CS 305 Lab Tutorial
Lab14 ARP, Switch(Layer2)

Dept. Computer Science and Engineering
Southern University of Science and Technology

SUSTech
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Thanks to Wei WANG

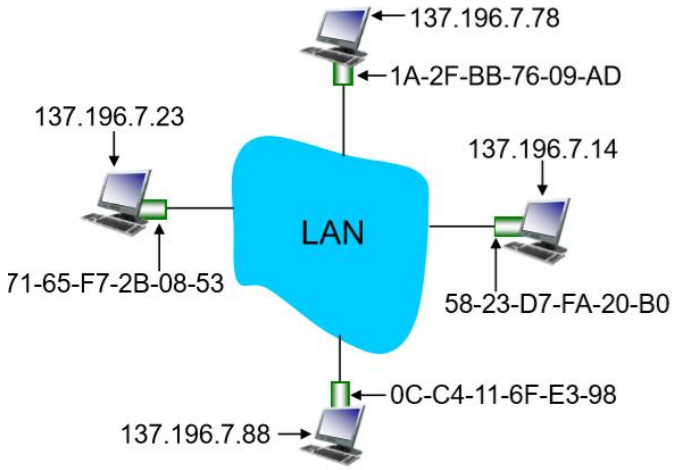
Topic

- Layer2 packet Generation
  - MAC Address
  - Address Resolution Protocol(ARP)
  - ARP Table
- Layer2 packet forwarding
  - Switch(Layer2)
    - MAC Address Table
    - Layer2 Broadcast & STP
    - VLAN (access & trunk)
- Practice

MAC address

- MAC (or LAN or physical or Ethernet) address:
  - function: *used 'locally" to get frame from one interface to another physically-connected interface (same network, in IP-addressing sense)*
  - 48 bit MAC address (for most LANs) burned in NIC ROM, also sometimes software settable
  - e.g.: 1A-2F-BB-76-09-AD

hexadecimal (base 16) notation
(each "numeral" represents 4 bits)



Q1: What's the MAC address of the Network Card of your PC?
Q2: What's the MAC address of the Network Card of a reachable network node? How to get it?
Q3: Is there any MAC address on router, for example, is there any MAC address on the default Gateway of your PC?

ARP(Address Resolution Protocol)

```
   23 3.409057   Micro-St_b3:5c:39   Broadcast        ARP          Who has 172.18.130.25? Tell 172.18.130.27
   24 3.409348   Micro-St_b0:d9:cd   Micro-St_b3:5c… ARP          172.18.130.25 is at 44:8a:5b:b0:d9:cd
<
> Frame 23: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0
> Ethernet II, Src: Micro-St_b3:5c:39 (44:8a:5b:b3:5c:39), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
v Address Resolution Protocol (request)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: request (1)
    Sender MAC address: Micro-St_b3:5c:39 (44:8a:5b:b3:5c:39)
    Sender IP address: 172.18.130.27 (172.18.130.27)
    Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
    Target IP address: 172.18.130.25 (172.18.130.25)
```

```
   24 3.409348   Micro-St_b0:d9:cd   Micro-St_b3:5c… ARP          172.18.130.25 is at 44:8a:5
<
> Frame 24: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
> Ethernet II, Src: Micro-St_b0:d9:cd (44:8a:5b:b0:d9:cd), Dst: Micro-St_b3:5c:39 (44:8a:5b:
v Address Resolution Protocol (reply)
    Hardware type: Ethernet (1)
    Protocol type: IPv4 (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: reply (2)
    Sender MAC address: Micro-St_b0:d9:cd (44:8a:5b:b0:d9:cd)
    Sender IP address: 172.18.130.25 (172.18.130.25)
    Target MAC address: Micro-St_b3:5c:39 (44:8a:5b:b3:5c:39)
    Target IP address: 172.18.130.27 (172.18.130.27)
```

ARP(requst , reply)

- While a network node just know the destination IP but have no idea about the **destination MAC address**, it would initiate an **ARP request** and **broadcast** it.
- While the destination node receive the ARP repuest, it would send back a **ARP reply** with its IP address and MAC address in it.

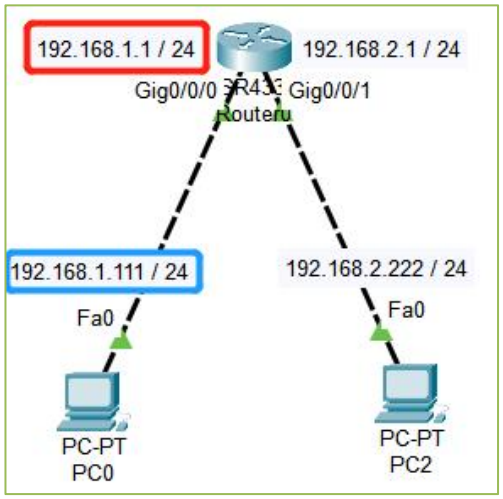
https://www.rfc-editor.org/rfc/rfc826.txt

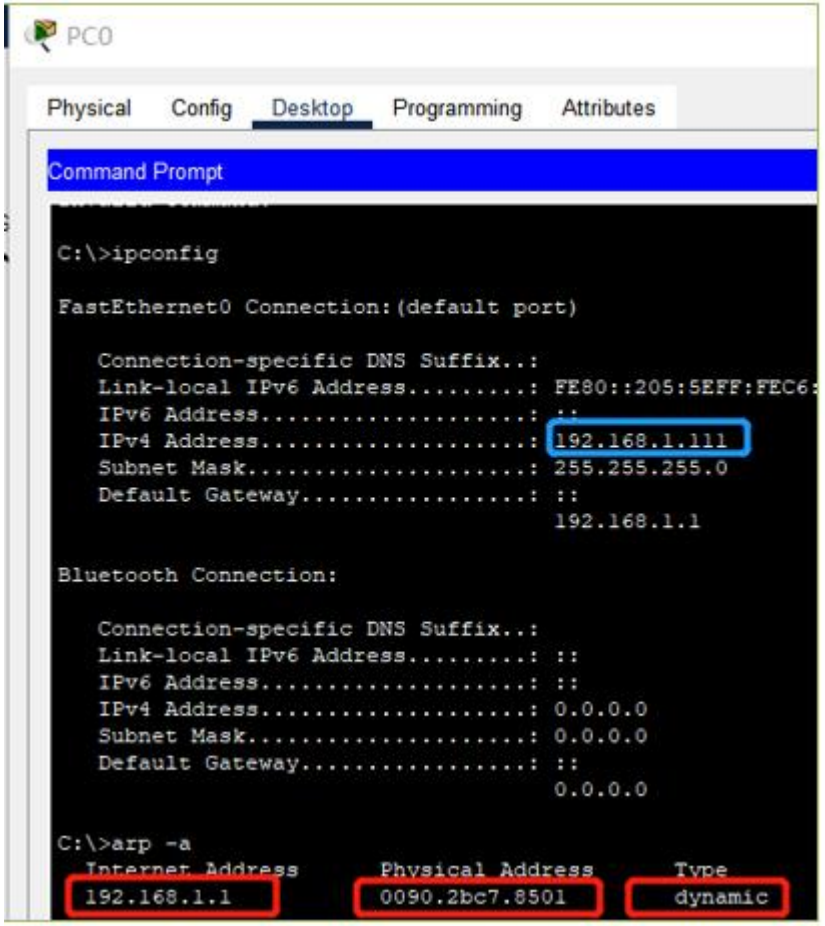
ARP table(1)

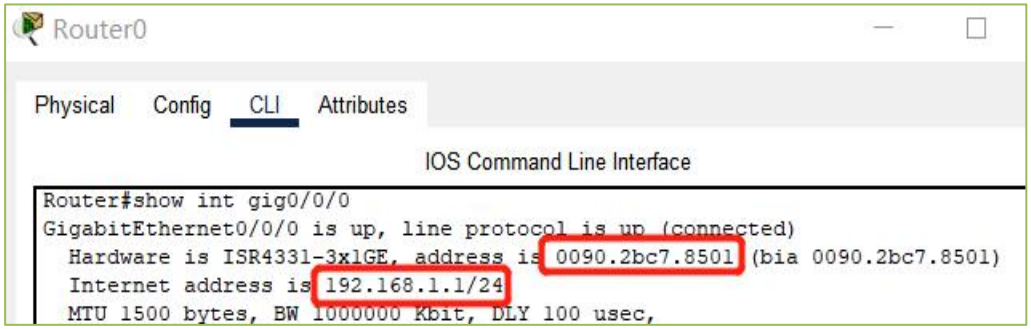
Q: How to get the MAC address of the default gateway of your PC0 ?

A: invoke “ping ” on PC0, the destination could be:

1) IP address of default gateway ?
2) IP address of PC2 ?
3) IP address of Gig0/0/1 of the router ?







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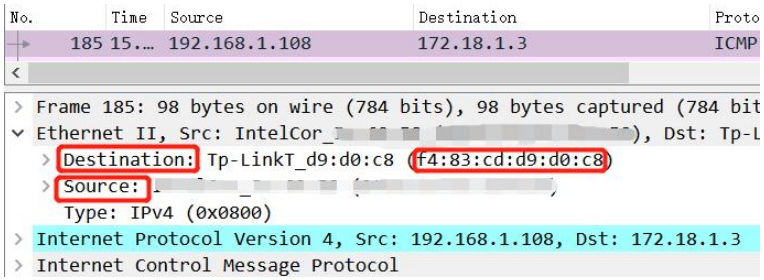
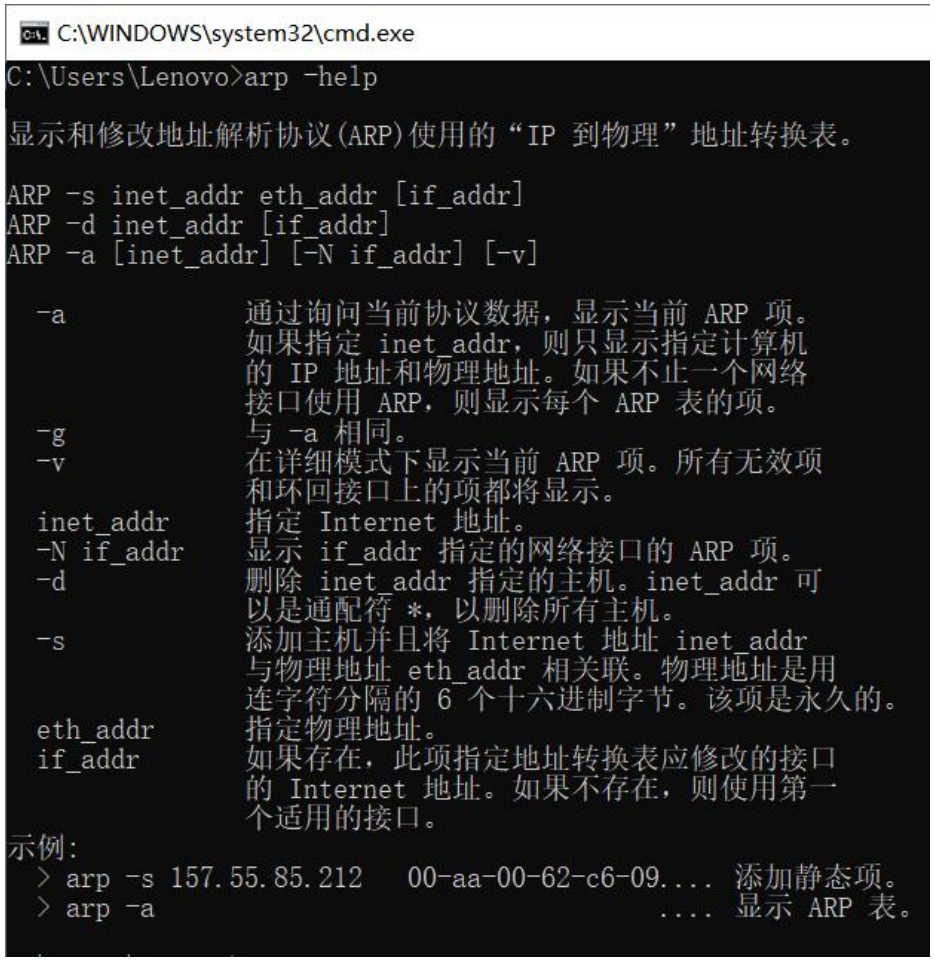
https://www.rfc-editor.org/rfc/rfc826.txt

ARP table(2)

- Network node learn the relationship between the IP and the MAC address, store them in the ARP table.
- The ARP information items in the ARP table could be set, learned and deleted.
  - in windows, using "arp" command (--------->)





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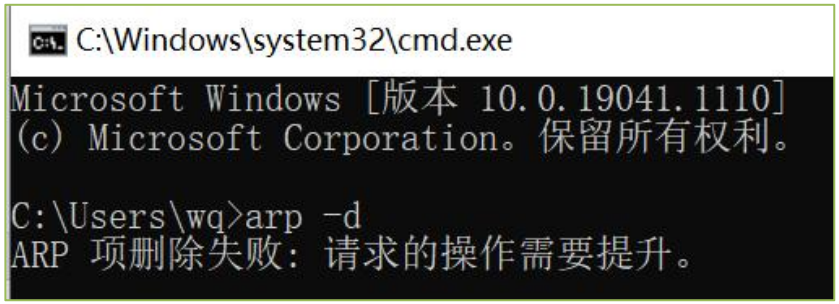
https://www.rfc-editor.org/rfc/rfc826.txt

Tips about “arp -d”



If you are not allowed(as the prompt info showed on the left top hand) to use “arp -d” , it is suggested to:

1) Firstly **open a new command** window as **administrator**(as showed on the left buttom hand).

2) Then run the “arp -d” command in the new window.

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Practice 13.1(ARP&ARP-Table)

To find the MAC Address of 1) your PC's default Gateway 2) a reachable network node.

Using Wireshark to capture the ARP request and ARP reply, and answer the following question.

part1:

1) While there **is** a record about the IP and MAC address of default Gateway in the current host:

- "**ping**" the default gateway and capturing packets to see **whether there is an arp query message**. **If no, explain the reason. If yes, what is the destination IP in the arp query?**

2) While there is **NO** record about the IP and MAC address of default Gateway in the current host:

- "**ping**" the default gateway and capturing packets to see **whether there is an arp query message**. **If no, explain the reason. If yes, what is the destination IP in the arp query?**

part2:

Use "arp -d" to **clear the arp table information** in the current host, "**ping**" the address of a server in the network to see **whether there is an arp query message**. **If no, explain the reason. If yes, what is the destination IP in the arp query?**

TIPs on Wireshark:

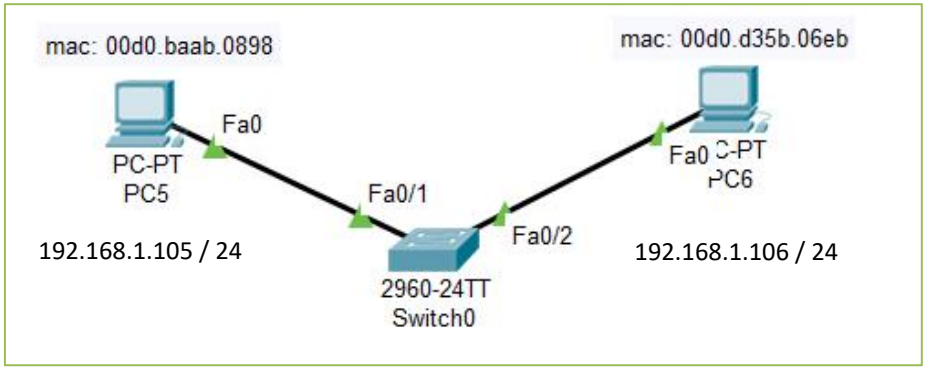
1. "arp" could be used as capture filter.
2. "eth.addr == **:**:**:**:**:**" could be used as display filter.

Switch(Layer 2) - MAC Address Table(1)

- **Switch** use the **MAC Address Table** to **forward the package on Layer2**.

Make PC5 “ping” PC6’s IPv4 address to invoke **Switch0** to switch packets.

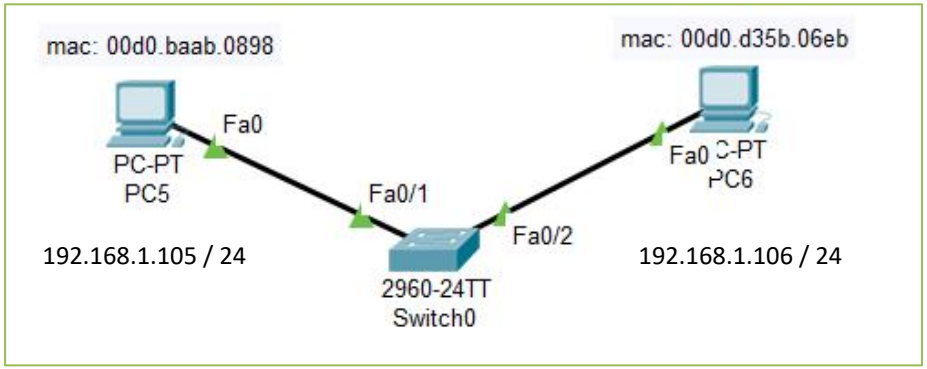
```
Switch# show mac address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    00d0.baab.0898    DYNAMIC     Fa0/1
   1    00d0.d35b.06eb    DYNAMIC     Fa0/2
Switch#
```



Q1: If the destination MAC address of a packet is a **broadcast address**, how would the **swith** do after receiving the packet?
Q2: If the PC5 and PC6 are **in the different subnets**, could the switch build the MAC Address Table?

Switch(Layer 2) - MAC Address Table(2)

Switch is a **plug and play** device, it can buil **MAC Address Table by learning from the received packet**: to record the interface id and the source mac address of the packet which is received by the interface.




```
Switch# show mac address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    00d0.baab.0898    DYNAMIC     Fa0/1
   1    00d0.d35b.06eb    DYNAMIC     Fa0/2
Switch#
```

Here the Switch build the MAC Address Table by the ARP packets it received.

Simulation Panel

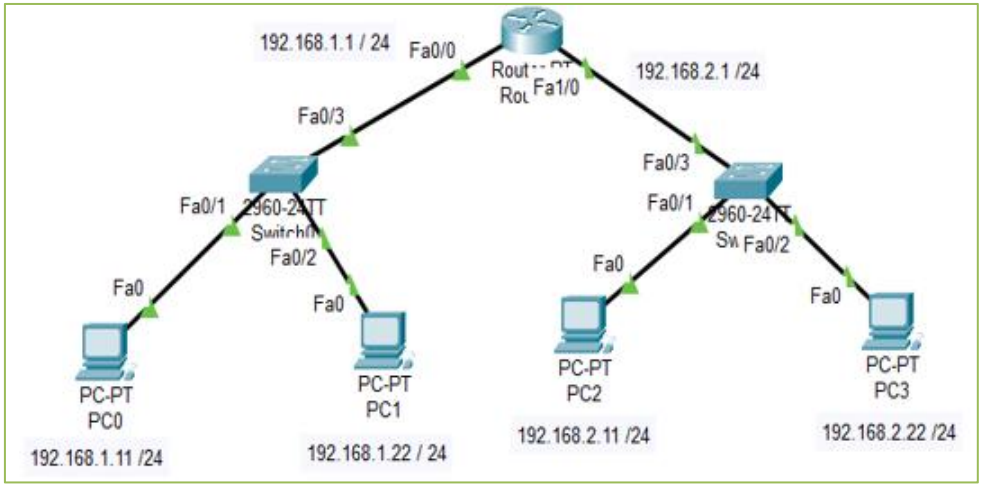
Event List

Vis.	Time(sec)	Last Device	At Device	Type
	0.000	--	PC5	ICMP
	0.000	--	PC5	ARP
	0.001	PC5	Switch0	ARP
	0.002	Switch0	PC6	ARP
	0.003	PC6	Switch0	ARP
	0.004	Switch0	PC5	ARP
	0.004	--	PC5	ICMP
	0.005	PC5	Switch0	ICMP
	0.006	Switch0	PC6	ICMP
	0.007	PC6	Switch0	ICMP
	0.008	Switch0	PC5	ICMP
	1.011	--	PC5	ICMP

Practice 13.2-1(ARP & Switch)

Build the network as below topology, do the following test on **simulation mode** of Packet-Tracer

- Clear the arp table on PC0, then invoke“ping”on PC0 to reach PC1
  - Describe the transmission path of arp request and arp reply.
  - What does switch do after receive the arp request or arp reply: send back, forward or drop ?
  - What does router do after receive the arp request or arp reply: send back, forward or drop ?



Tips about Packet-Tracer: 1)***“arp -d”*** could be used to clear the arp-table on PC; 2) **Turn off the interface**(the CLI command is “**shutdown**”) on **Switch** / **Route** could **clear** its related **arp-table/ mac-address table**.

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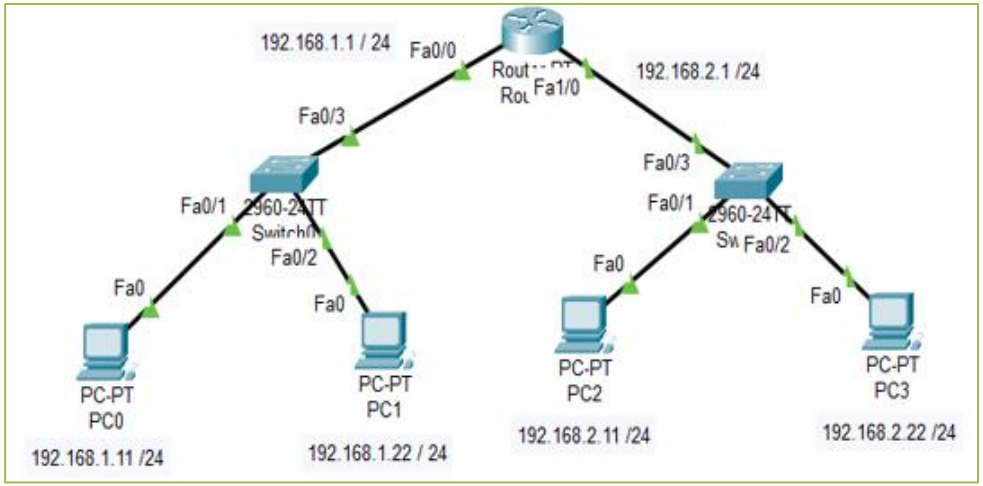
Practice 13.2-2(ARP & Default-Gatway)

Build the network as below topology, do the following test on **simulation mode** of Packet-Tracer

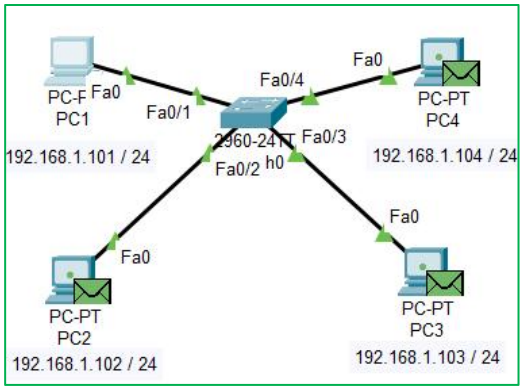
- Clear the arp table on PC0, then invoke "ping" on PC0 to reach PC2
  - Describe the transmission path of arp request and arp reply.
  - Which device(s) invoke the arp request(s)? what the "target IP address" in the arp request(s)?
  - Which device(s) invoke the arp reply(s)?
  - Is there any info about gateway in these arp request(s) or arp reply(s)?



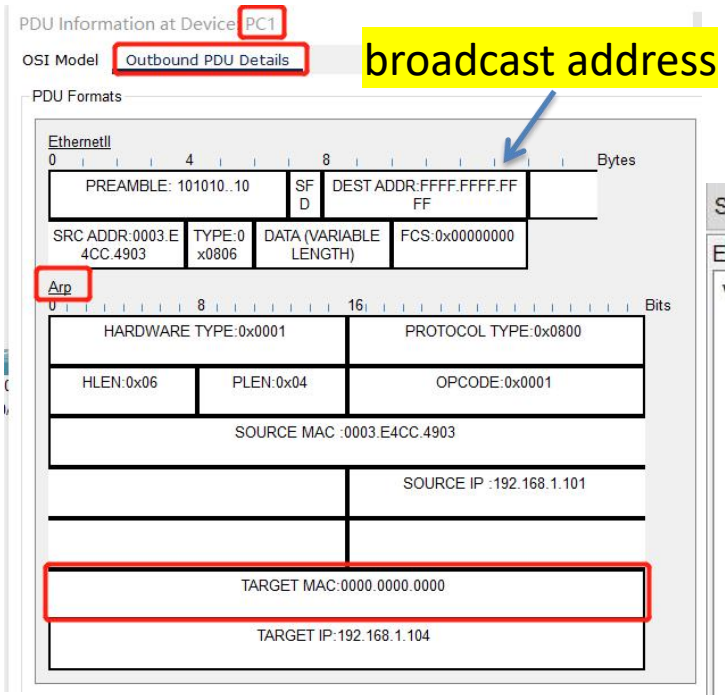
Tips about Packet-Tracer: 1)***"arp -d"*** could be used to clear the arp-table on PC; 2) **Turn off the interface**(the CLI command is "**shutdown**") on **Switch** / **Route** could **clear** its related **arp-table/ mac-address table**.

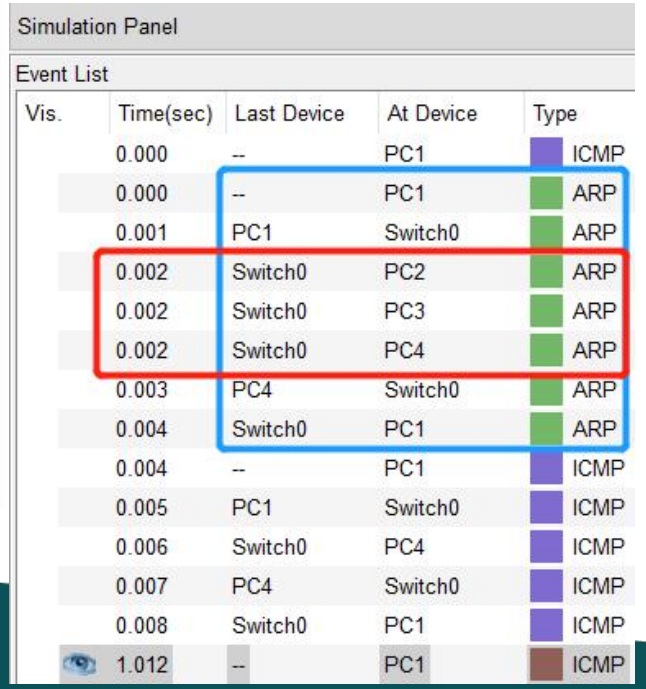
Switch-Broadcast

- MAC Broadcast Address : all the 48 bits is 1.
- Switch: When the switch receives a broadcast packet, the switch forwards the packet to all interfaces except the interface receiving the packet.



Test: build the network, then invoke “ping 192.168.1.104” on PC1





Switch-STP(Spanning-Tree Protocol)

- **When there is(are) loop(s) in the network, broadcast will bring broadcast storm!**
- **Spanning Tree** algorithm is always used in the Ethernet network to **create a spanning tree** with a interface of a switch as the root, automatically block one or more redundant ports in logic **to avoid loops**.


```
SS1#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0090.0C79.A27E
              This bridge is the root
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15
sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0090.0C79.A27E
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15
sec
              Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- --------
--------------------------------
Fa0/3            Desg FWD 19        128.3    P2p
Fa0/2            Desg FWD 19        128.2    P2p
Fa0/1            Desg FWD 19        128.1    P2p
```

```
SS2#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0090.0C79.A27E
              Cost        19
              Port        1(FastEthernet0/1)
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15
sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     00D0.5837.D0AC
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15
sec
              Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- --------
--------------------------------
Fa0/1            Root FWD 19        128.1    P2p
Fa0/2            Desg FWD 19        128.2    P2p
Fa0/3            Altn BLK 19        128.3    P2p
```

Switch-VLAN(1): default VLAN

- **VLAN**(Virtual Local Area Network) is a communication technology that **divides a physical LAN into multiple broadcast domains logically**.
  - **The hosts in VLAN can communicate with each other directly**.
  - **All the interface of a Switch are in the same VLAN by default**.

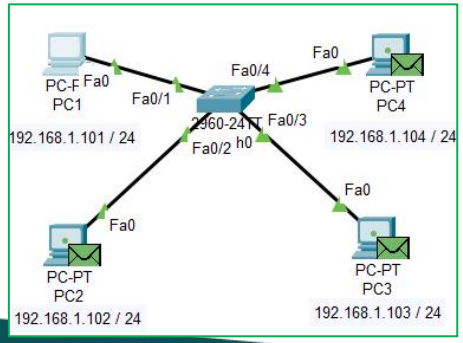
Switch0

Physical Config CLI Attributes

IOS Command Line Interface

```
Switch#show vlan brief

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
                                                 Gig0/1, Gig0/2
1002 fddi-default                      active
1003 token-ring-default                active
1004 fddinet-default                   active
1005 trnet-default                     active
Switch#
```



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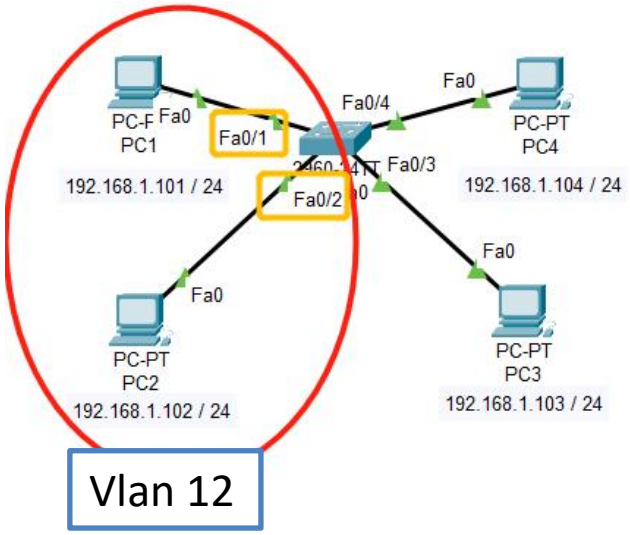
Switch-VLAN(2-1) - Build a VLAN

- **VLAN**(Virtual Local Area Network) is a communication technology that **divides a physical LAN into multiple broadcast domains logically**.
  - **The VLANs cannot communicate with each other directly, so the broadcast message is limited in one VLAN.**
  - All the interface of a Switch are in the same VLAN by default.



To build a Vlan, follow the following steps:

1: **creat** a Vlan on the switch

```
Switch(config)#vlan 12
```

2: make the **interface** to **access** to the vlan

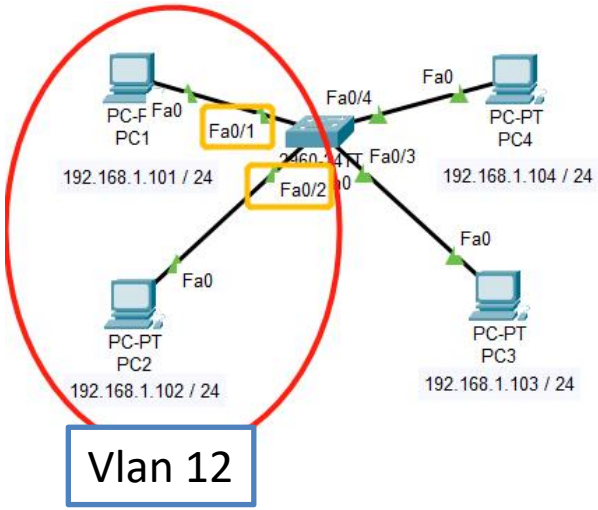
```
Switch(config)#int fa0/1
Switch(config-if)#switchport access vlan 12
Switch(config-if)#exit
Switch(config)#int fa0/2
Switch(config-if)#switchport access vlan 12
```

show the vlan brief info to check

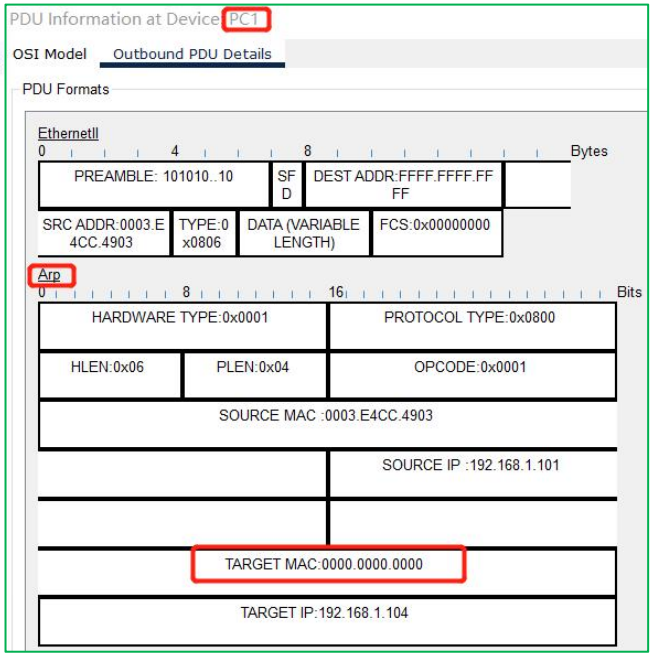
```
Switch#show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    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, Gig0/1, Gig0/2
12   VLAN0012                         active    Fa0/1, Fa0/2
```

Switch-VLAN(2-2) - Test a VLAN

- **VLAN**(Virtual Local Area Network) is a communication technology that **divides a physical LAN into multiple broadcast domains logically**.
  - The hosts in VLAN can communicate with each other directly.
  - **The VLANs cannot communicate with each other directly, so the broadcast message is limited in one VLAN.**



Test: After build Vlan 12, invoke “arp -d”, “ping 192.168.1.104” on PC1



1) The broadcast ARP request can only reach PC2 which is in the same VLAN as PC1.
2) PC4 is unreachable from PC1.

Simulation Panel

Event List

Vis.	Time(sec)	Last Device	At Device	Type
	0.000	--	PC1	ICMP
	0.000	--	PC1	ARP
	0.001	PC1	Switch0	ARP
	0.002	Switch0	PC2	ARP
	0.797	--	Switch0	STP
	0.798	Switch0	PC1	STP
	0.798	Switch0	PC2	STP
	0.966	--	Switch0	STP
	0.967	Switch0	PC4	STP
	0.967	Switch0	PC3	STP
	2.002	--	PC1	ICMP
	2.795	--	Switch0	STP

Switch-VLAN(3-1) - switchport mode

```
Switch(config-if)#switchport mode ?
  access    Set trunking mode to ACCESS unconditionally
  dynamic   Set trunking mode to dynamically negotiate access or trunk mode
  trunk     Set trunking mode to TRUNK unconditionally
```

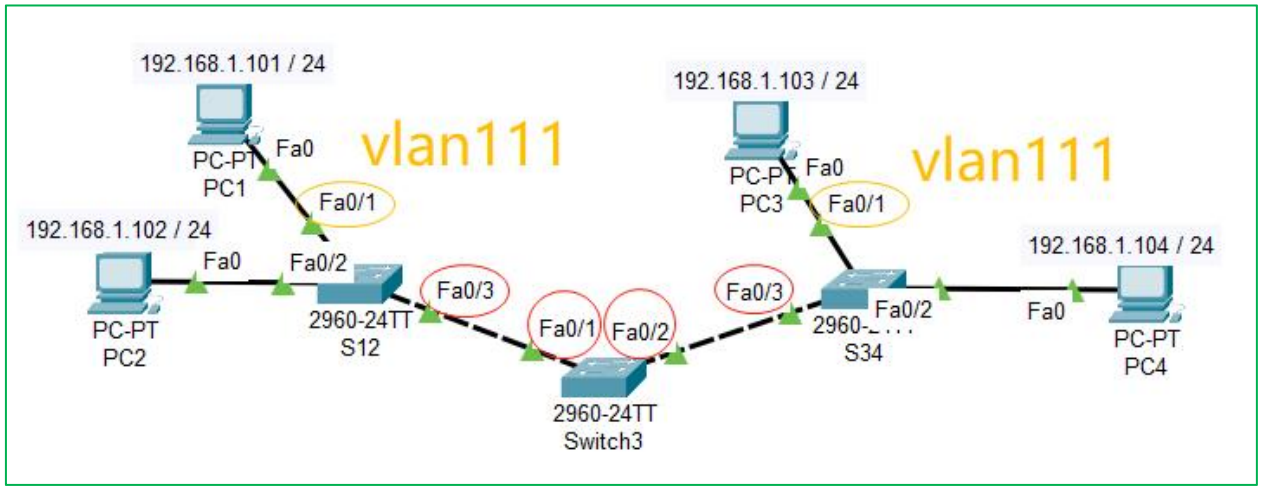
- **Access Link:**
  - A link used to connect **a user host to a switch**. Generally, the host does not need to know which VLAN it belongs to, and the host hardware usually does not recognize the frame with VLAN tag. Therefore, the frames sent and received by the host are untagged frames.
- **Trunk Link:**
  - Used for **interconnection between switches or connection between switches and routers**. The trunk link can carry multiple different VLAN data. When the data frame is transmitted on the trunk link, the devices at both ends of the trunk link need to be able to identify which VLAN the data frame belongs to, so the frames transmitted on the trunk link are tagged frames.

```
Switch(config)#interface fa 0/3
Switch(config-if)#switchport mode trunk
Switch(config-if)#exit
```


http://grouper.ieee.org/groups/802/1/pages/802.1Q.html

Switch-VLAN(3-2) - switchport mode

- **Access Link:**
  - A link used to connect **a user host to a switch**.
- **Trunk Link:**
  - Used for **interconnection between switches or connection between switches and routers**. The trunk link can carry multiple different VLAN data.



1) Creat Vlan 111 on switchs (**S12**, **S34** and **Switch3**)

2) Set the **fa0/1** of switchs(**S12**, **S34**) to **access vlan 111**

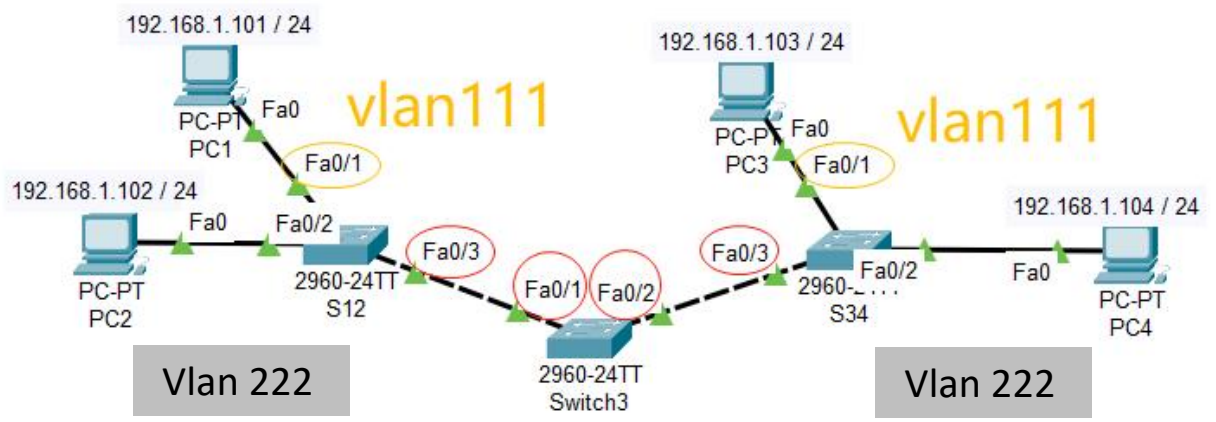
3) Set the **fa0/1** and **fa0/2** of **Switch3** and **fa0/3** of switchs(**S12, S34**) as "**switchport mode trunk**"

Q: while invoke "ping" on PC1 to PC2,PC3 and PC4 respectivly, which PC(s) is reachable from PC1?

Practice 13.3

Build the network as following topology, set the interfaces and the vlans follow the steps described on the right hand. Answer the following question:

- Q1: invoke “ping” on PC2 to PC1,PC3 and PC4 respectivly, which PC(s) is reachable from PC2?
- Q2: If PC4 is not reachable from PC2, how to make PC4 reachable from PC2?



1) Creat Vlan 111 on switchs (S12, S34 and Switch3)

2) Set the **Fa0/1** of switchs(**S12, S34**) to **access vlan 111**

3) Set the **Fa0/1** and **Fa0/2** of **Switch3** and **Fa0/3** of switchs(**S12, S34**) as “**switchport mode trunk**”

4) **Creat Vlan 222 on switchs (S12, S34**)

5) Set the **Fa0/2** of switchs(**S12, S34**) to **access vlan 222**

...