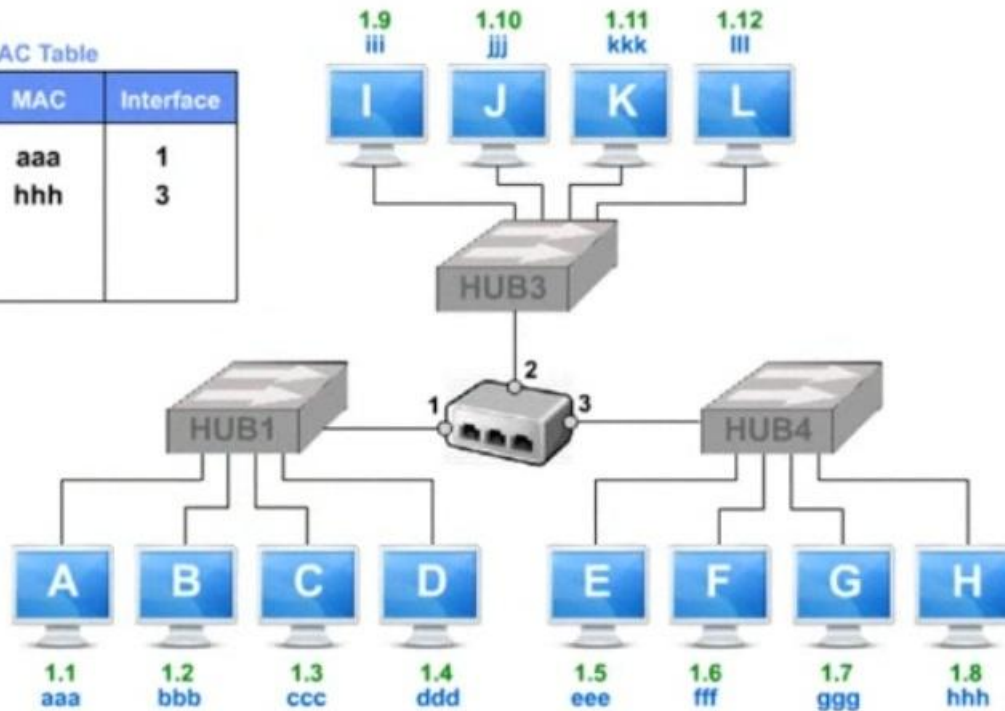


Bridge operation

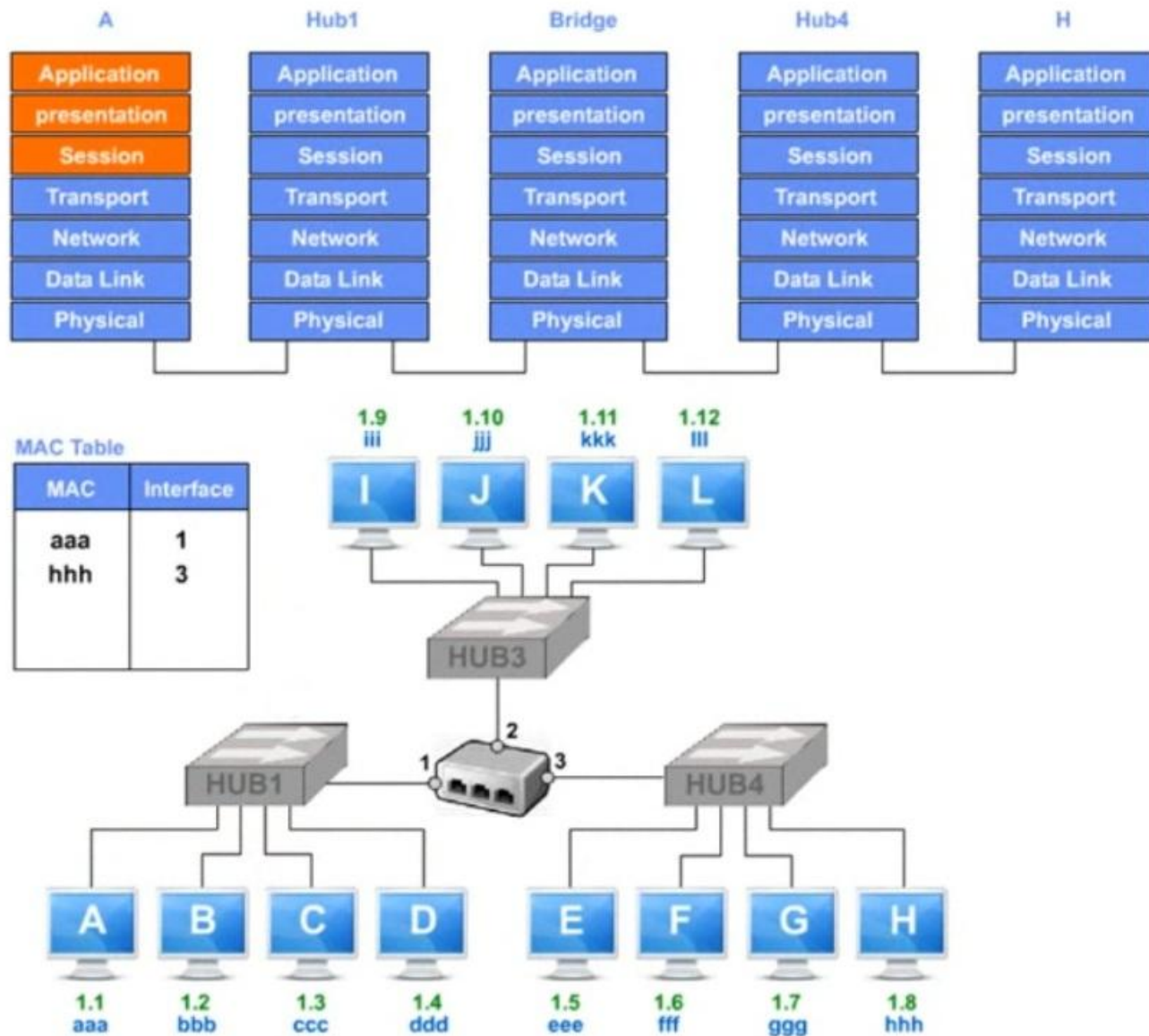


MAC Table

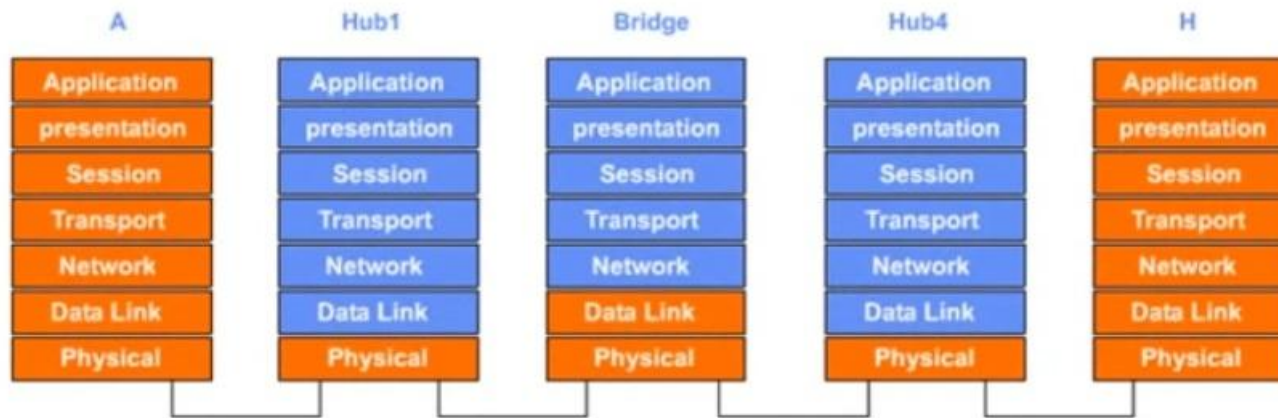
MAC	Interface
aaa	1
hhh	3



Bridge operation

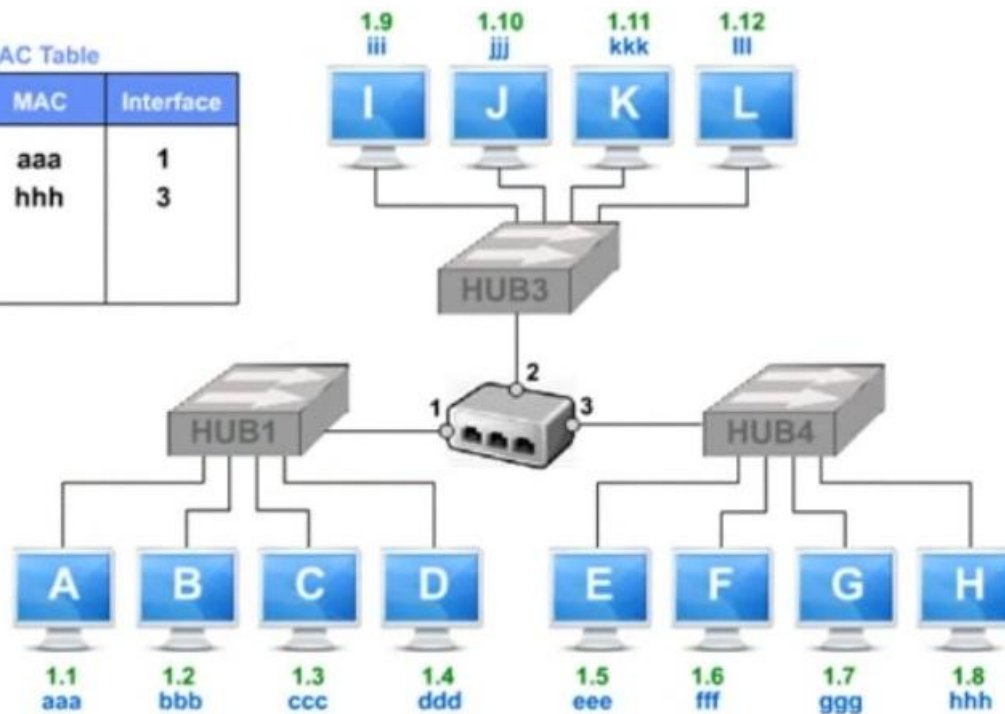


Bridge operation

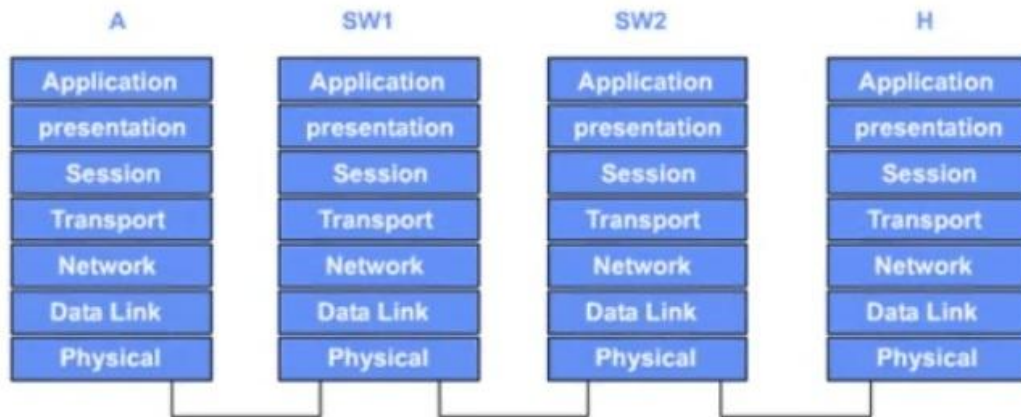


MAC Table

MAC	Interface
aaa	1
hhh	3



Switch operation



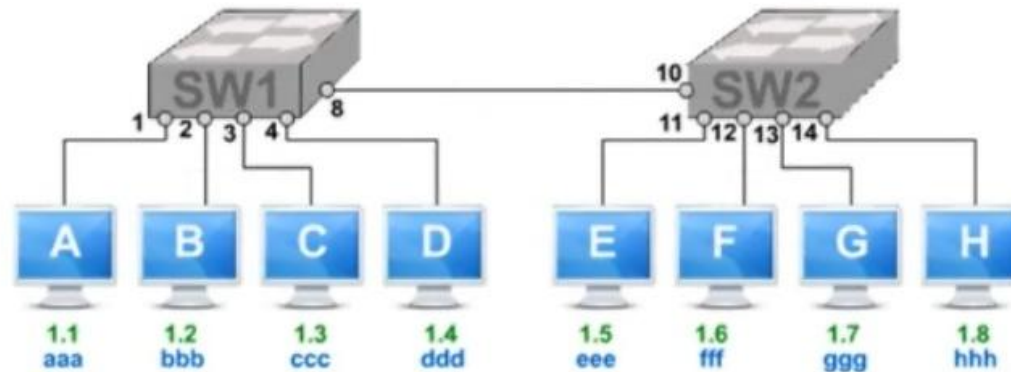
SW1 MAC Table

MAC	Interface

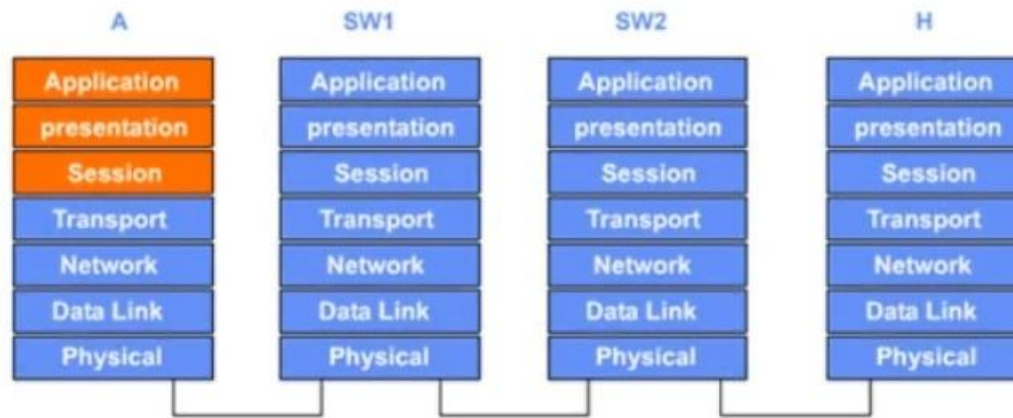
SW2 MAC Table

MAC	Interface

A is going to transmit data to **H**.



Switch operation

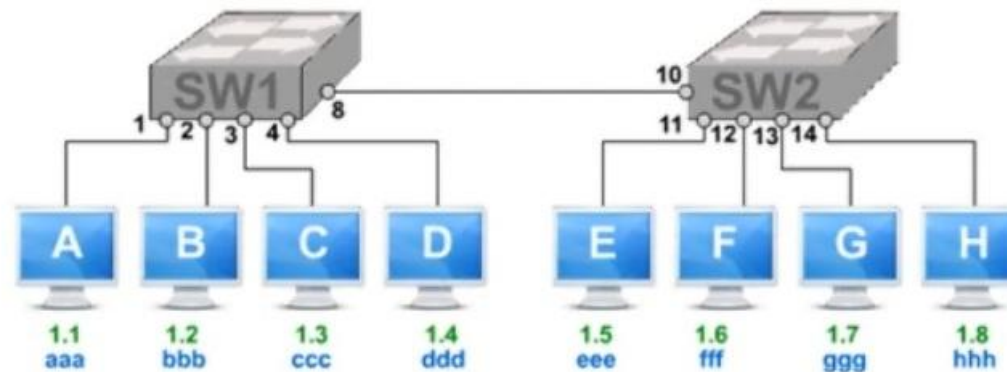


SW1 MAC Table

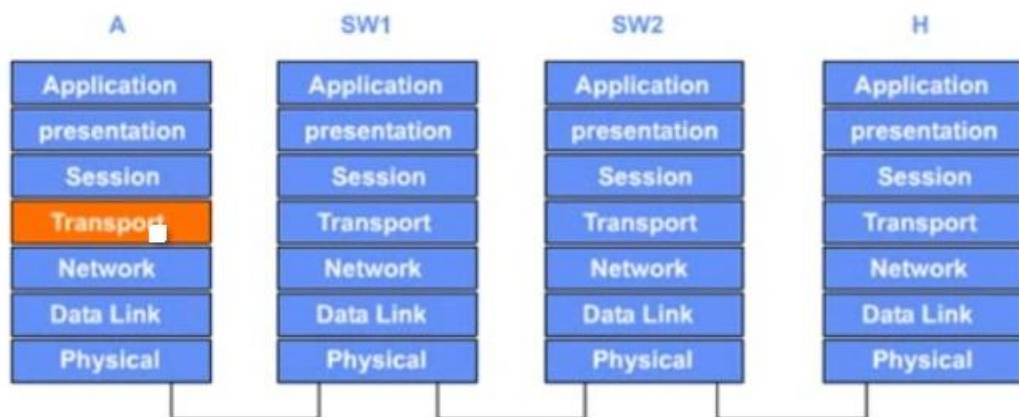
MAC	Interface

SW2 MAC Table

MAC	Interface



Switch operation

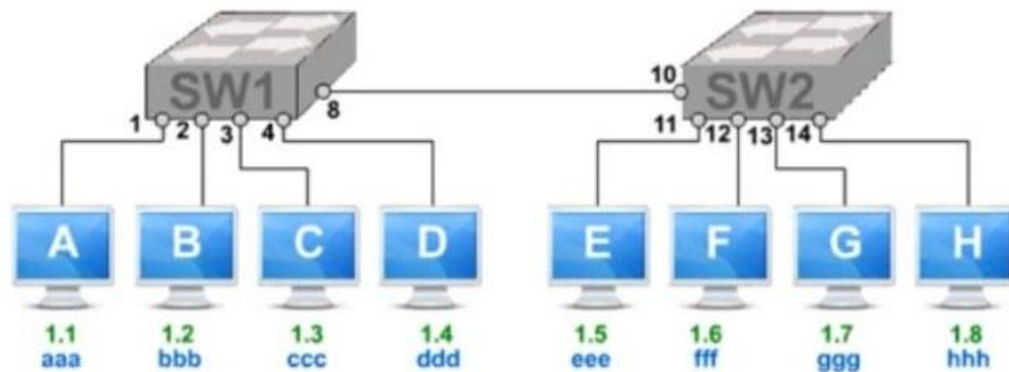


SW1 MAC Table

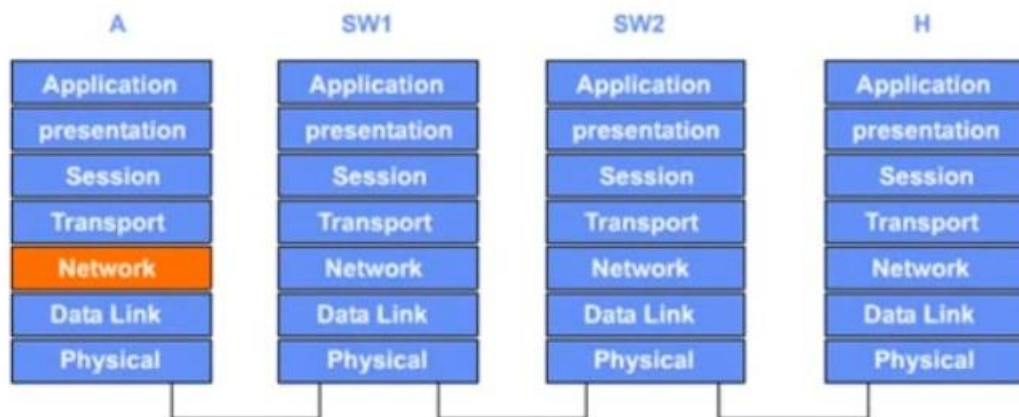
MAC	Interface

SW2 MAC Table

MAC	Interface



Switch operation

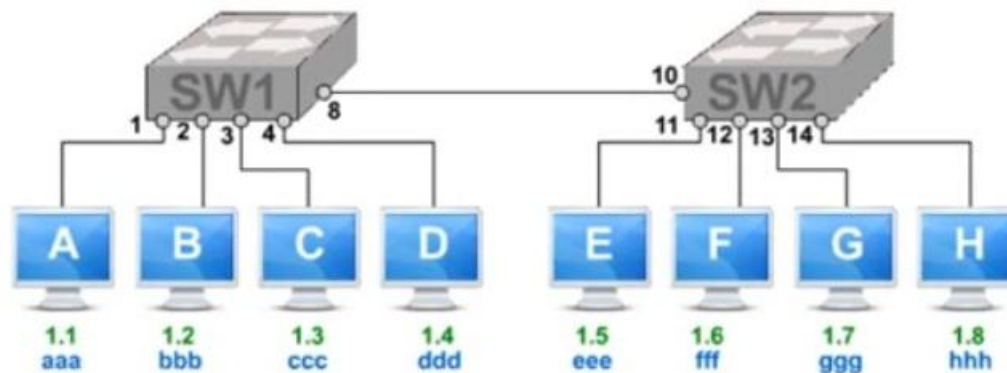
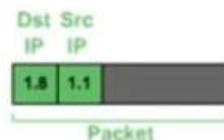


SW1 MAC Table

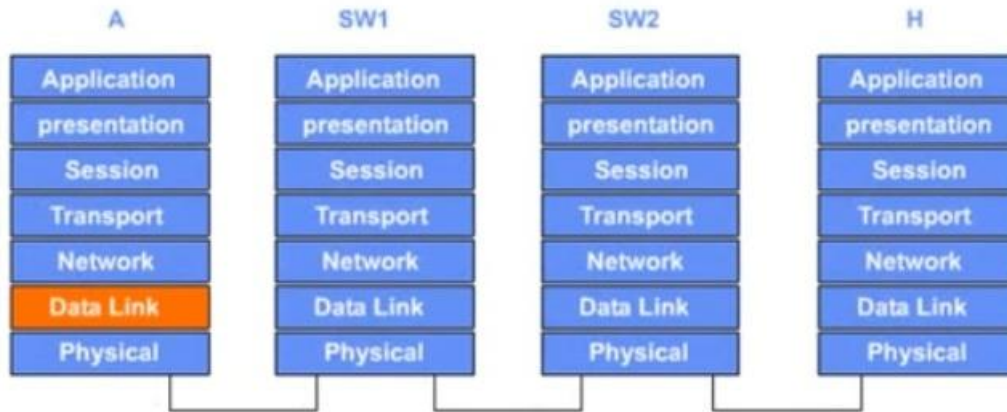
MAC	Interface

SW2 MAC Table

MAC	Interface



Switch operation

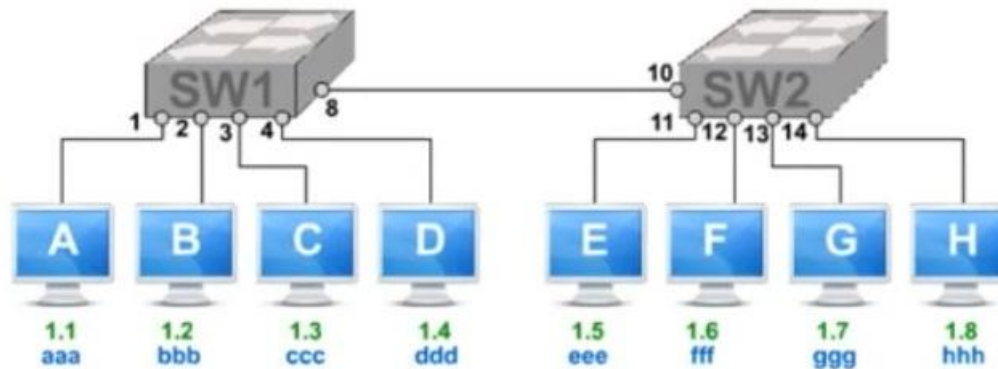


SW1 MAC Table

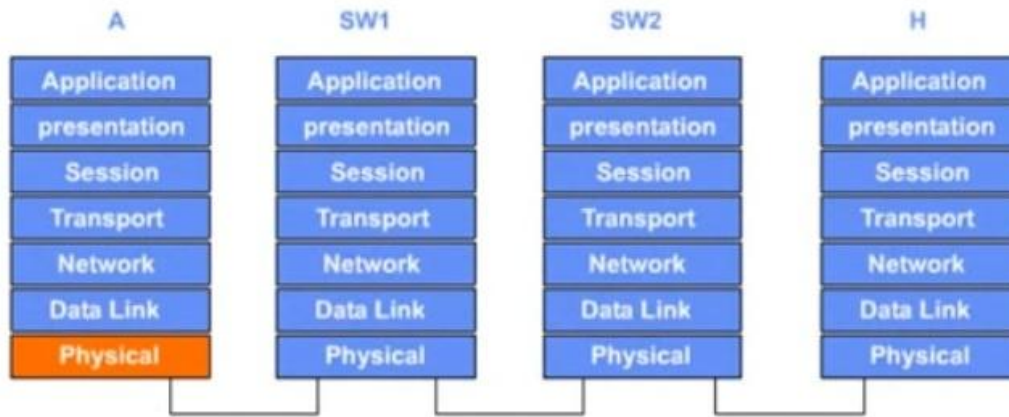
MAC	Interface

SW2 MAC Table

MAC	Interface



Switch operation

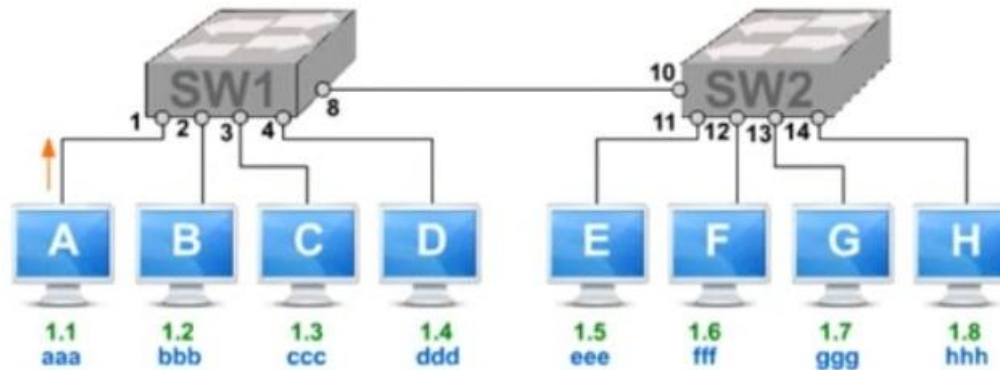
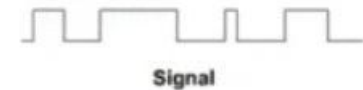


SW1 MAC Table

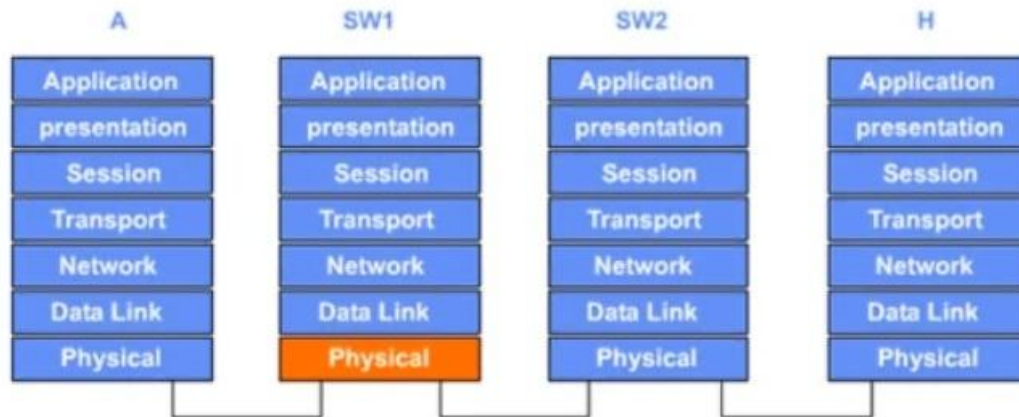
MAC	Interface

SW2 MAC Table

MAC	Interface



Switch operation

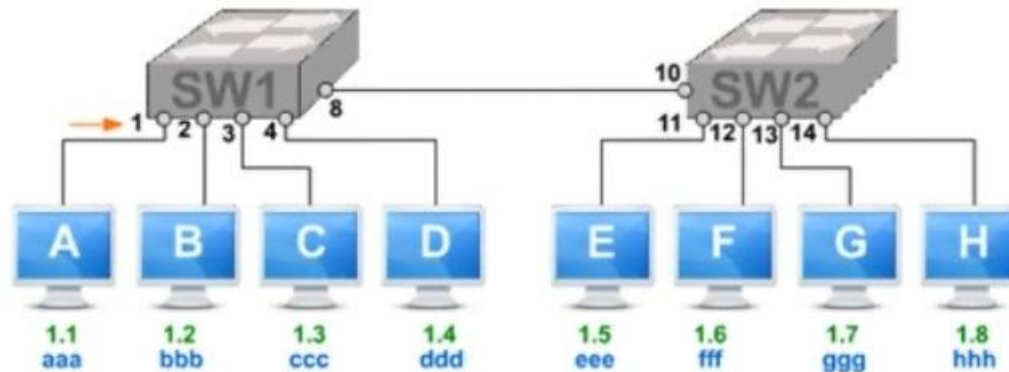
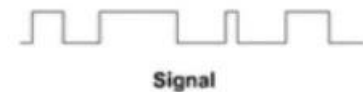


SW1 MAC Table

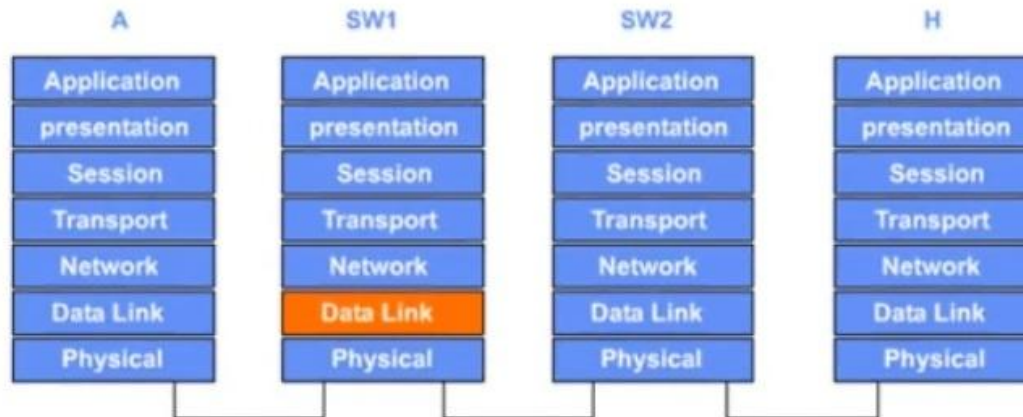
MAC	Interface

SW2 MAC Table

MAC	Interface



Switch operation



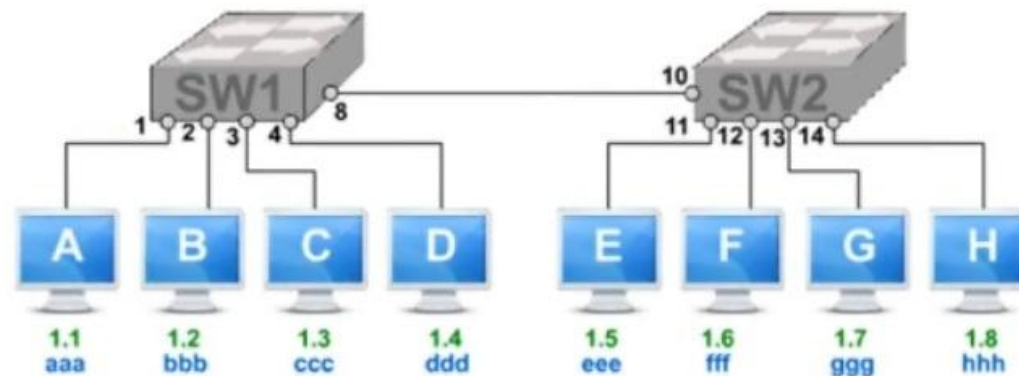
SW1 MAC Table

MAC	Interface

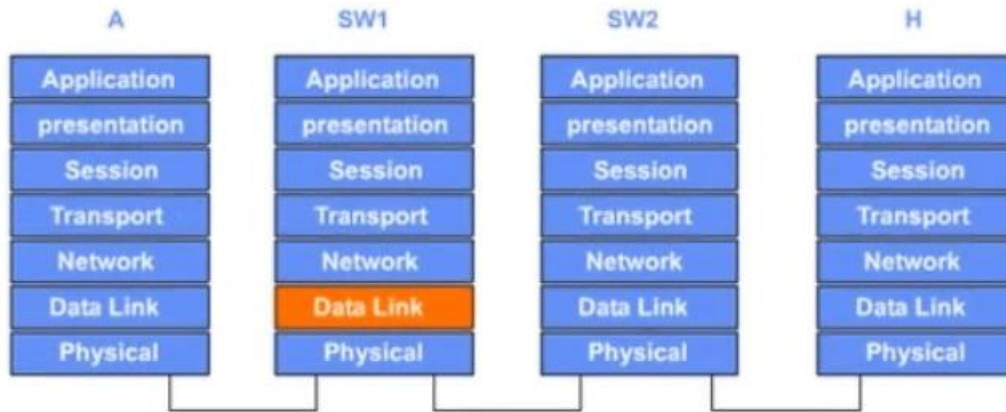
SW2 MAC Table

MAC	Interface

Dst Src
MAC MAC



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1

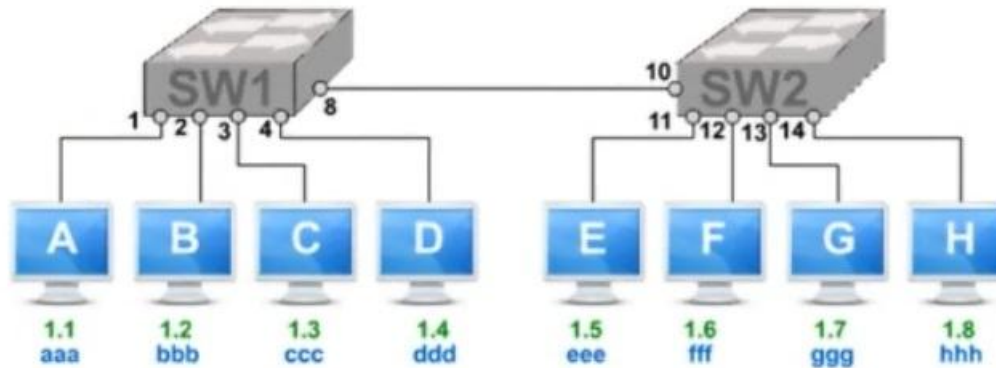
SW2 MAC Table

MAC	Interface

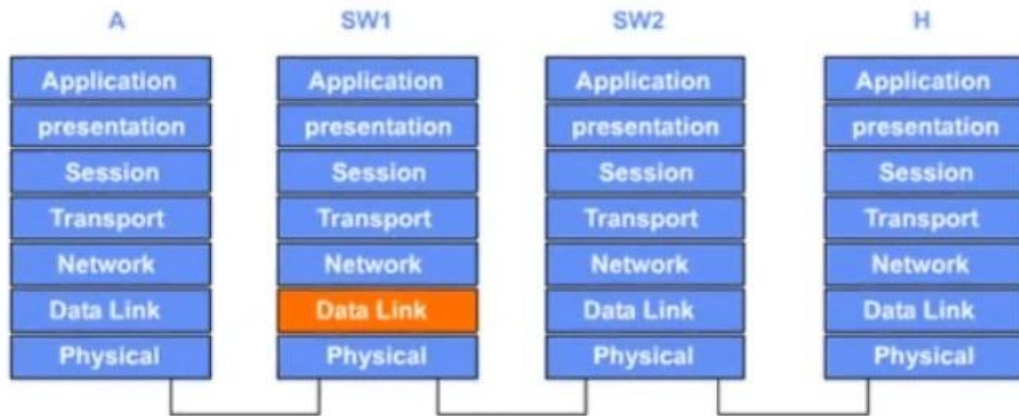
Dst Src
MAC MAC



1. Learning (Src MAC)



Switch operation

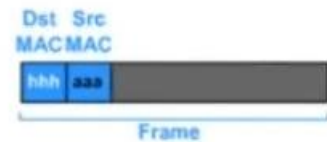


SW1 MAC Table

MAC	Interface
aaa	1

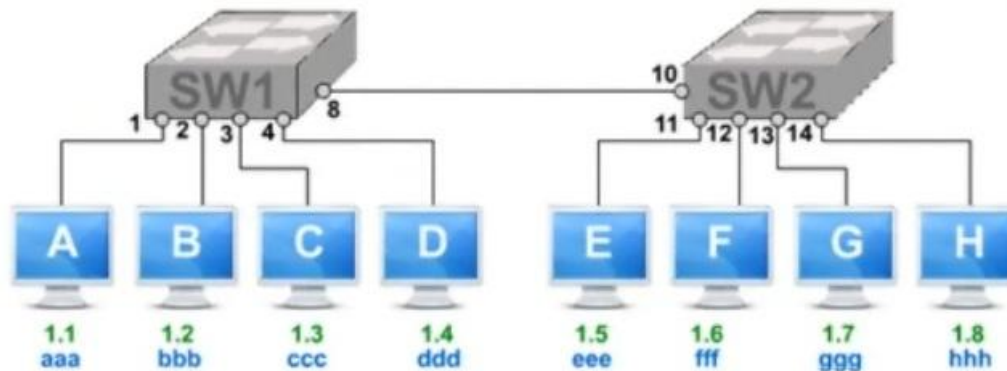
SW2 MAC Table

MAC	Interface

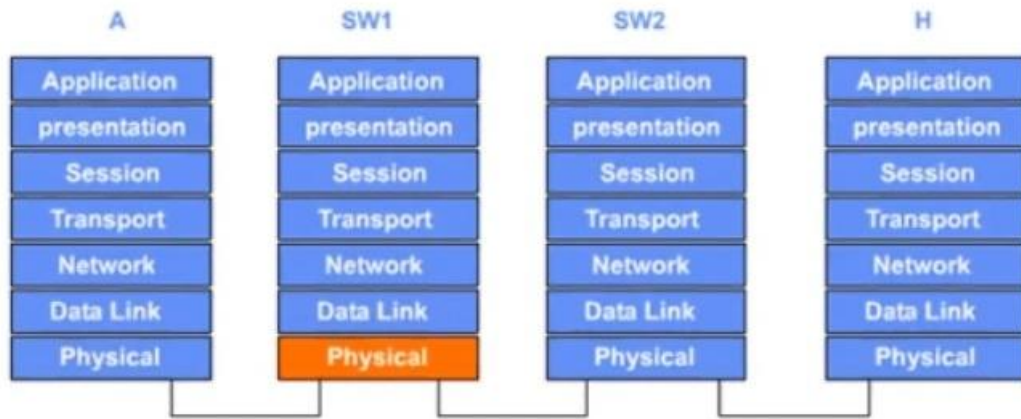


2. Forwarding (Dst MAC)

Unicast
Unknown Unicast
 Broadcast



Switch operation

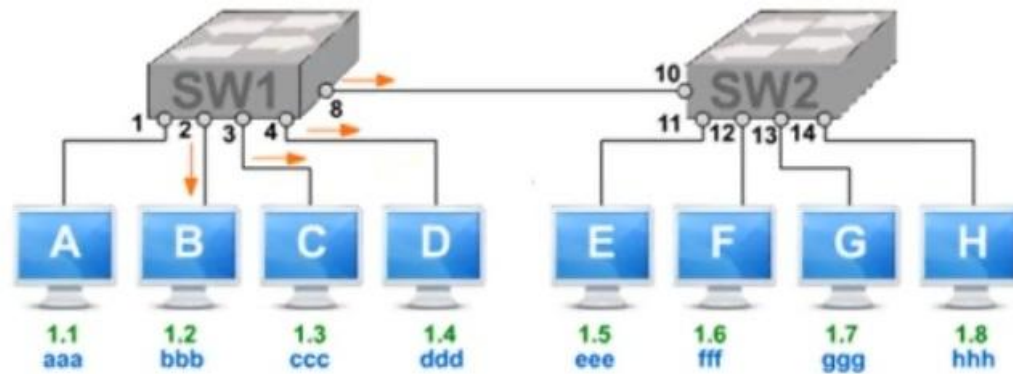


SW1 MAC Table

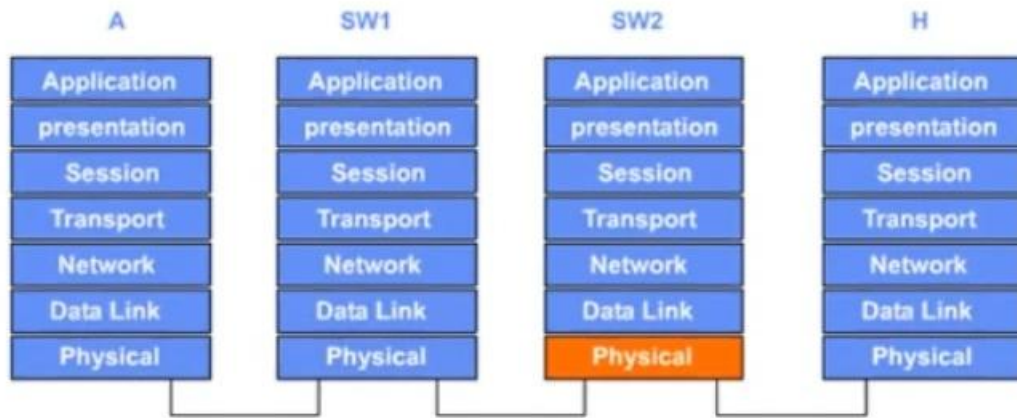
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
-----	-----------



Switch operation

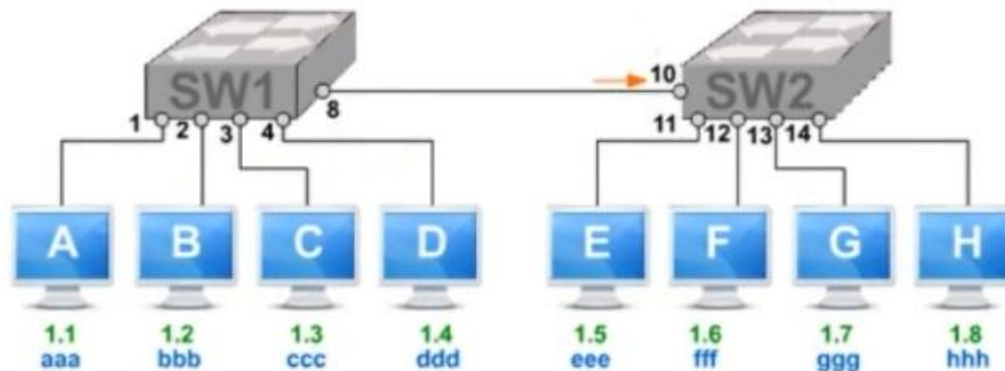
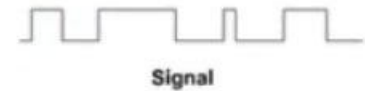


SW1 MAC Table

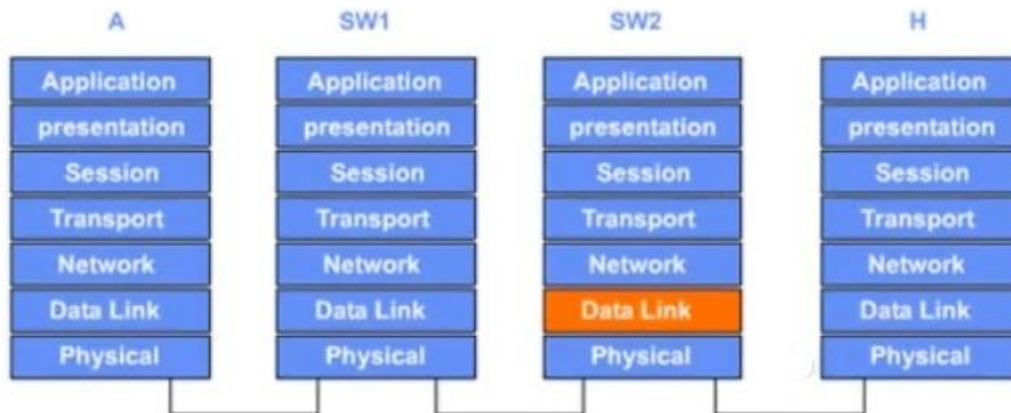
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
-----	-----------



Switch operation



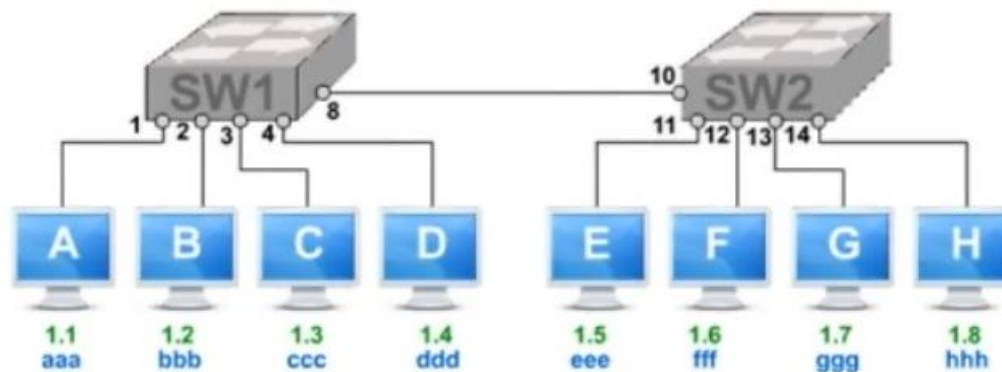
SW1 MAC Table

MAC	Interface
aaa	1

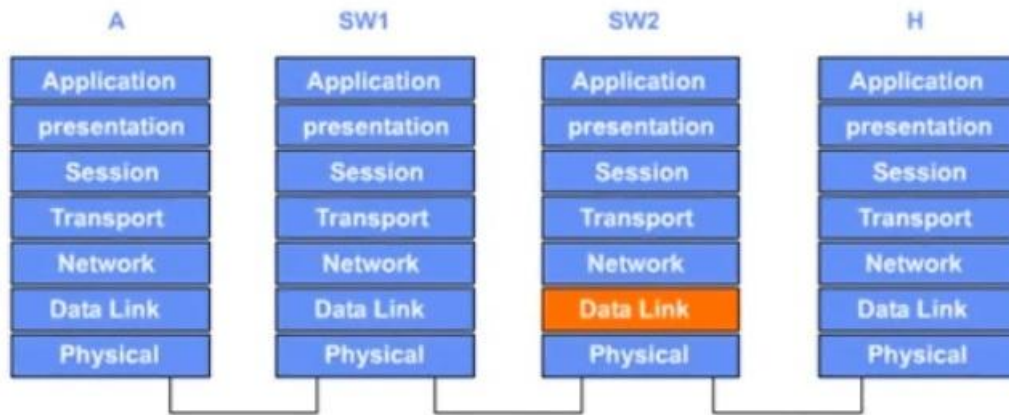
SW2 MAC Table

MAC	Interface
-----	-----------

Dst Src
MAC MAC



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1

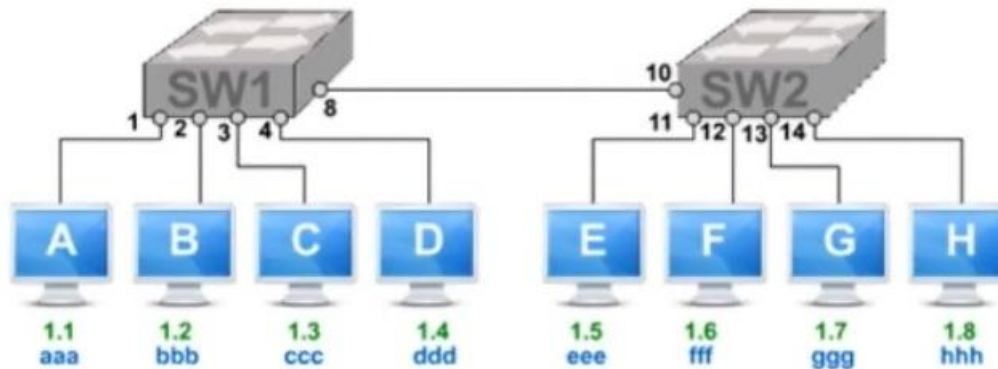
SW2 MAC Table

MAC	Interface
aaa	10

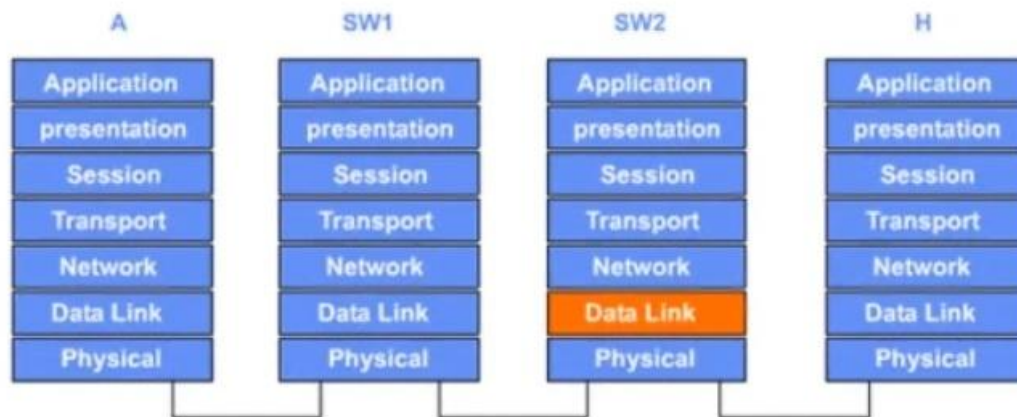
Dst Src
MAC MAC



1. Learning (Src MAC)



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10

Dst Src
MAC MAC

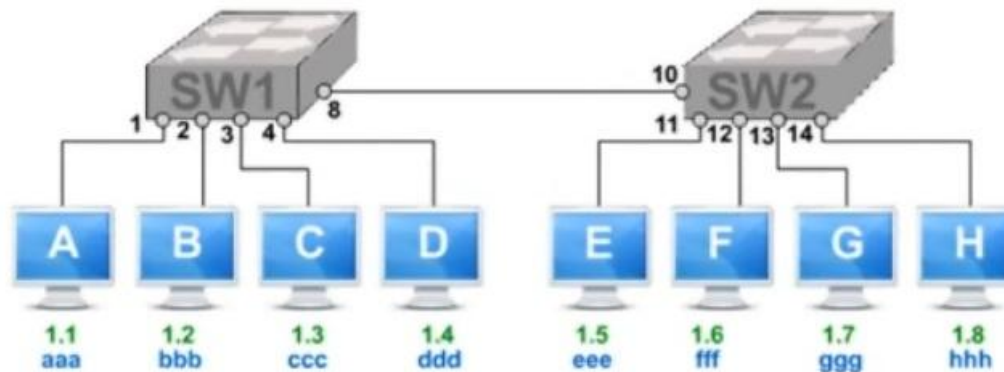


2. Forwarding (Dst MAC)

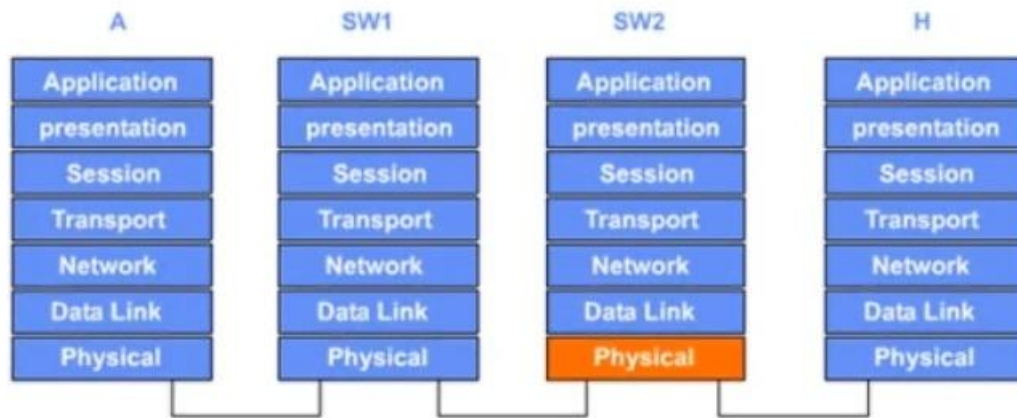
Unicast

Unknown Unicast

Broadcast



Switch operation

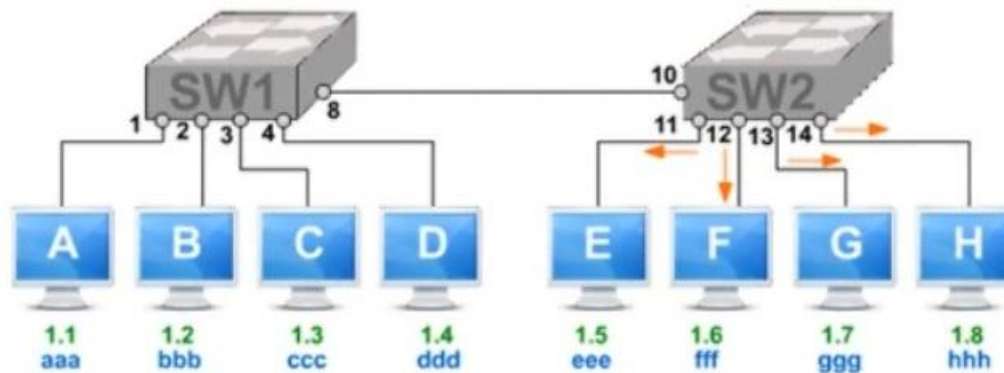
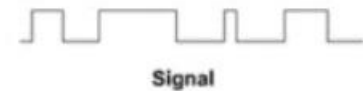


SW1 MAC Table

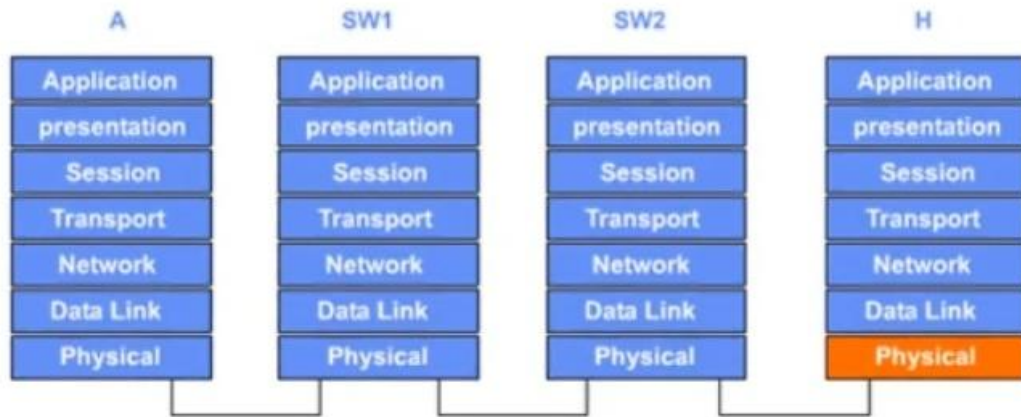
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

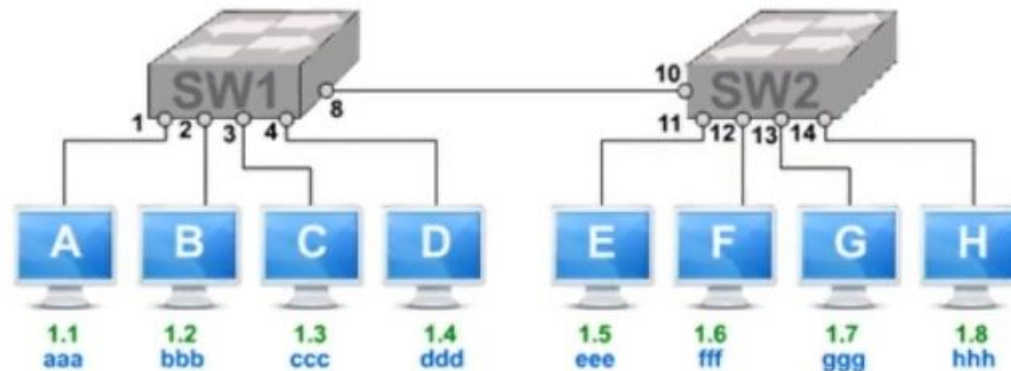
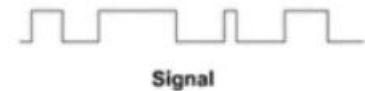


SW1 MAC Table

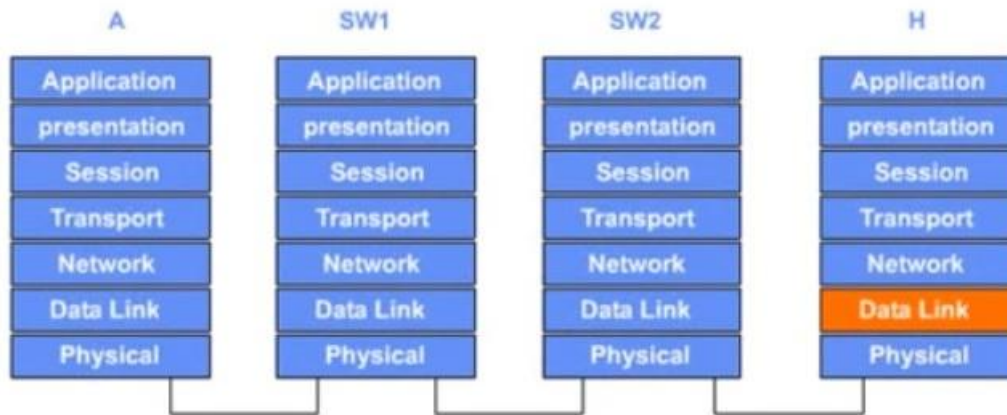
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

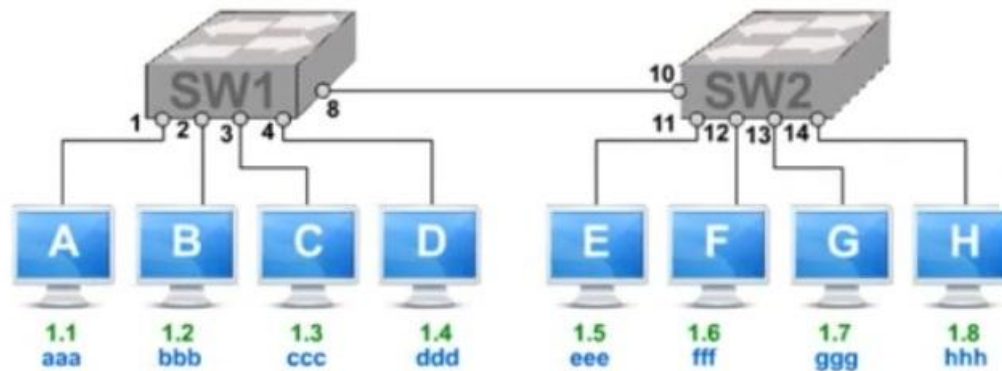


SW1 MAC Table

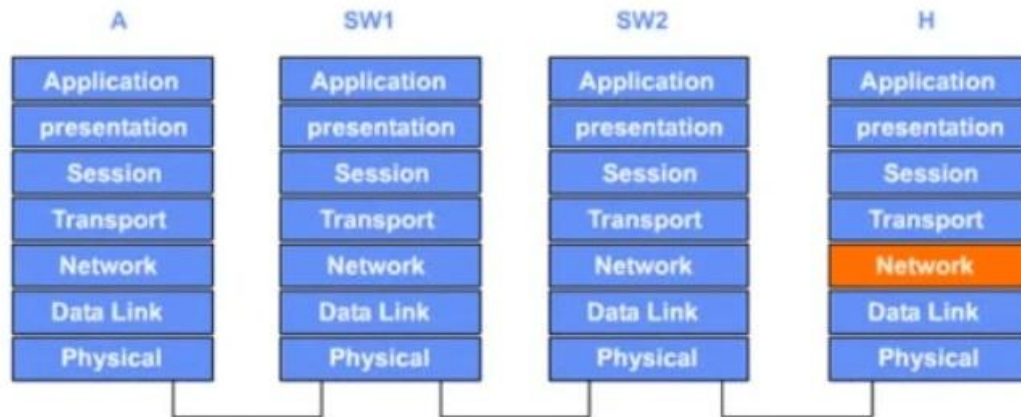
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

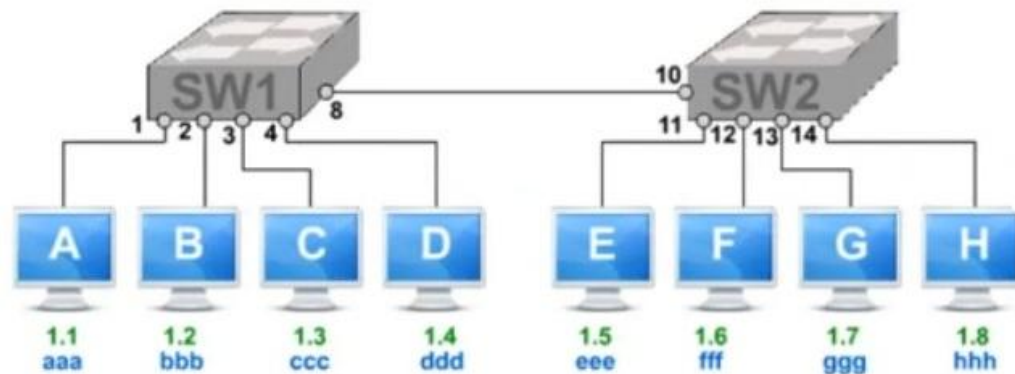


SW1 MAC Table

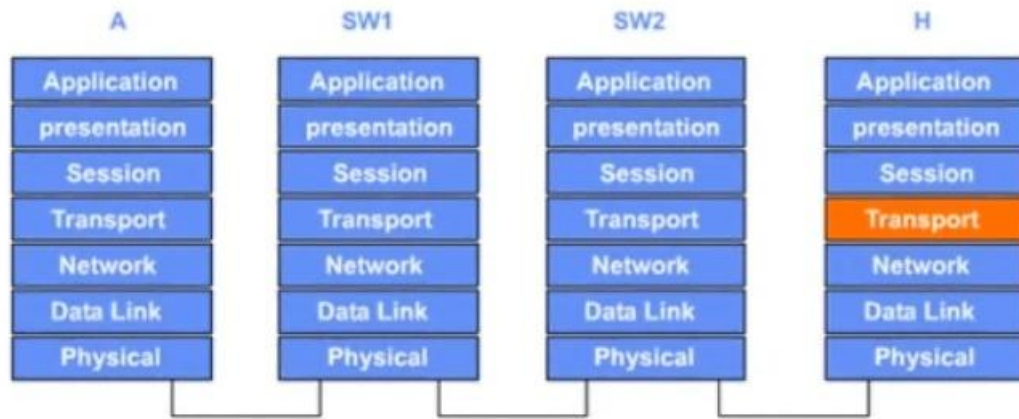
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

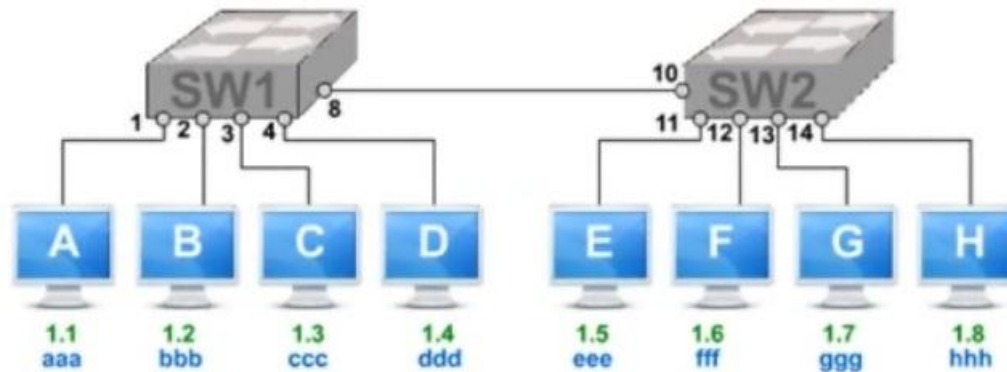


SW1 MAC Table

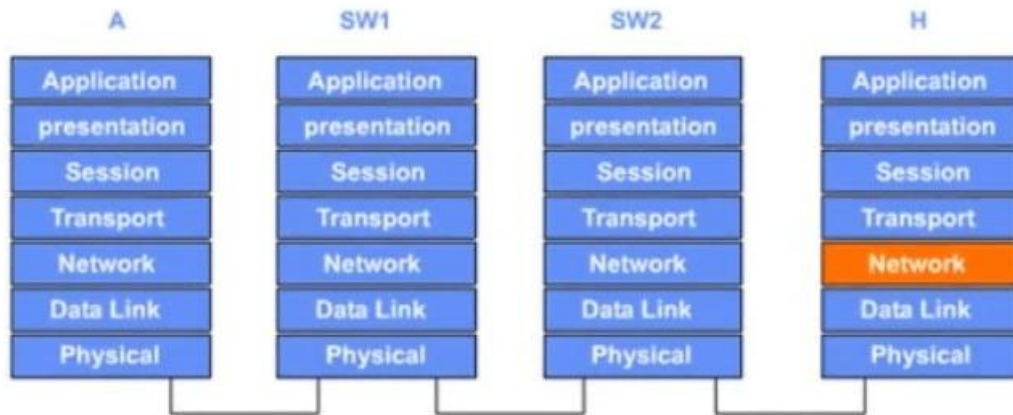
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

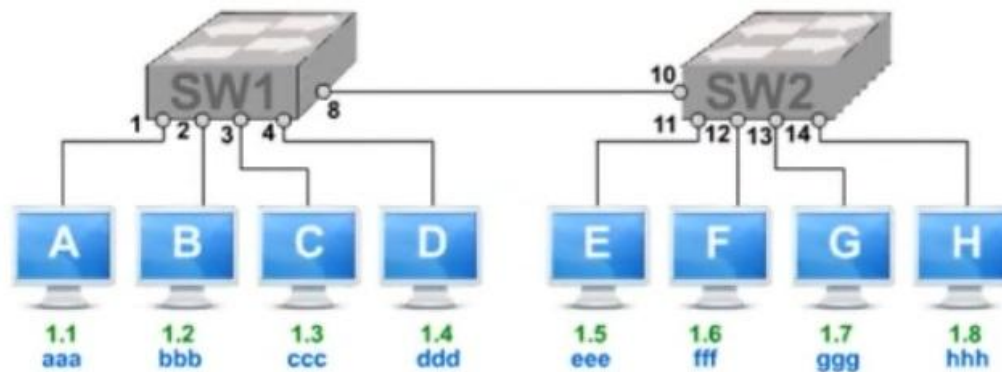
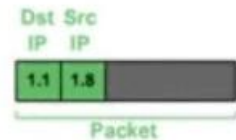


SW1 MAC Table

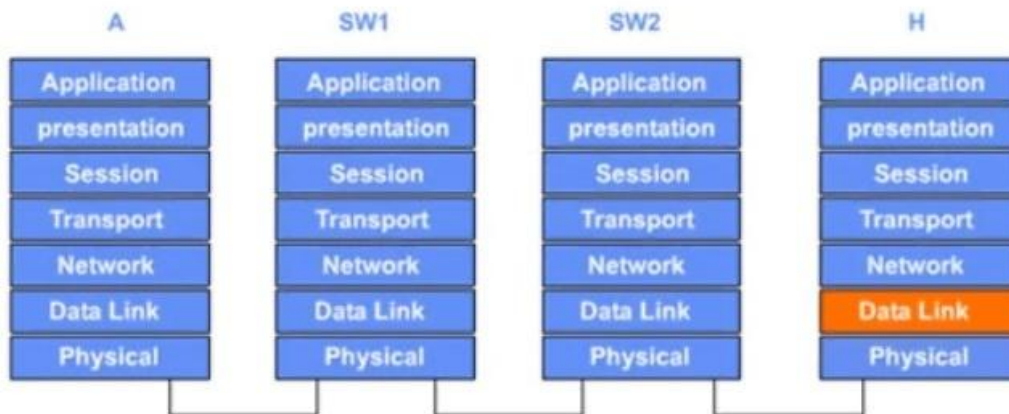
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

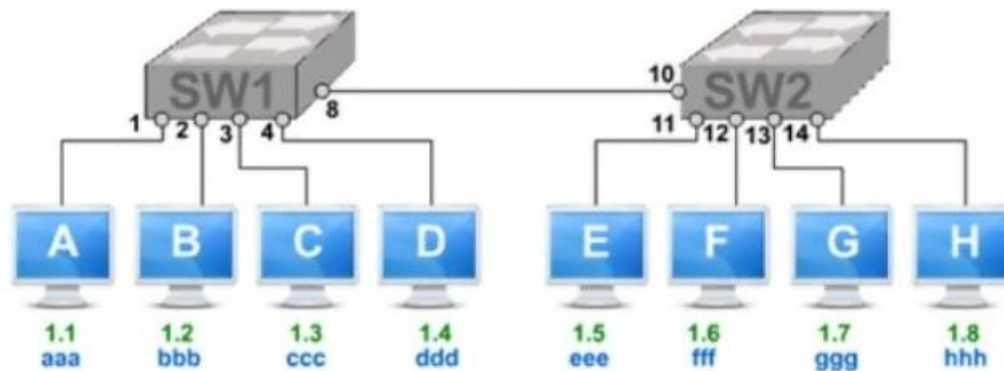
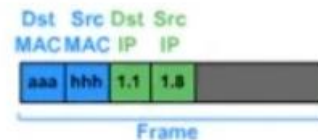


SW1 MAC Table

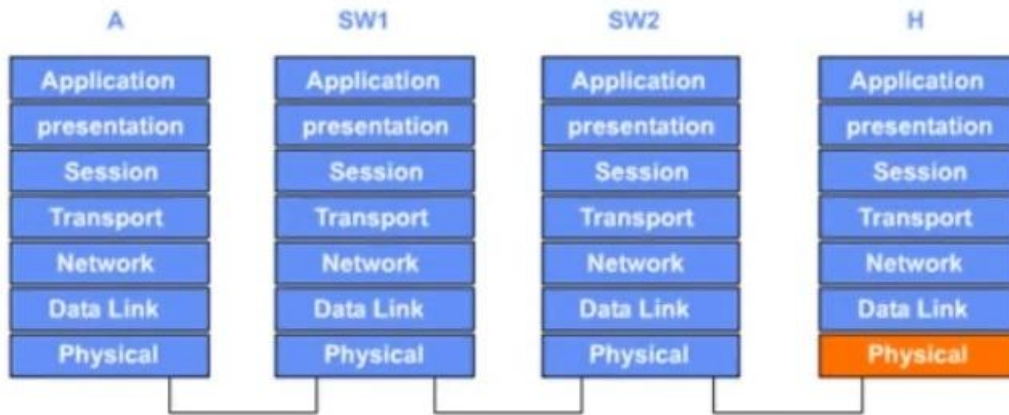
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

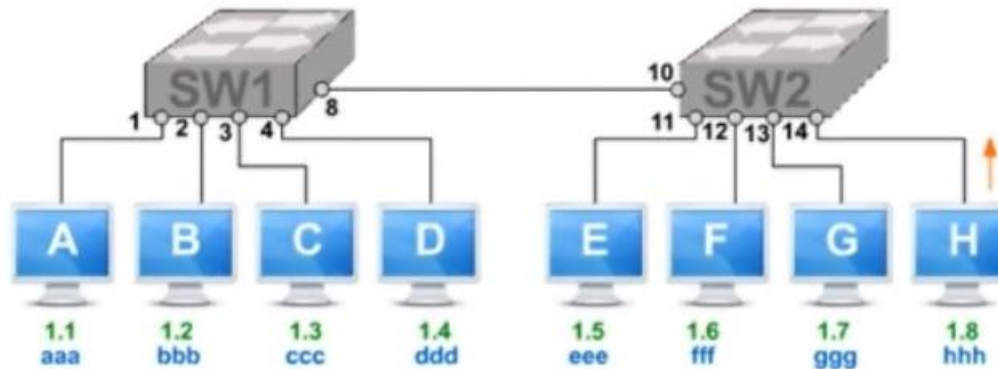
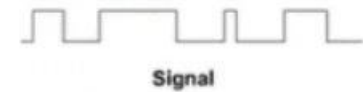


SW1 MAC Table

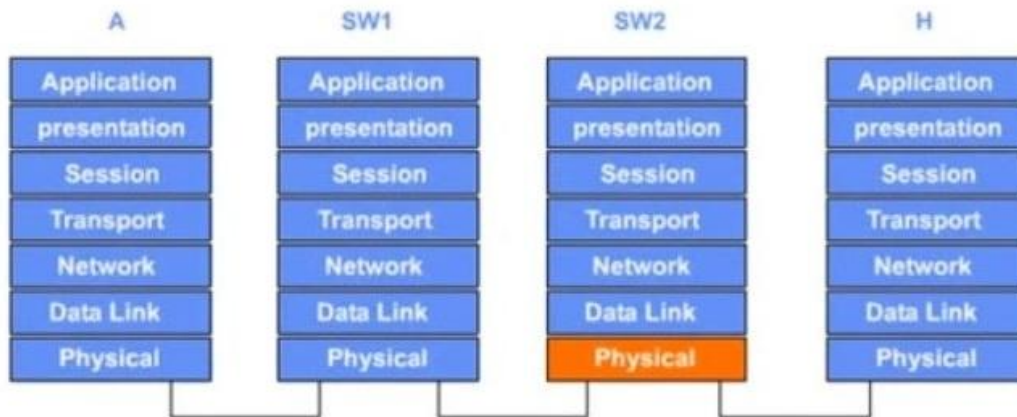
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation

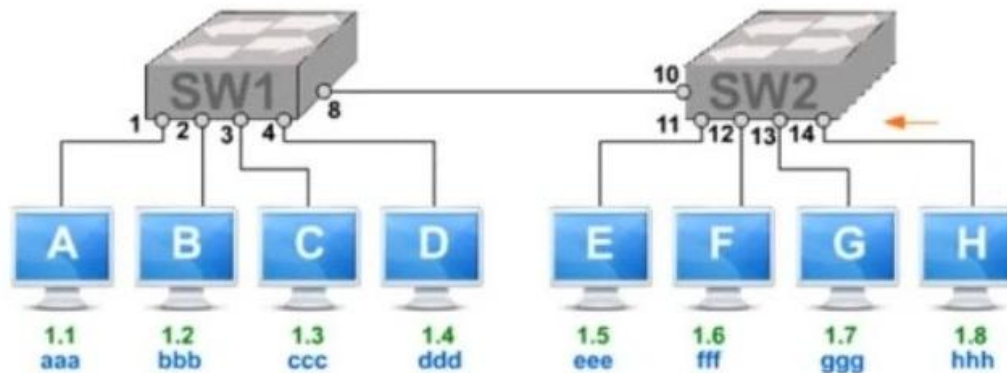
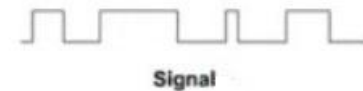


SW1 MAC Table

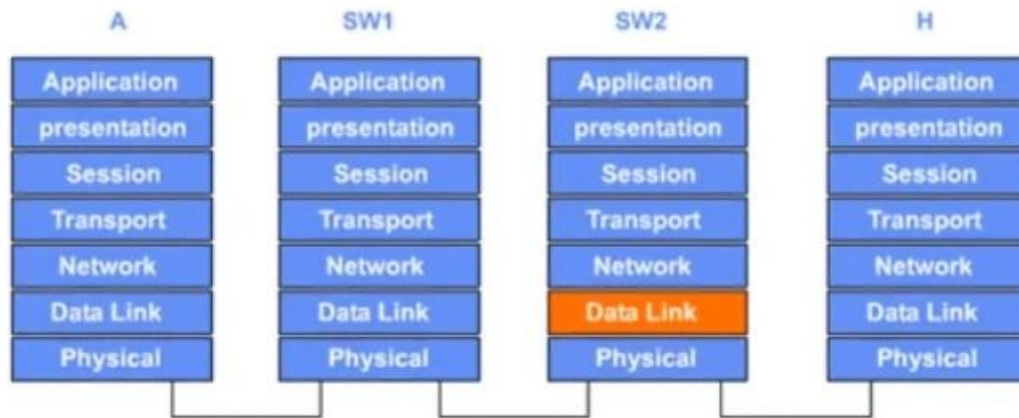
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10



Switch operation



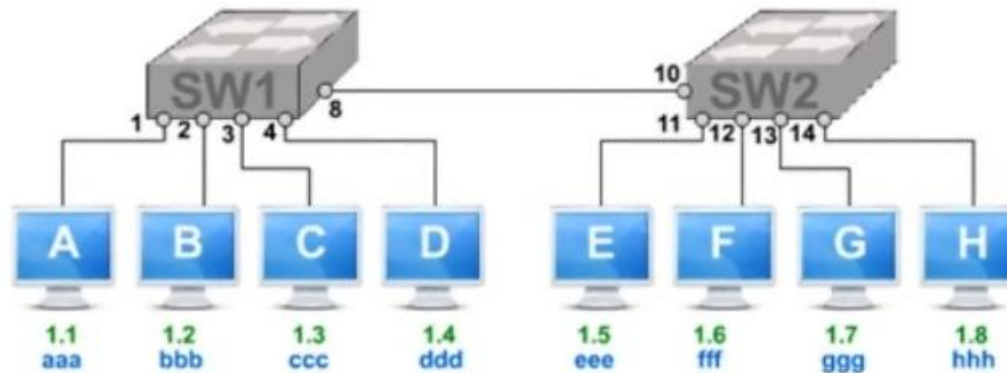
SW1 MAC Table

MAC	Interface
aaa	1

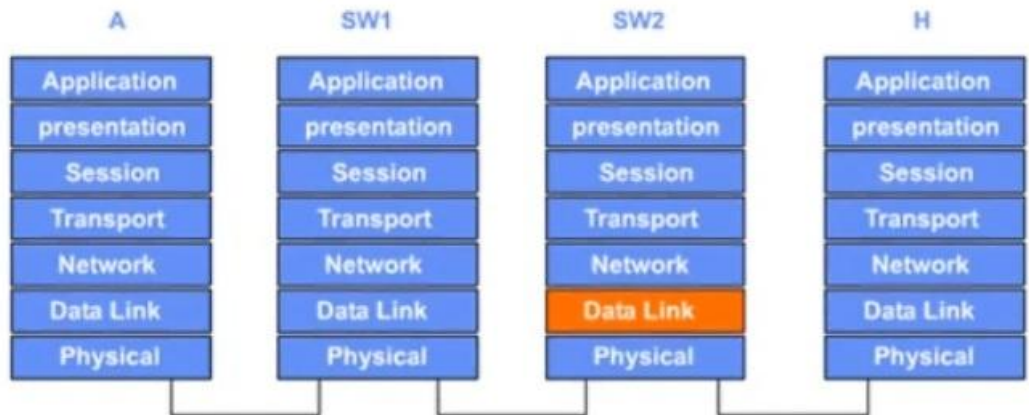
SW2 MAC Table

MAC	Interface
aaa	10

Dst Src
MAC MAC



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1

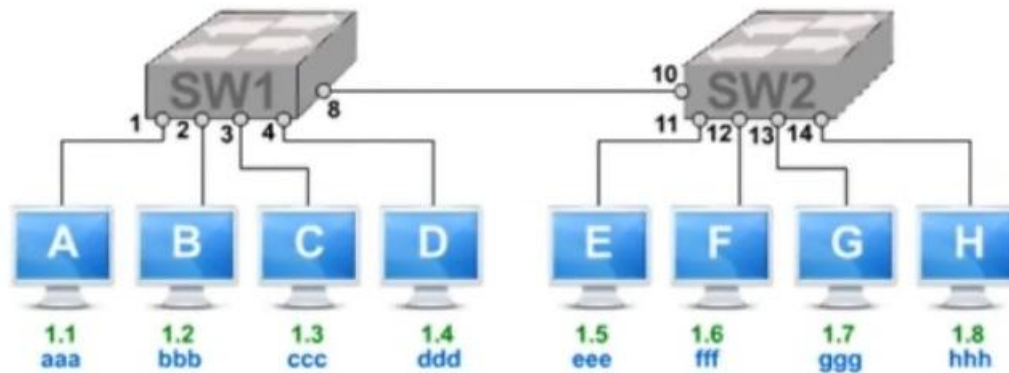
SW2 MAC Table

MAC	Interface
aaa	10
hhh	14

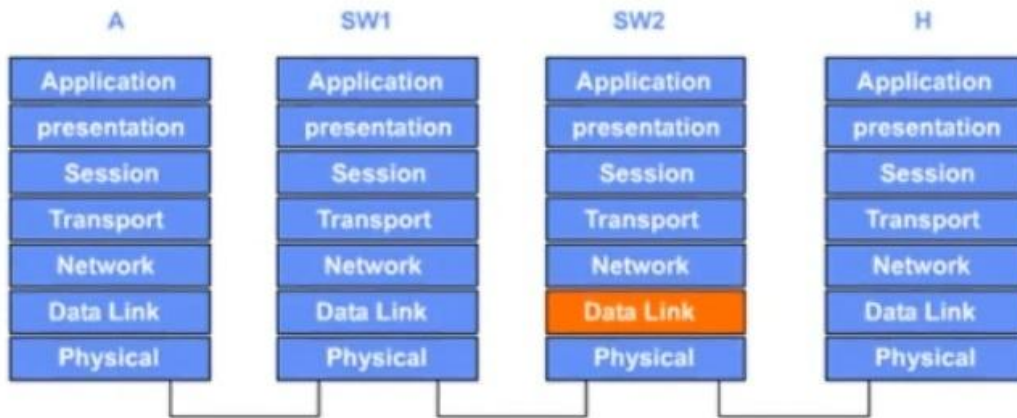
Dst Src
MACMAC



1. Learning (Src MAC)



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14

Dst Src
MAC MAC

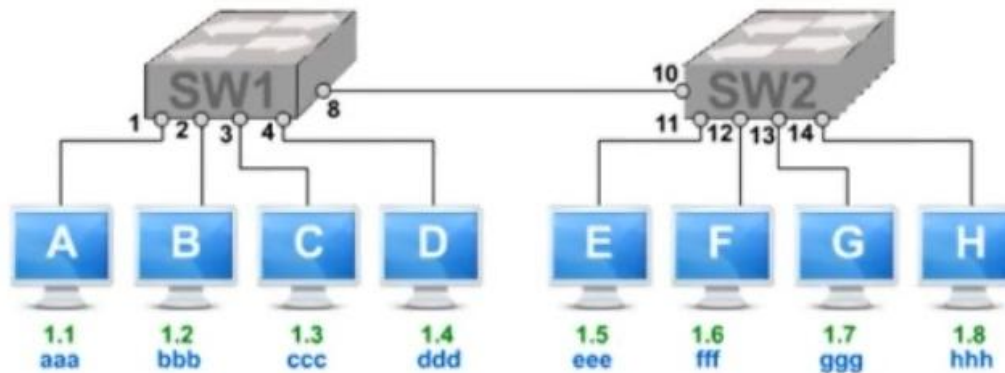


2. Forwarding (Dst MAC)

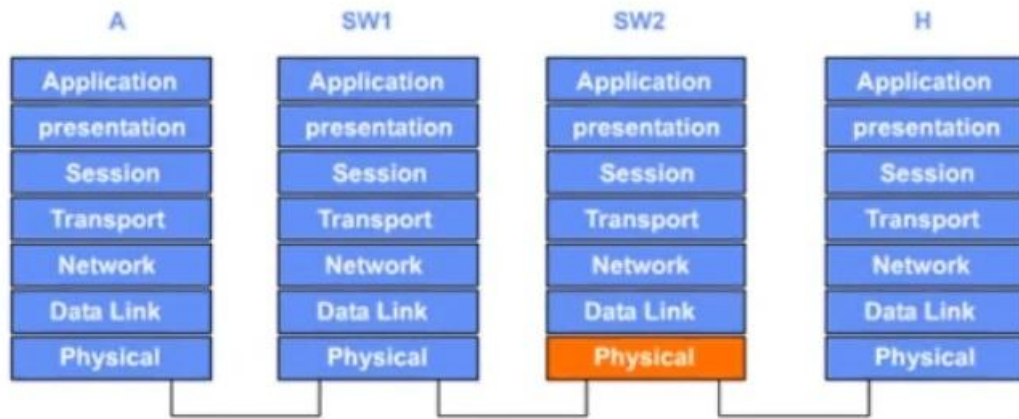
Unicast

Unknown Unicast

Broadcast



Switch operation

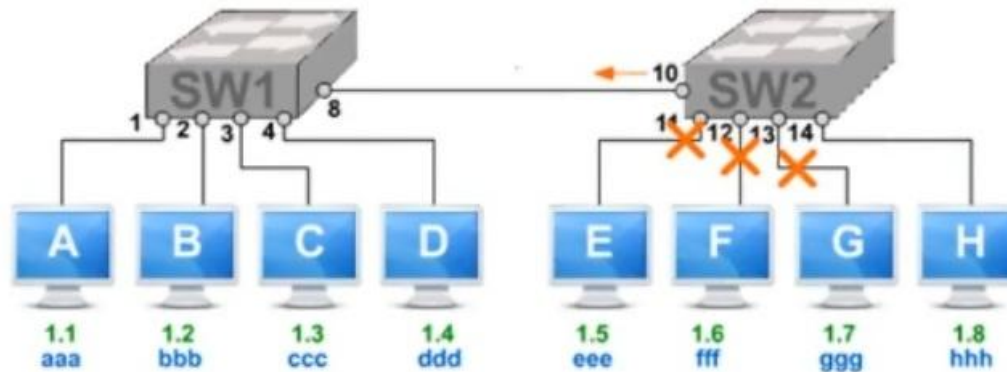
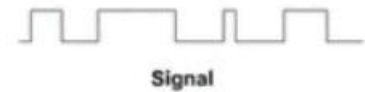


SW1 MAC Table

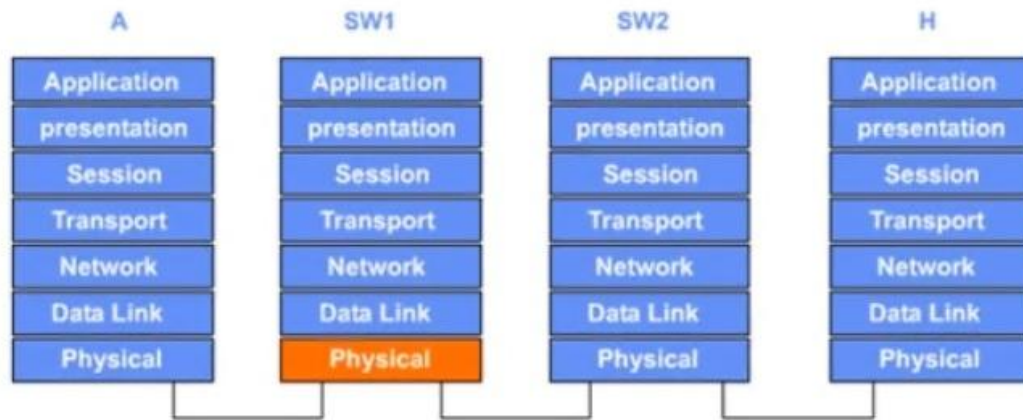
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

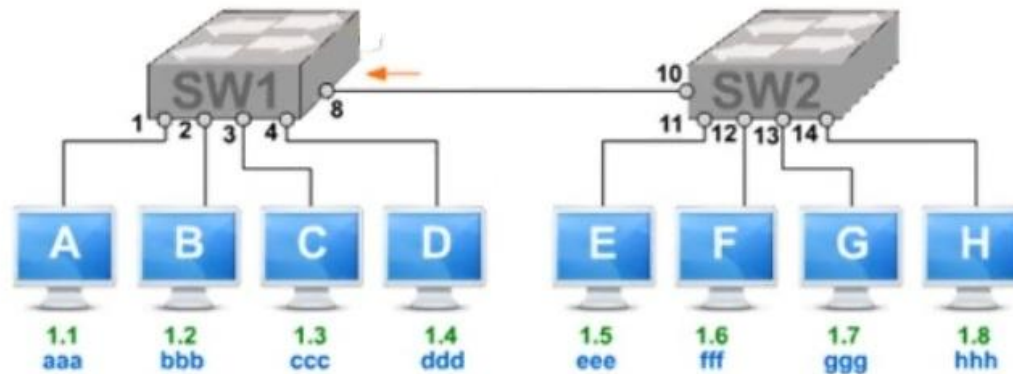
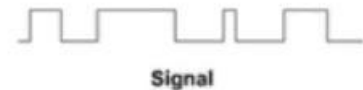


SW1 MAC Table

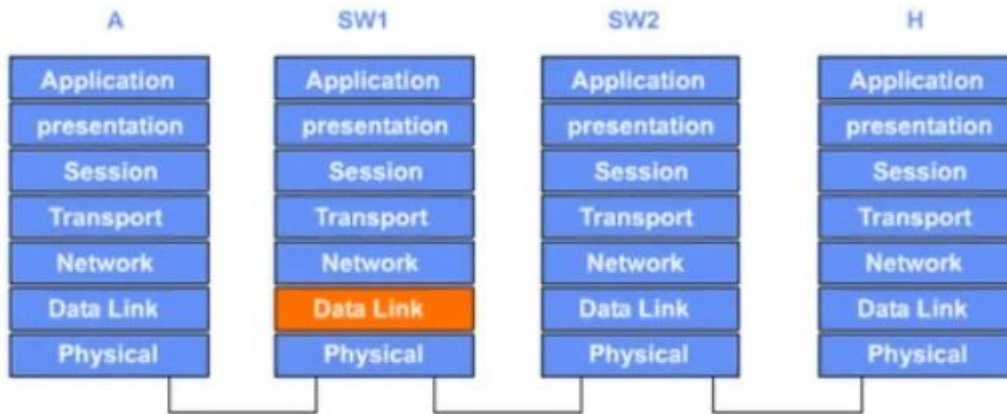
MAC	Interface
aaa	1

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation



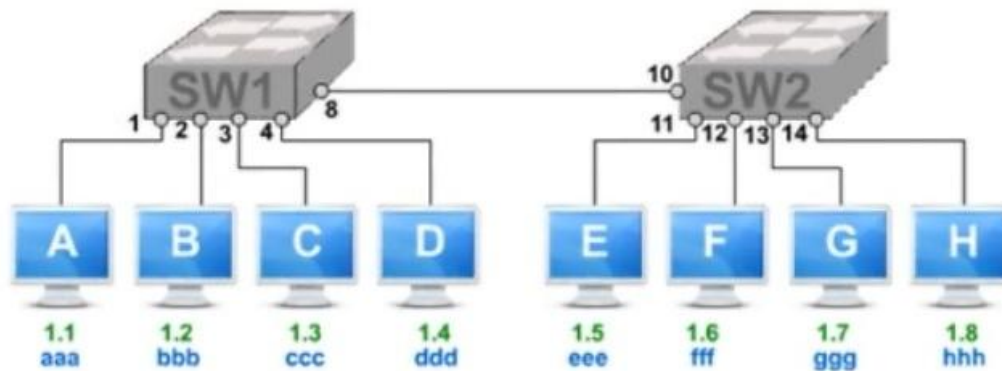
SW1 MAC Table

MAC	Interface
aaa	1

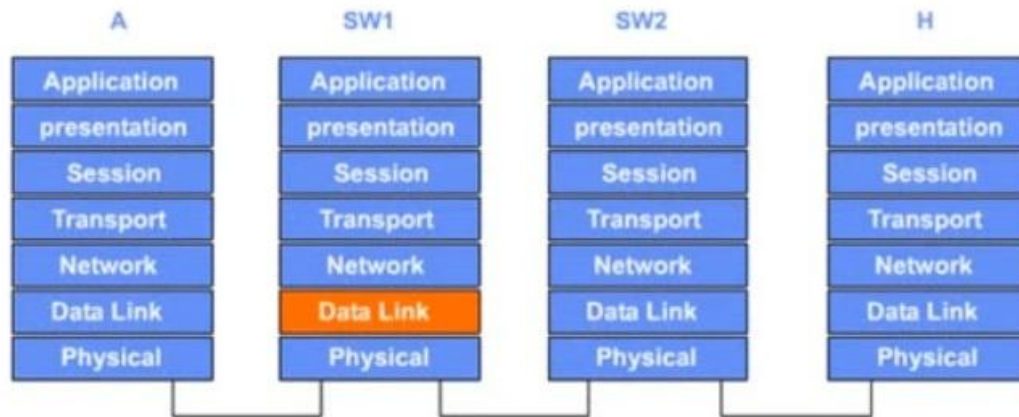
SW2 MAC Table

MAC	Interface
aaa	10
hhh	14

Dst Src
MAC MAC



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1
hhh	8

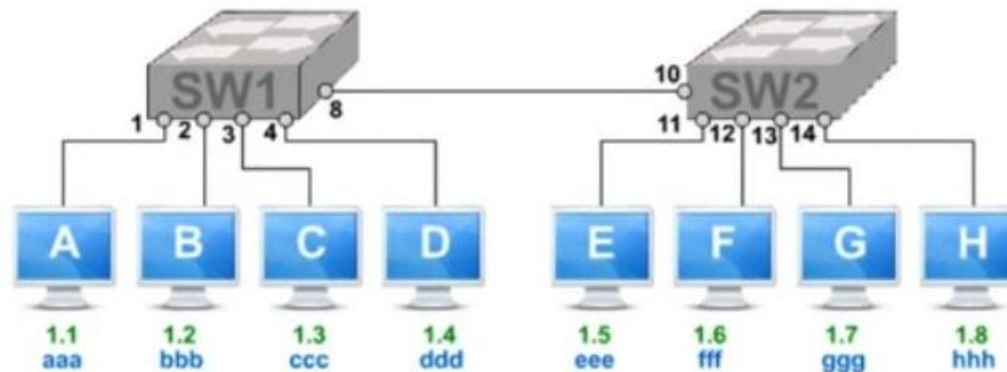
SW2 MAC Table

MAC	Interface
aaa	10
hhh	14

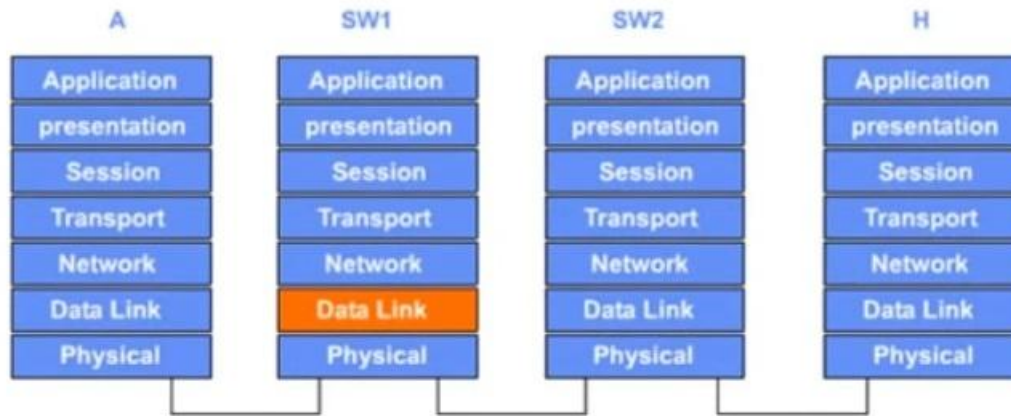
Dst Src
MAC MAC



1. Learning (Src MAC)



Switch operation



SW1 MAC Table

MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14

Dst Src
MAC MAC

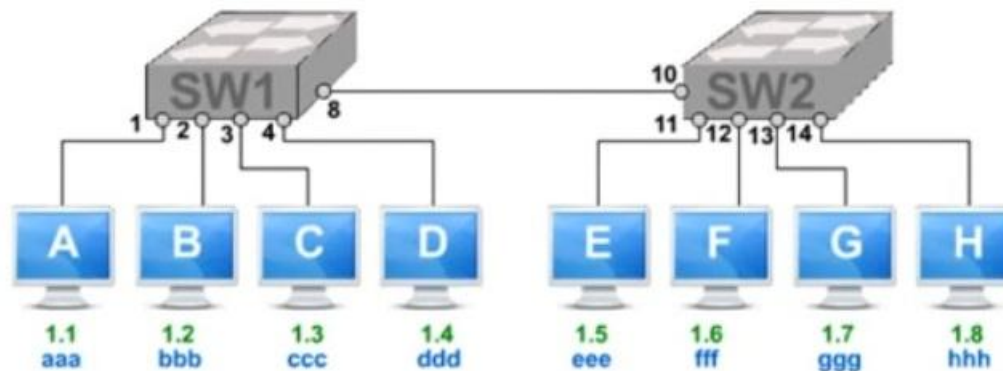


2. Forwarding (Dst MAC)

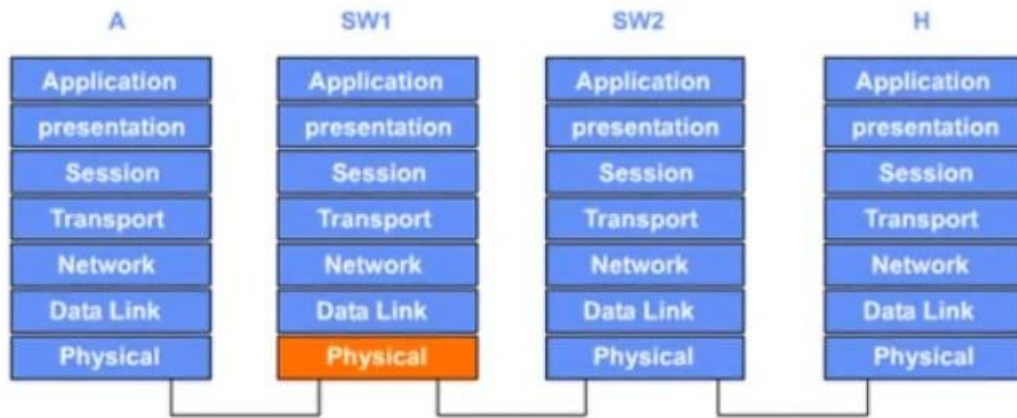
Unicast

Unknown Unicast

Broadcast



Switch operation

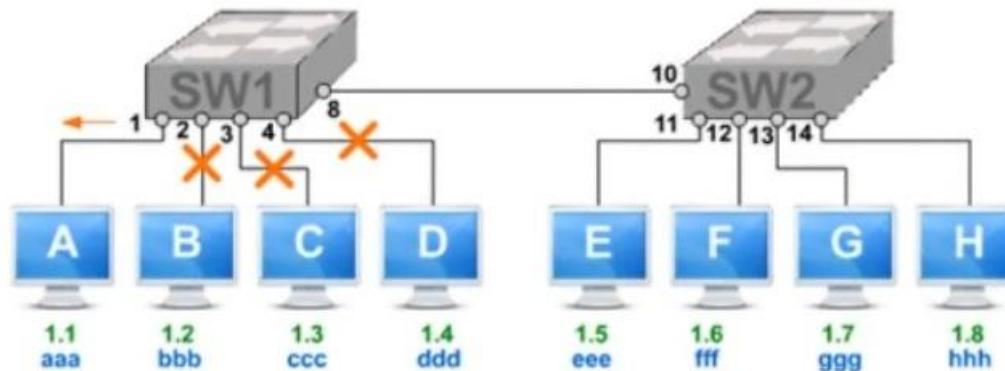
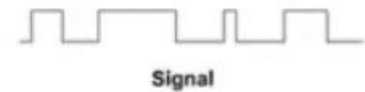


SW1 MAC Table

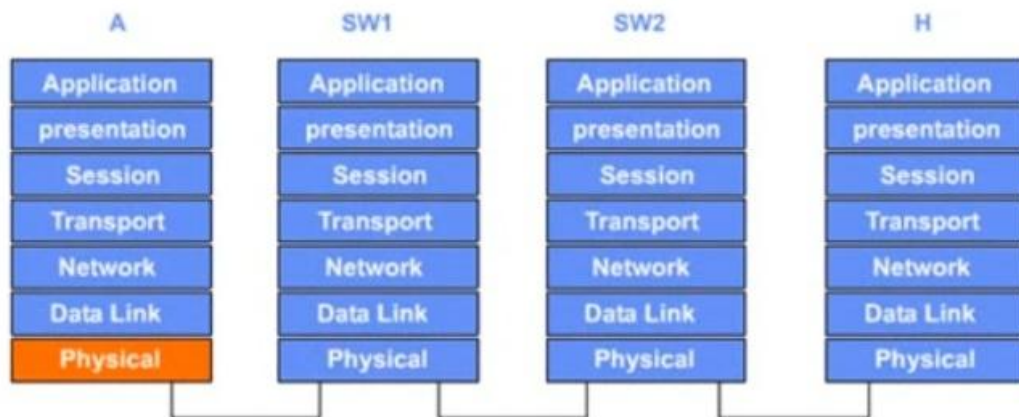
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

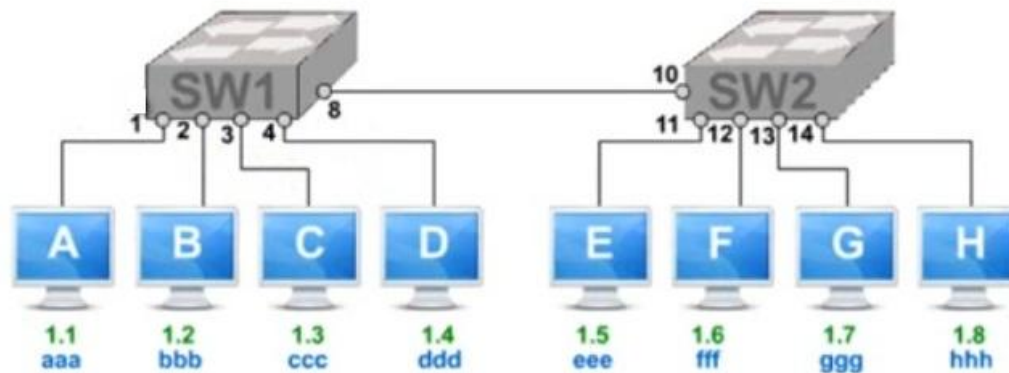
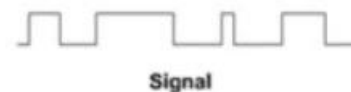


SW1 MAC Table

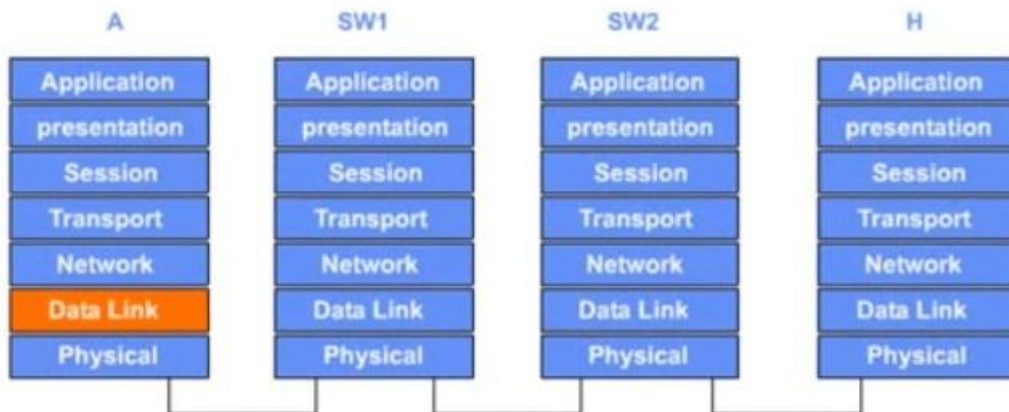
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

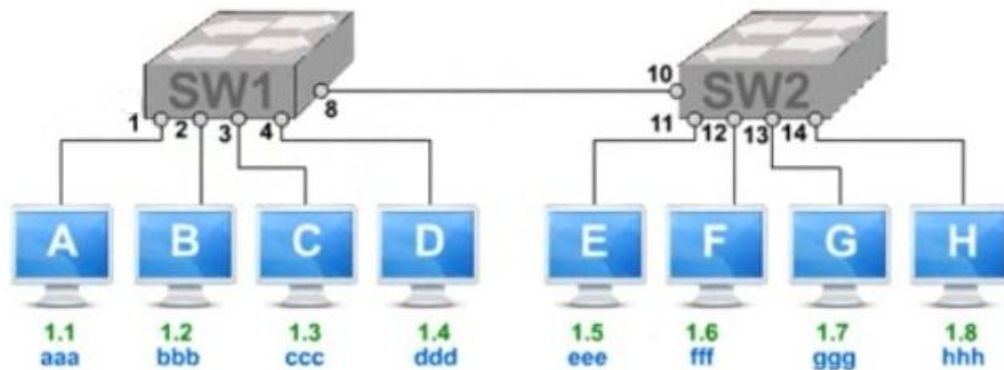


SW1 MAC Table

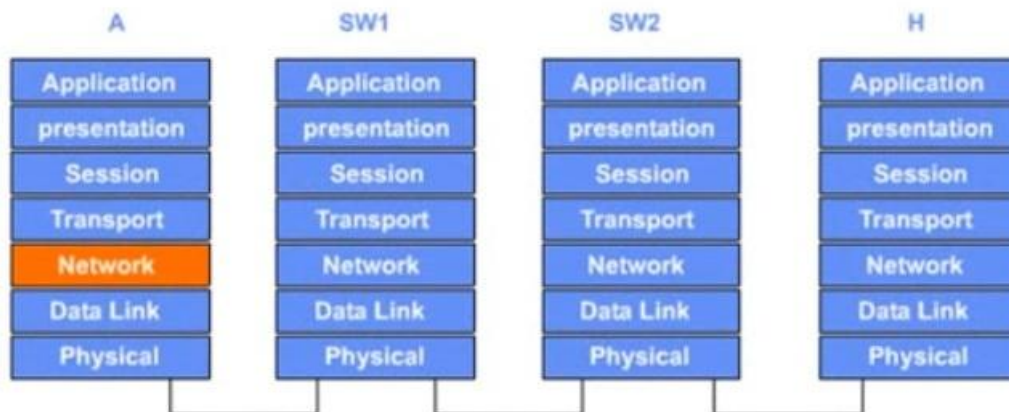
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

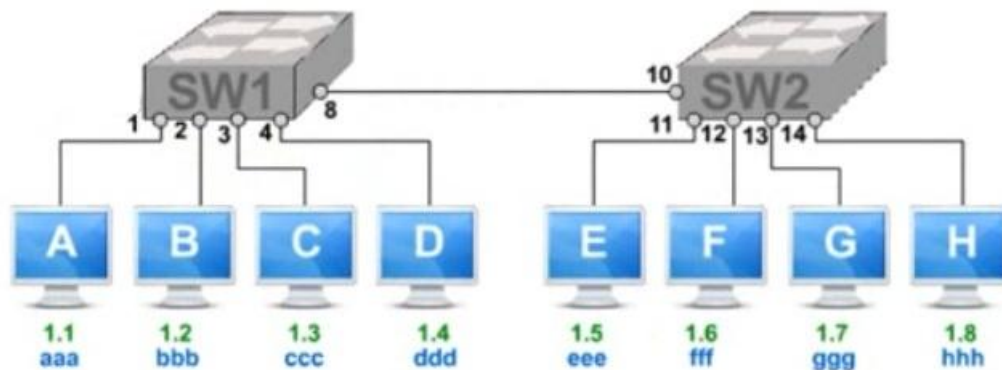


SW1 MAC Table

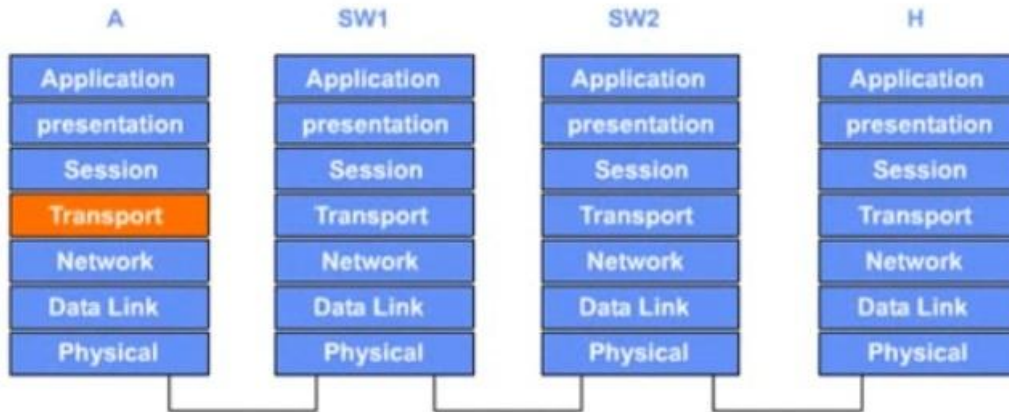
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

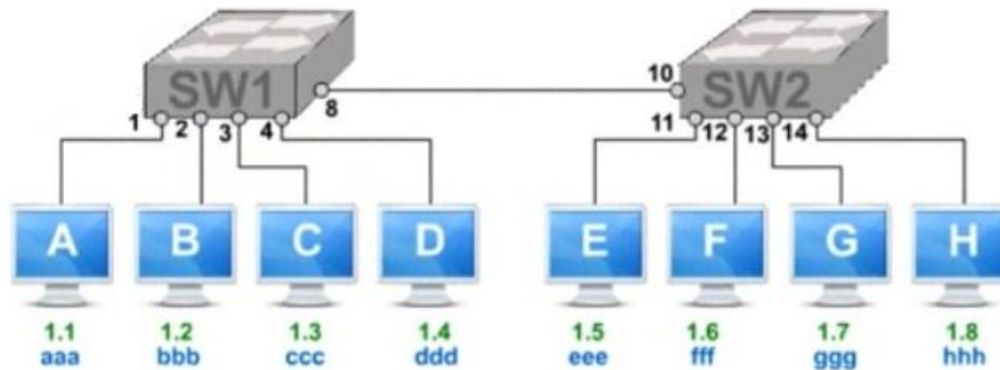


SW1 MAC Table

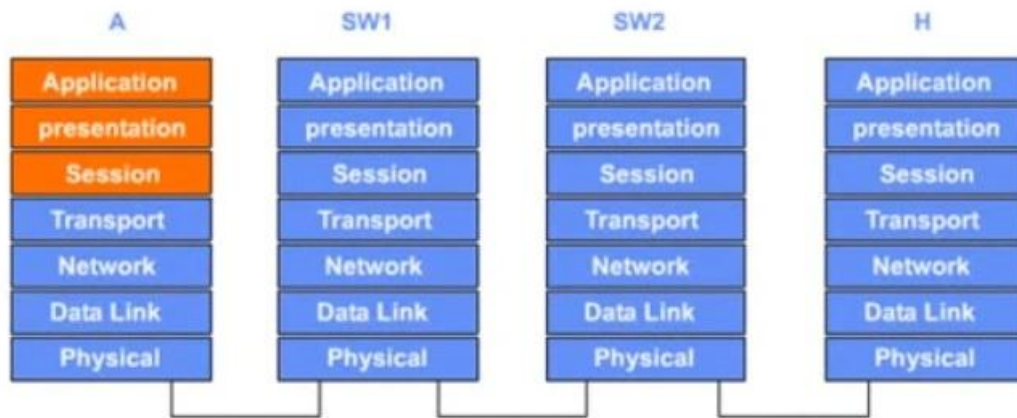
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

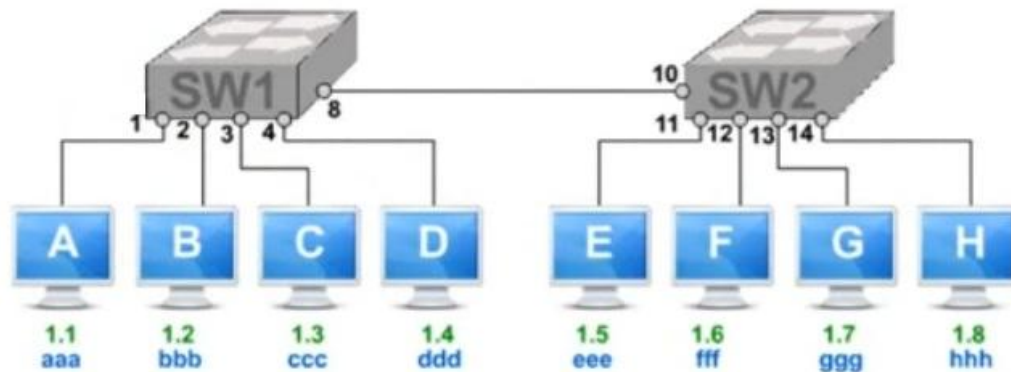


SW1 MAC Table

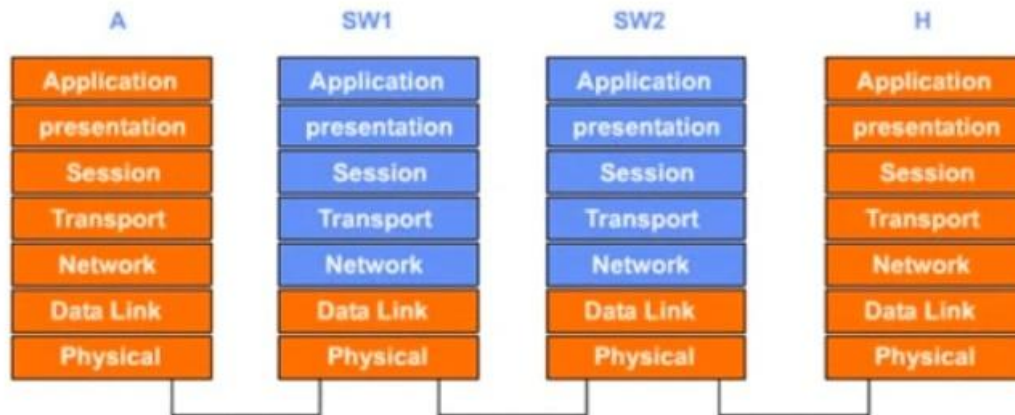
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

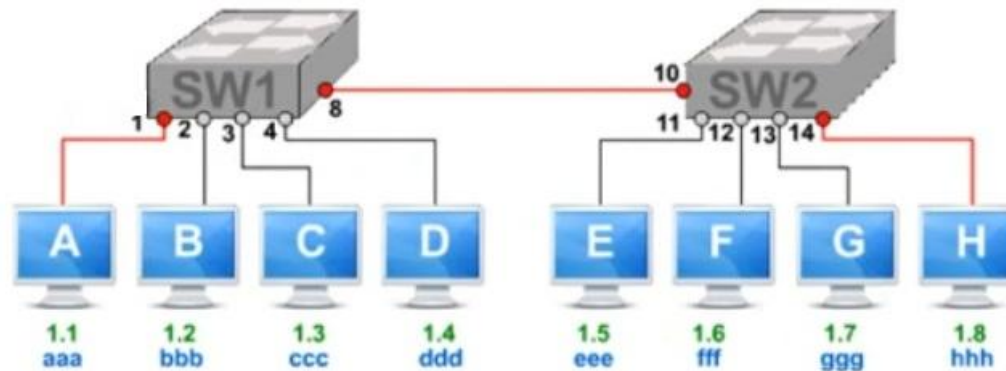


SW1 MAC Table

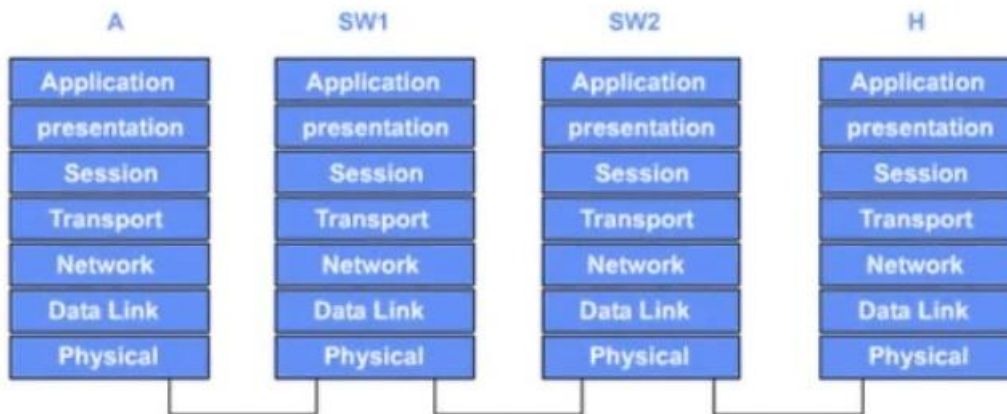
MAC	Interface
aaa	1
hhh	8

SW2 MAC Table

MAC	Interface
aaa	10
hhh	14



Switch operation

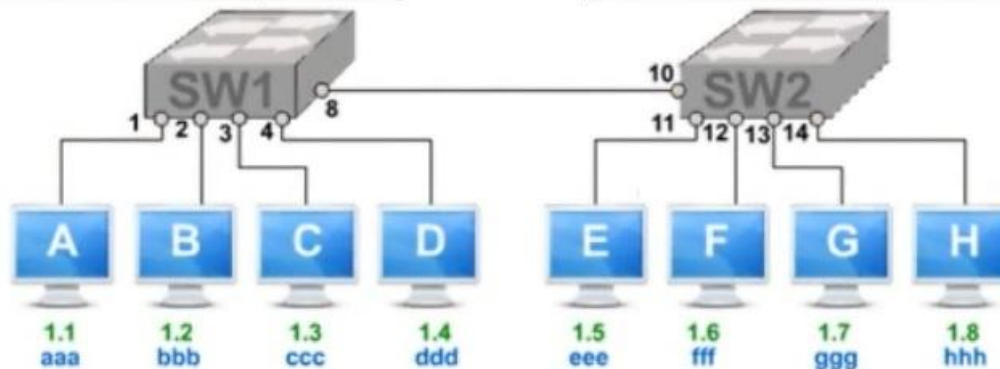


SW1 MAC Table

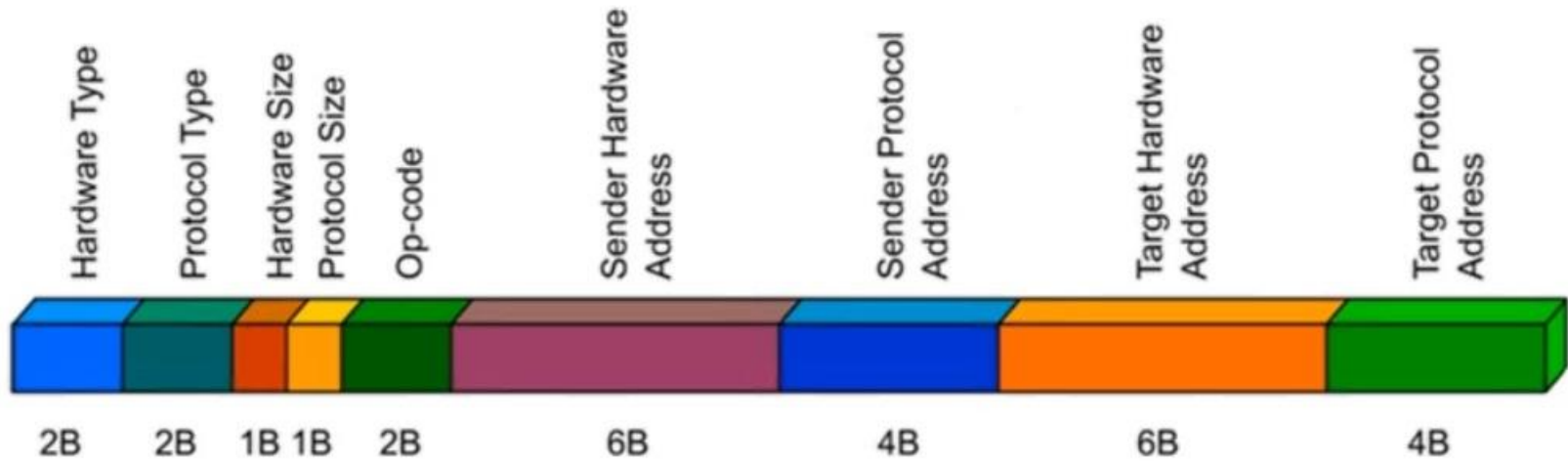
MAC	Interface
aaa	1
bbb	2
ccc	3
ddd	4
hhh , eee , fff , ggg	8

SW2 MAC Table

MAC	Interface
hhh	14
eee	11
fff	12
ggg	13
aaa , bbb , ccc , ddd	10



ARP (Address Resolution Protocol)



ARP (Address Resolution Protocol)

- What is the term "**Arp Communication**"?
- What is the term "**Arp caching**"?

ARP (Address Resolution Protocol)

```
Microsoft Windows [Version 6.1.7600]  
Copyright (c) 2009 Microsoft Corporation. All rights reserved.
```

```
C:\Users\shariaty.a>arp -a
```

```
Interface: 10.140.1.225 --- 0xc  
Internet Address      Physical Address      Type  
10.140.1.15           00-1e-0b-c7-22-2a    dynamic  
10.140.1.17           00-1e-0b-da-3a-10    dynamic  
10.140.1.21           00-1e-0b-bc-cc-86    dynamic  
10.140.1.26           18-a9-05-62-fa-ba    dynamic  
10.140.1.48           00-0c-29-43-fb-7d    dynamic  
10.140.1.53           00-24-81-e9-1a-0e    dynamic  
10.140.1.56           00-24-81-e9-37-a0    dynamic  
10.140.1.84           00-1f-16-01-05-67    dynamic  
10.140.1.90           00-22-5f-27-09-83    dynamic  
10.140.1.102          f0-4d-a2-83-34-38    dynamic  
10.140.1.119          f0-4d-a2-83-35-62    dynamic  
10.140.1.154          00-1f-16-01-4b-6e    dynamic  
10.140.1.202          00-1a-80-55-e7-55    dynamic  
10.140.1.203          00-13-e8-5c-0a-41    dynamic  
10.140.1.205          00-1f-d0-09-3d-b8    dynamic  
10.140.1.217          00-1f-16-01-b6-6c    dynamic  
10.140.1.222          00-1e-8c-93-a6-0a    dynamic  
10.140.1.255          ff-ff-ff-ff-ff-ff    static  
224.0.0.22           01-00-5e-00-00-16    static  
224.0.0.252          01-00-5e-00-00-fc    static  
239.255.255.250      01-00-5e-7f-ff-fa    static
```