CS 305 Lab Tutorial
Lab10 Router

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

SUSTech
Southern University
of Science and Technology

Thanks to Wei WANG

Topic

- Interface of Route
  - features
  - configuration
- Route and forward
  - Routing-table
    - direct routing entry
    - static routing entry
    - route aggregation
- Other functions of the router(Optional)
  - DHCP service

Tips

- useful commands while in CLI
  - display
    - dis this
    - dis int brief
    - dis ip routing-table
  - configure interface
    - ip address [IPv4-address in dotted decimal] [mask]
  - configure static routing entry
    - ip route-static [destination-netID] [mask] [next-hop]
  - Configure dhcp
    - dhcp enable
    - ip pool
    - dhcp select ...

Router-introduction

A **router** is a hardware device that **connects two or more networks** and serves as a gateway between them. It is a specialized intelligent network device that **reads the address** in each packet and **determines how to transmit it.**

Function list:

- connects two or more networks
  - different types of the interfaces
  - transmit packet by the packet's destination and the route table
- conmunicate with other routers
  - Routing protocol
- other function:
  - telnet server, dhcp server,...etc.

the front

the back

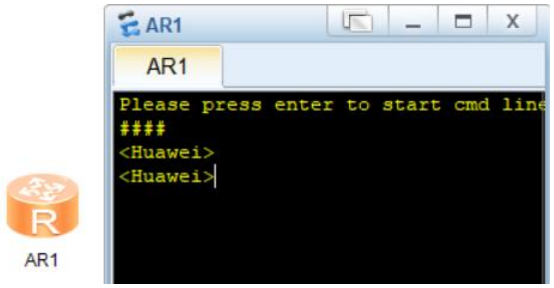
Router: in eNSP

AR-Router (access router (AR))

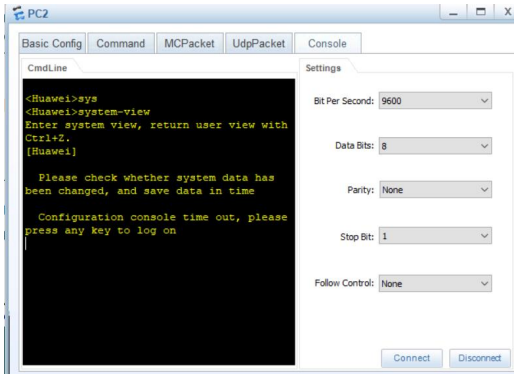
- Function list: WAN、LAN、IP application(ARP,IPv4/IPv6,DNS,DHCP,NAT,IPv6 transmission)、IP routing, Multicast, MPLS, QoS, Security(ACL,AAA,Firewall...), Reliablility, VPN, Network management(SNMP, Mirroring...)

How to configure a router on eNSP

- **Double click on the Router** to invoke the **CLI**(Command Line Interface)



- **PC** connect with Router by **CTL**(Console Line),PC logs in to the router through the terminal and **configures the router in the terminal window**



NOTE: in ENSP, Network devices can only be set up after being started!

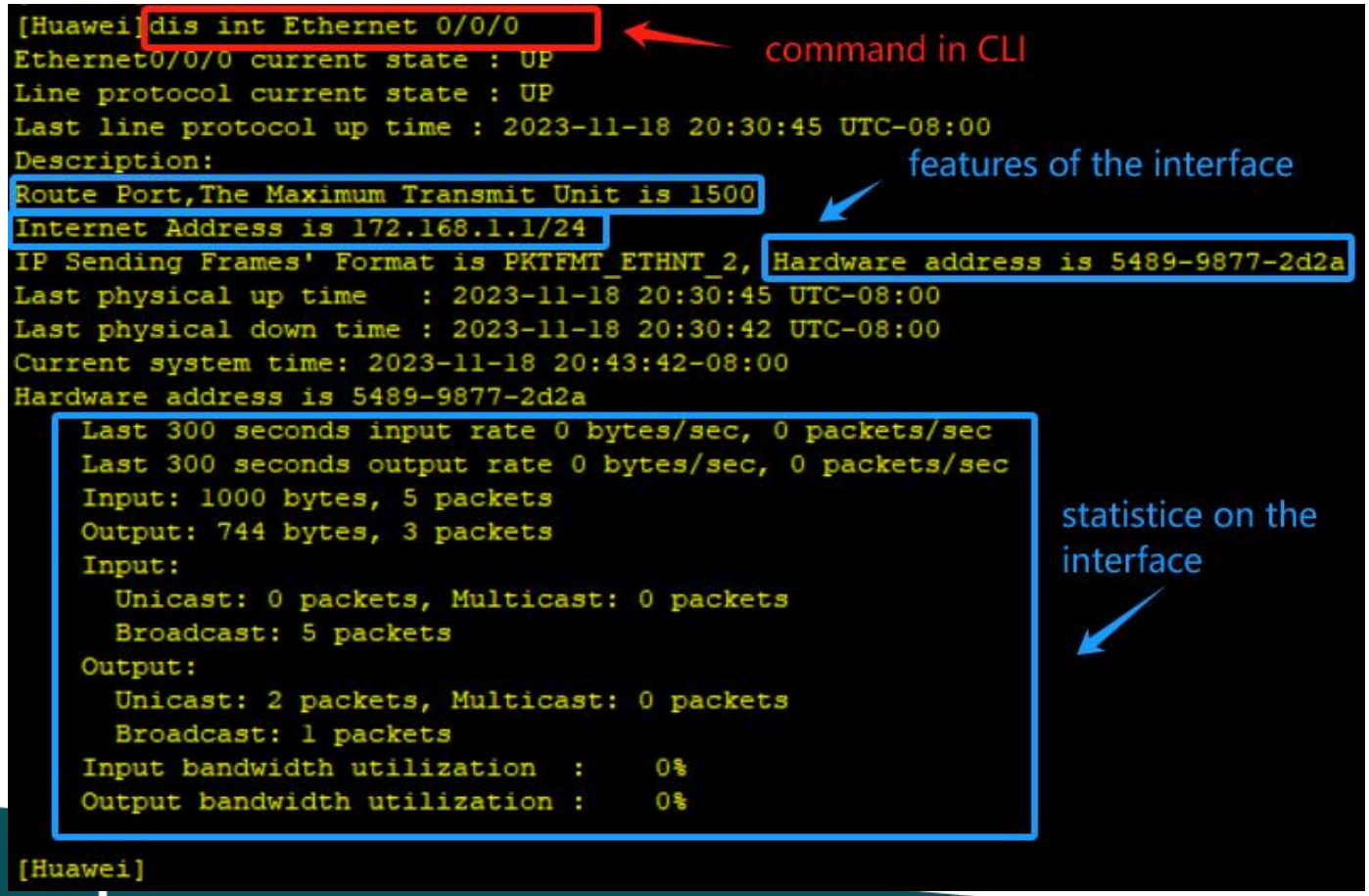
Router: interface(1)

1. interface

- Function
  - Ethernet(for connection), Console (for configuration by CLI)
- Bandwith
  - Ethernet(10Mbps), Fastethernet(100Mbps), Gigaethernet(1000Mbps)
- Layer
  - Layer2(no IP funciton), Layer3(IP function)
  - Layer2/3(Can switch between Layer2 and Layer3)

Router: interface(2)

2. Commands *in* ***system view***
   - **dis**play **int**erface *port-name port-index*



Router: interface(2)

3. Commands in **interface function view**
   - Common
     - **display**
     - **undo**
     - …
   - IP function
     - ***ip***
     - *ipv6*
     - *nat*
     - *ospf*
     - *rip*
     - …
   - Appliction Layer function
     - **dhcp**
     - …
   - Testing
     - *ping*
     - *tracert*
     - …

```
[Huawei-Ethernet0/0/0]dis this
#
interface Ethernet0/0/0
 ip address 172.168.1.1 255.255.255.0
 dhcp select interface
 dhcp server dns-list 114.114.114.114
#
return
[Huawei-Ethernet0/0/0]
```

```
[Huawei-Ethernet0/0/0]ip ?
  address               Address
  apply                 Apply security policy
  binding               Enable binding of an interface with a VPN instance
  forward-broadcast     Specify IP directed broadcast information
  netstream             Netstream feature
  policy-based-route    Enable policy based routing on the interface
  relay                 DHCP relay
  topology              The name of topology
  verify                IP verify

[Huawei-Ethernet0/0/0]ip address ?
  X.X.X.X       IP address
  bootp-alloc   IP address allocated by BOOTP
  dhcp-alloc    IP address allocated by DHCP
  unnumbered    Share an address with another interface

[Huawei-Ethernet0/0/0]ip address 192.168.1.101 ?
  INTEGER<0-32>  Length of IP address mask
  X.X.X.X        IP address mask

[Huawei-Ethernet0/0/0]ip address 192.168.1.101
                                             ^
Error:Incomplete command found at '^' position.
[Huawei-Ethernet0/0/0]ip address 192.168.1.101 ?
  INTEGER<0-32>  Length of IP address mask
  X.X.X.X        IP address mask
```

SUSTech
Southern University of Science and Technology

Router: route-forward

The core functions of routers: forward packets according to the routing table

- 1) **search** the **destination IP address** of the packet in the **routing table**
- 2) **find** the corresponding **routing table entry** based on the **longest matching principle**
- 3) **forward packet** according to the routing table entry

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        127.0.0.0/8  Direct  0    0           D   127.0.0.1       InLoopBack0
        127.0.0.1/32 Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24   Direct  0    0           D   192.168.1.1     Ethernet0/0/0
    192.168.1.1/32   Direct  0    0           D   127.0.0.1       Ethernet0/0/0
    192.168.2.0/24   Direct  0    0           D   192.168.2.1     Ethernet0/0/1
    192.168.2.1/32   Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

Router: routing-table(1)

- **Destination/Mask**: Indicates the destination network address and network mask of this route.
- **Protocol:** The protocol type of the route, that is, the protocol through which the router learns about the route.
- **Pre (Preference):** Indicates the routing protocol priority of this route.The highest priority (with the lowest value) will become the current optimal route.
- **Cost(**Routing cost**):** When multiple routes reaching the same destination have the same routing priority, the one with the lowest routing cost will become the current optimal route.
- **NextHop:** Refers to the next hop address of the destination network that the router points to for this router. This field indicates the next device for data forwarding.
- **Interface:** represents the outbound interface of this route. Indicate which interface of this router the data will be forwarded from.

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 7        Routes : 7

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Direct  0    0           D   192.168.1.1     Ethernet0/0/0
    192.168.1.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
    192.168.2.0/24  Static  60   0          RD   192.168.3.1     Ethernet0/0/1
    192.168.3.0/24  Direct  0    0           D   192.168.3.254   Ethernet0/0/1
  192.168.3.254/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

SUSTech
Southern University of Science and Technology

Router: routing-table(2)

- How to generate the routing table entrie in the routing-table ?
  - **Direct**
    - After the router's interface completes IP address configuration, the corresponding routing table entries are automatically generated

Destination/Mask	Proto	Pre	Cost	Flags	NextHop	Interface
127.0.0.0/8	Direct	0	0	D	127.0.0.1	InLoopBack0
127.0.0.1/32	Direct	0	0	D	127.0.0.1	InLoopBack0
192.168.1.0/24	Direct	0	0	D	192.168.1.1	Ethernet0/0/0
192.168.1.1/32	Direct	0	0	D	127.0.0.1	Ethernet0/0/0

  - **Static**

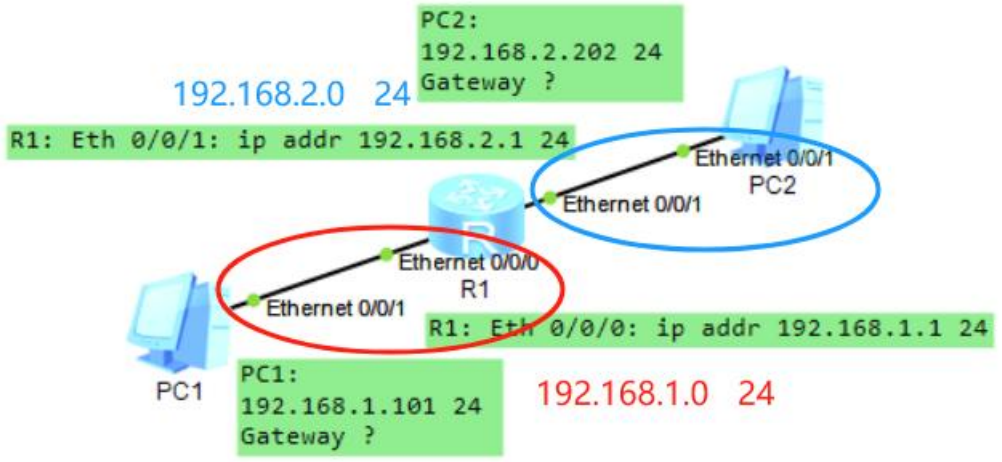
192.168.2.0/24	Static	60	0	RD	192.168.3.1	Ethernet0/0/1

    - Add through relevant configurations
      - **[Huawei] ip route-static 192.168.2.0 255.255.255.0 192.168.3.1**
        - **192.168.2.0 255.255.255.0: Destination and Mask**
        - **192.168.3.1: next hop**
  - **Dynamic**
    - Generated by routing protocol(RIP, OSPF, BGP...)

Demo1: Direct routing entry(1)

Build a network topology, PC1 and PC2 are not in the same sub-network, do the configuration to make PC1 could send/received packet to/from PC2.

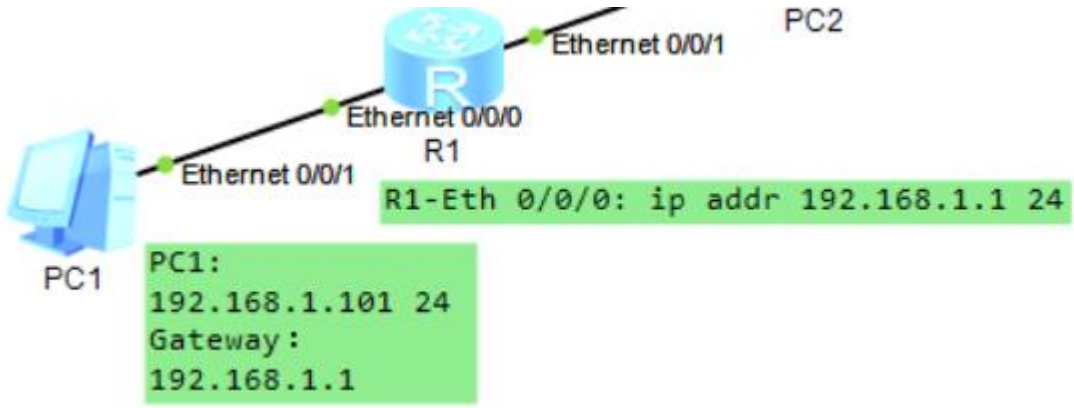
- step1: build the network topology, design the IP settings
  - PC1: 192.168.1.101/24 PC2: 192.168.2.202 /24
  - Ethernet 0/0/0 of R1: in the same sub-network with PC1, 192.168.1.1/24
  - Ethernet 0/0/1 of R2: in the same sub-network with PC1, 192.168.2.1/24
  - How about the configurations of Gateway on PC1 and PC2
    - ?
- step2: Start all the device
- step3: Do the configuration on the PCs and the Router R1
- step4: test by using command “ping”



Demo1: Direct routing entry (2)

Analysis:

- PKT1 from **PC1 to R1-Eth 0/0/0**



1) **PC1 generate PKT1**(*source IP: 192.168.1.101 , destination IP: 192.168.2.202*)

2) **PC1 caculate the network ID on source and destionation**

source IP & subnet mask of source *destination IP & subnet mask of source*

souce network ID : *192.168.1.101 & 255.255.255.0 =* ***192.168.1.0***

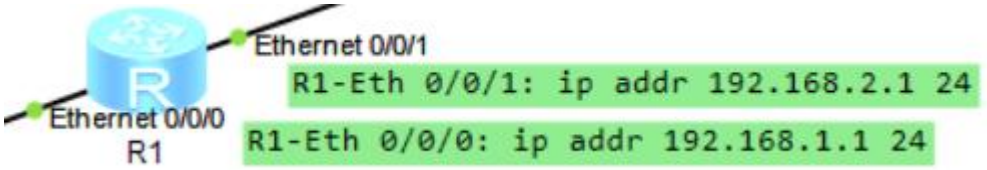
destination network ID : *192.168.2.202 & 255.255.255.0 =* ***192.168.2.0***

3) **PC1 check if destination network ID equal to souce network ID**

- ✓ ***if not, PC1 forward the PKT1 to the Gateway of PC1*** *(Ethernet 0/0/0 of R1)*
  - ✓ *the Gateway of PC1 could be configured with: 192.168.1.1 (IP address on Ethernet 0/0/0 of R1)*

Demo1: Direct routing entry(3)

- PKT1 from R1-Eth 0/0/0 to R1-Eth 0/0/1



1) R1 **search the destination IP(** 192.168.2.202**) of PKT1 in the routing-table**
2) R1 **find item "192.168.2.0/24" meet longest matching principle**
   - ✓ The matching length with PKT1 destination IP(192.168.2.202) and (192.168.2.0/24) is 24
   - The matching length with PKT1 destination IP(192.168.2.202) and (192.168.2.1/32) is 0
3) R1 **forward the PKT1 to the NextHop** 192.168.2.1 which is on the Eth0/0/1

```
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        127.0.0.0/8  Direct  0    0           D   127.0.0.1       InLoopBack0
        127.0.0.1/32 Direct  0    0           D   127.0.0.1       InLoopBack0
      192.168.1.0/24 Direct  0    0           D   192.168.1.1     Ethernet0/0/0
      192.168.1.1/32 Direct  0    0           D   127.0.0.1       Ethernet0/0/0
      192.168.2.0/24 Direct  0    0           D   192.168.2.1     Ethernet0/0/1
      192.168.2.1/32 Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

Tips:

*After the router's **interface is configured with an IP address**, the router will directly generate a **direct route** in the routing table based on the correspondence between the address and the interface.*

Demo1: Direct routing entry(4)

- PC2 send the PKT2 to PC1

1) **PC2 generate PKT2**(*source IP: 192.168.2.202 , destination IP: 192.168.1.101*)
2) **PC2 caculate the network ID on source and destionation**

source IP & subnet mask of source destination IP & subnet mask of source

souce network ID : *192.168.2.202 & 255.255.255.0 =* ***192.168.2.0***

destination network ID : *192.168.1.101 & 255.255.255.0 =* ***192.168.1.0***

3) **PC2 check if destination network ID equal to souce network ID**
   - ✓ ***if not, PC2 forward the PKT2 to the Gateway of PC2*** *(Ethernet 0/0/1 of R1)*
     - ✓ *the Gateway of PC2 could be configured with:* ***192.168.2.1*** *(IP address on Ethernet 0/0/1 of R1)*

4) **Route R1 forward the PKT2 to it's interface Ethernet0/0/0** by the PKT2's destinaiton IP address and the routing-table (the related routing entry is generated directly by the Route)

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Direct  0    0           D   192.168.1.1     Ethernet0/0/0
    192.168.1.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
    192.168.2.0/24  Direct  0    0           D   192.168.2.1     Ethernet0/0/1
    192.168.2.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

Demo1: Direct routing entry(5)

Q1. If the destinaiton IP of PKT is 192.168.2.1, what would the R1 do after receive the PKT ?

A1. R1 find item "192.168.2.1/32" meet longest matching principle, forward it to the Ethernet0/0/1(destination), 127.0.0.1 is the Inloopback0 interface of R1, R1 receive the PKT, don't forward it out.

The matching length with PKT destination IP(192.168.2.202) and (192.168.2.0/24) is 24

✓ The matching length with PKT destination IP(192.168.2.202) and (192.168.2.1/32) is 32

```
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        127.0.0.0/8  Direct  0    0           D   127.0.0.1       InLoopBack0
        127.0.0.1/32 Direct  0    0           D   127.0.0.1       InLoopBack0
      192.168.1.0/24 Direct  0    0           D   192.168.1.1     Ethernet0/0/0
      192.168.1.1/32 Direct  0    0           D   127.0.0.1       Ethernet0/0/0
      192.168.2.0/24 Direct  0    0           D   192.168.2.1     Ethernet0/0/1
      192.168.2.1/32 Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

Q2. If the destinaiton IP of PKT couldn't match the items of the routing-table, what would the R1 do after receive the PKT ?

A2. R1 drop the PKT

Q3. Does the router know the routing information to all destinations? Is there any way to forward packets without knowing it's rout?

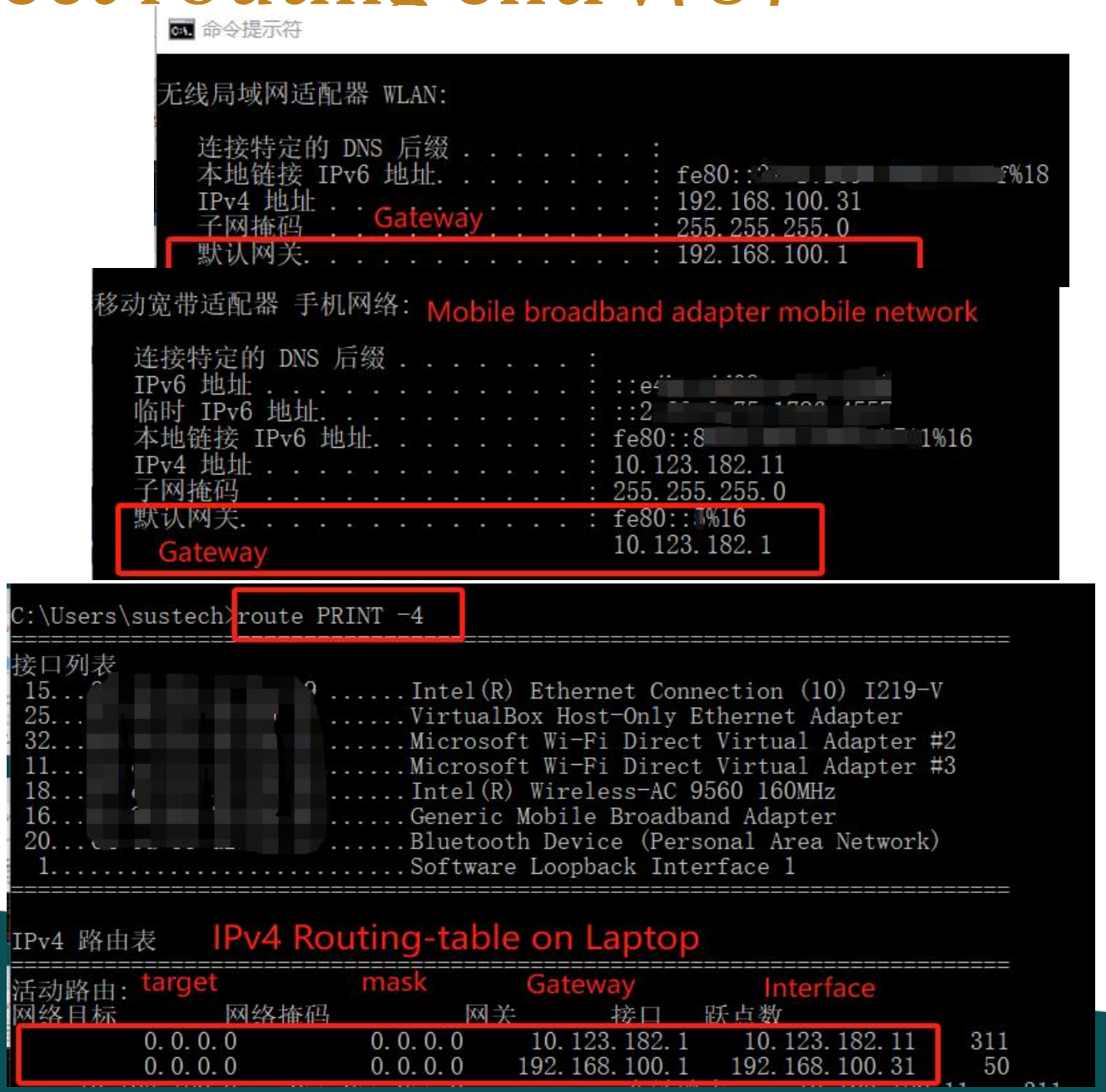
Demo1: Direct routing entry(6)

Q3. Does the router know the routing information to all destinations? Is there any way to forward packets without knowing it's rout?

A3. some tips from the routing-table on the end device(e.t. laptop)

Default route is the route selected by the router when no other route exists for the destination address in the IP packet. All packets whose destination is not in the router's routing table will use the default route.

here two items with **0.0.0.0 as target and 0.0.0.0 as mask** is the **default route**



SUSTech
Southern University of Science and Technology

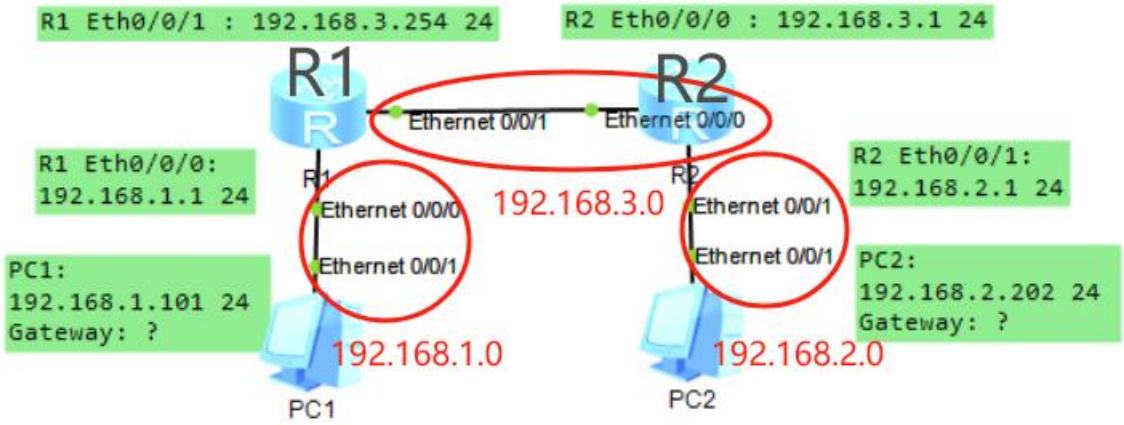
Demo2： static routing entry(1)

- Build a network topology, there are 2 PCs(PC1 and PC2) and 2 Routers(R1 and R2) , the connects and the basic configuration are as shown in the following figure, complete the configurations to make PC1 could send/ receive PKT to/from PC2.

Q1. What's the configuration on Gateway of PC1 and PC2?

Q2. What's the direct routing entries of R1 and R2?

Q3. While R1 receives the PKT(it's destination is PC2) from PC1, could R1 forward the PKT to PC2 directly? would the direct routing entry in R1 help it to do it?

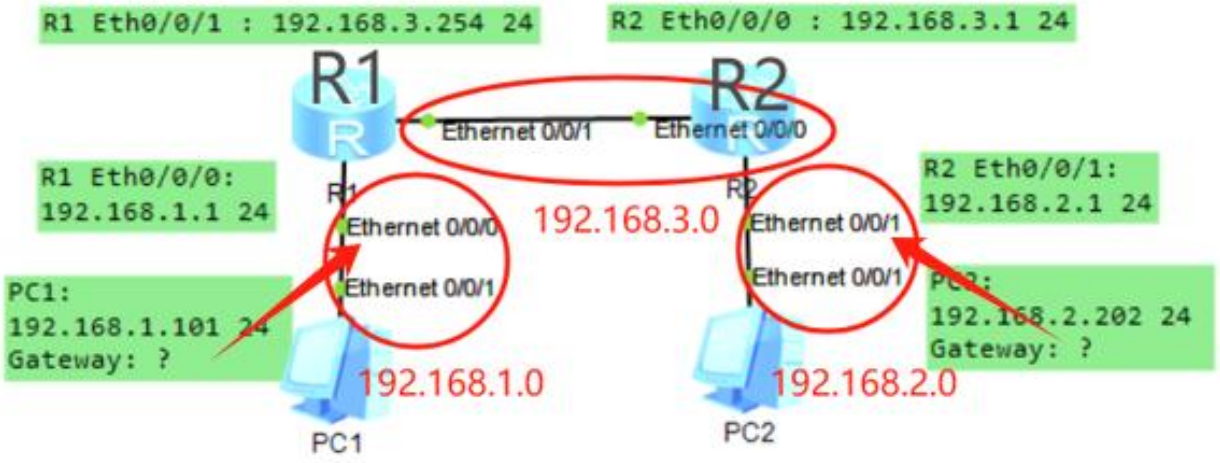


Q4. While R2 receives the PKT(it's destination is PC1) from PC2, could R2 forward the PKT to PC1 directly? would the direct routing entry in R2 help it to do it?

Demo2： static routing entry(2)

- Build a network topology, there are 2 PCs(PC1 and PC2) and 2 Routers(R1 and R2) , the connects and the basic configuration are as shown in the following figure, complete the configurations to make PC1 could send/ receive PKT to/from PC2.

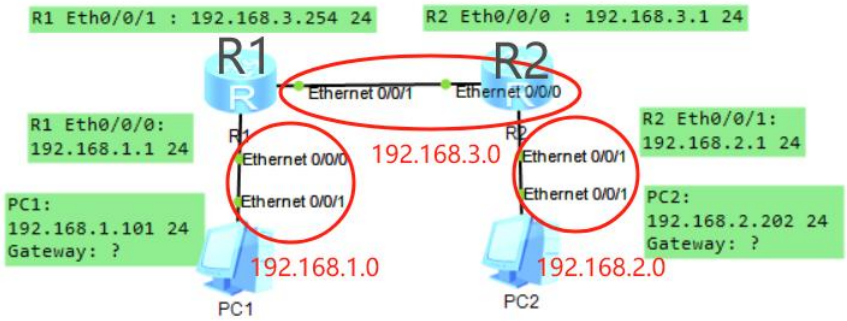
Q1. What's the configuration on Gateway of PC1 and PC2?



Demo2： static routing entry(3)

- Build a network topology, there are 2 PCs(PC1 and PC2) and 2 Routers(R1 and R2) , the connects and the basic configuration are as shown in the following figure, complete the configurations to make PC1 could send/ receive PKT to/from PC2.

Q2. What's the direct routing entries of R1 and R2?



R1

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Direct  0    0           D   192.168.1.1     Ethernet0/0/0
    192.168.1.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
    192.168.3.0/24  Direct  0    0           D   192.168.3.254   Ethernet0/0/1
  192.168.3.254/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

R2

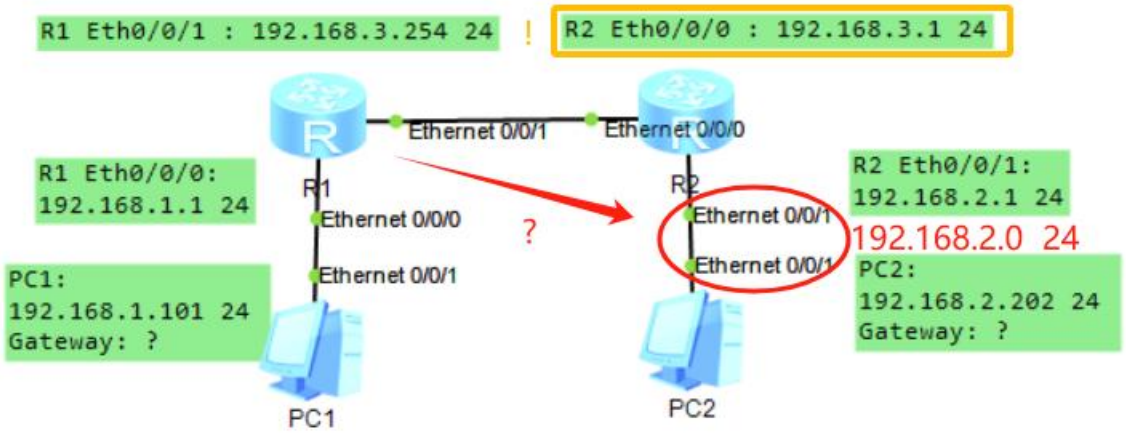
```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.2.0/24  Direct  0    0           D   192.168.2.1     Ethernet0/0/1
    192.168.2.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
    192.168.3.0/24  Direct  0    0           D   192.168.3.1     Ethernet0/0/0
    192.168.3.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
```

SUSTech
Southern University of Science and Technology

Demo2： static routing entry(4)

Q3. While R1 receives the PKT(its destination is PC2) from PC1, could R1 forward the PKT to PC2 directly? would the direct routing entry in R1 help it to do it?

A3. No, No



Q4. While R2 receives the PKT(its destination is PC1) from PC2, could R2 forward the PKT to PC1 directly? would the direct routing entry in R2 help it to do it?

A4. Same as R1

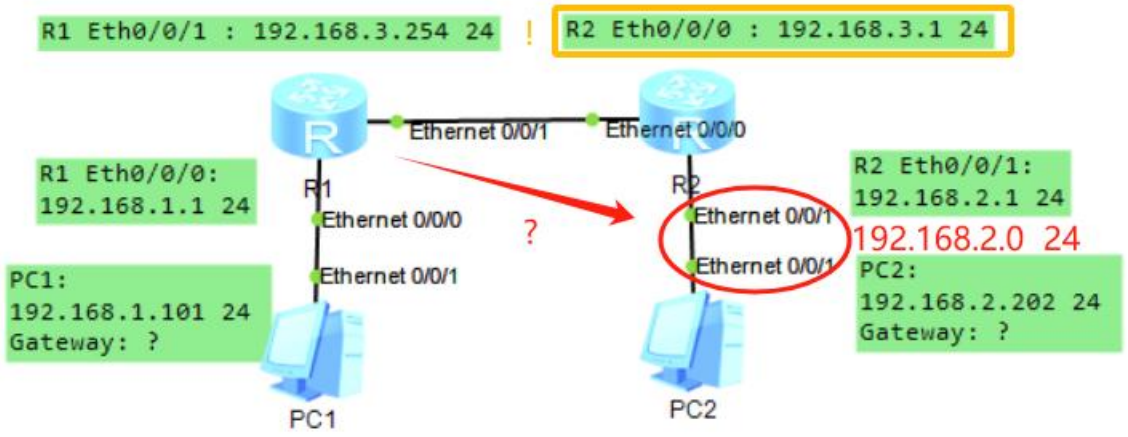
R1

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 6        Routes : 6

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
        127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Direct  0    0           D   192.168.1.1     Ethernet0/0/0
    192.168.1.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
    192.168.3.0/24  Direct  0    0           D   192.168.3.254   Ethernet0/0/1
  192.168.3.254/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

Demo2： static routing entry(5)

In this case, static routing entry could help the Route the forward the PKT to the next hop.

- **R1** forward the PKT (**destination network ID is 192.168.2.0, mask is 255.255.255.0**) to the interface Eth0/0/0(192.168.3.1) of R2
  - the IP address(**192.168.3.1**) of interface Eth0/0/0 on R2 is the **next hop**
  - the interface Eth0/0/0(192.168.3.1) of R2 is in the same subnet as the **interface Eth0/0/1 of R1**, it could be reached directly without other router's forwarding
  - After the PKT reaches R2, R2 send the PKT according to its direct routing entry.




```
[Huawei]ip route-static 192.168.2.0 24 192.168.3.1
```

R1

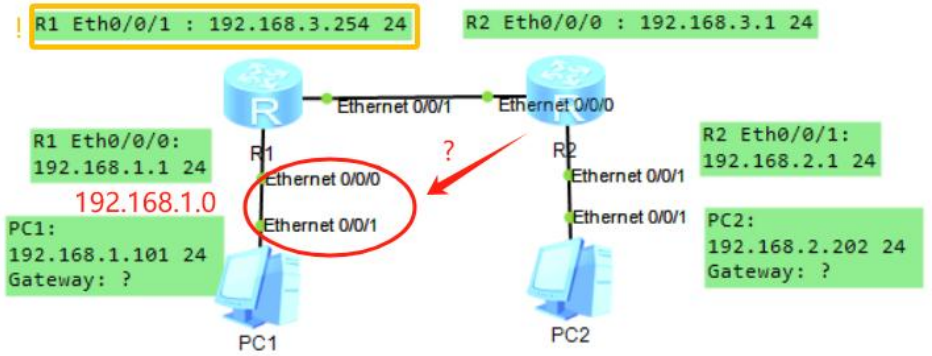
```
<Huawei>dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 7        Routes : 7

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
        127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24    Direct  0    0           D   192.168.1.1     Ethernet0/0/0
    192.168.1.1/32    Direct  0    0           D   127.0.0.1       Ethernet0/0/0
    192.168.2.0/24    Static  60   0          RD   192.168.3.1     Ethernet0/0/1
    192.168.3.0/24    Direct  0    0           D   192.168.3.254   Ethernet0/0/1
  192.168.3.254/32    Direct  0    0           D   127.0.0.1       Ethernet0/0/1
```

SUSTech
Southern University of Science and Technology

Router: static routing entry(6)

In this case, static routing entry could help the router to forward the PKT to the next hop.

- **R2** forward the PKT (**destination network ID is 192.168.1.0, mask is 255.255.255.0**) to the interface Eth0/0/1(192.168.3.254) of R1
  - the IP address(**192.168.3.254**) of interface Eth0/0/1 on R1 is the **next hop**
  - the interface Eth0/0/1(192.168.3.254) of R1 is in the same subnet as the **interface Eth0/0/0 of R2**, it could be reached directly without other router's forwarding
    - After the PKT reaches R1, R1 send the PKT according to its direct routing entry.




```
[Huawei]ip route-static 192.168.1.0 24 192.168.3.254
```

R2

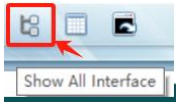
```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 7        Routes : 7

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Static  60   0          RD   192.168.3.254   Ethernet0/0/0
    192.168.2.0/24  Direct  0    0           D   192.168.2.1     Ethernet0/0/1
    192.168.2.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
    192.168.3.0/24  Direct  0    0           D   192.168.3.1     Ethernet0/0/0
    192.168.3.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0

[Huawei]
```

SUSTech
Southern University of Science and Technology

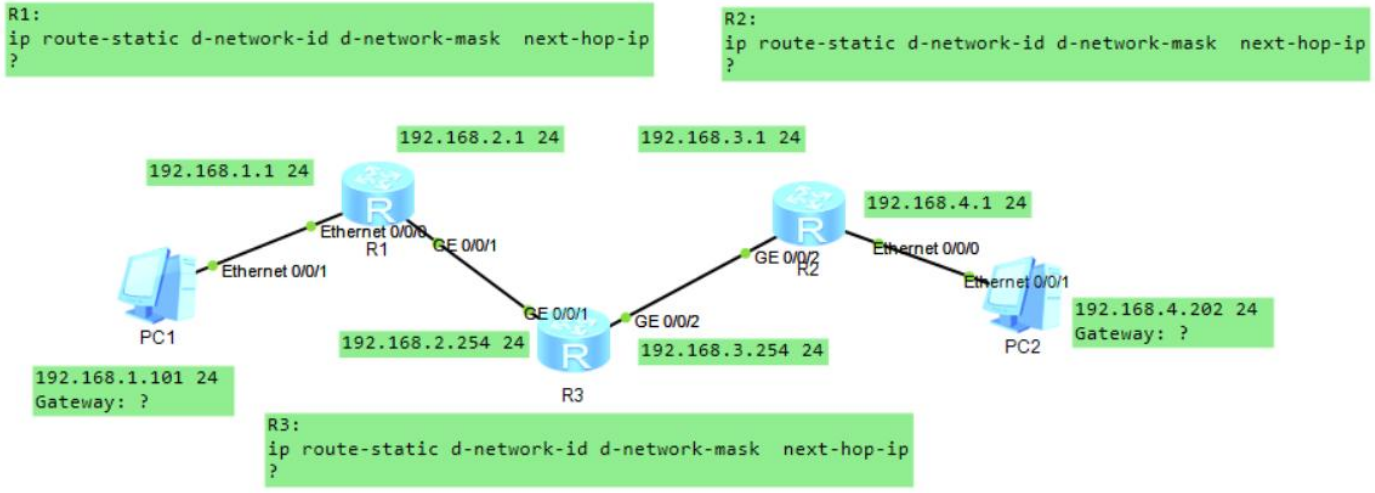
Router: practice1

Build a network topology, there are 2 PCs(PC1 and PC2) and 3 Routers(R1, R2 and R3) , the connects and the basic configuration are as shown in the following figure, complete the configurations to make PC1 could send/ receive PKT to/from PC2.

- NOTE：
  - Show all interface in the topology



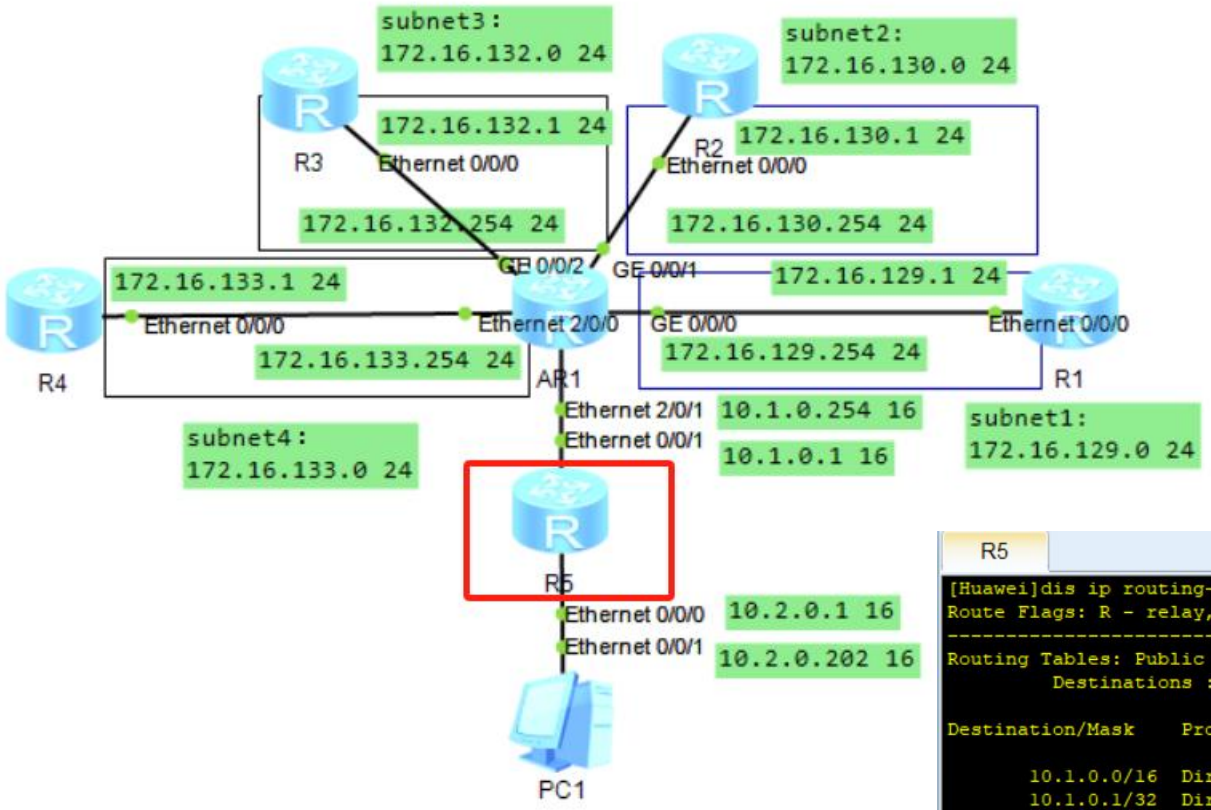
  - the configuration info are strongly suggested to record in the “text” of the topology
- Show the configuration on PCs
- Show the ip routing-table on each Route
  - Describe the specific role of routing table entries in PKT forwarding
- Testing by command “ping”



Route aggregation(1)

Q1: Why Route aggregation?

- smaller route-table, faster forword, more stable ...



In this demo, if R5 want to reach subnet1, subnet2, subnet3 and subnet4, 4 routing entries is needed to be added to routing table in normal way!

- 4 routing entries share the same nexthop(10.1.0.254)
- The high-order part of the destination in 4 routing entries are the same

R5

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 10        Routes : 10

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.1.0.0/16  Direct  0    0           D   10.1.0.1        Ethernet0/0/1
        10.1.0.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
        10.2.0.0/16  Direct  0    0           D   10.2.0.1        Ethernet0/0/0
        10.2.0.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
      127.0.0.0/8    Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32   Direct  0    0           D   127.0.0.1       InLoopBack0
    172.16.129.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
    172.16.130.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
    172.16.132.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
    172.16.133.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
```

Route aggregation(2)

Q2: How to make 4 subnets to be aggregated as 1 subnet

- 172.16.129.0/24
- 172.16.130.0/24
- 172.16.132.0/24
- 172.16.133.0/24

Step1: find the Maxim size of same continuous bit from highest bit to lowest bit among the 4 subnets IDs : **21**bits (**172.16.1000_0**)

Step2: using the bits get from step1 as hig bits of address, pad it with 0s to make a new 32bits subnet ID：(**172.16.1000_0000.0**)
172.168.128.0 / 21.

Now the 4 subnets are aggregated to be 1 subnet : **172.168.128.0 / 21.**

R5

```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 10        Routes : 10

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.1.0.0/16  Direct  0    0           D   10.1.0.1        Ethernet0/0/1
        10.1.0.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
        10.2.0.0/16  Direct  0    0           D   10.2.0.1        Ethernet0/0/0
        10.2.0.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
       127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
       127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    172.16.129.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
    172.16.130.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
    172.16.132.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
    172.16.133.0/24  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
```

R5

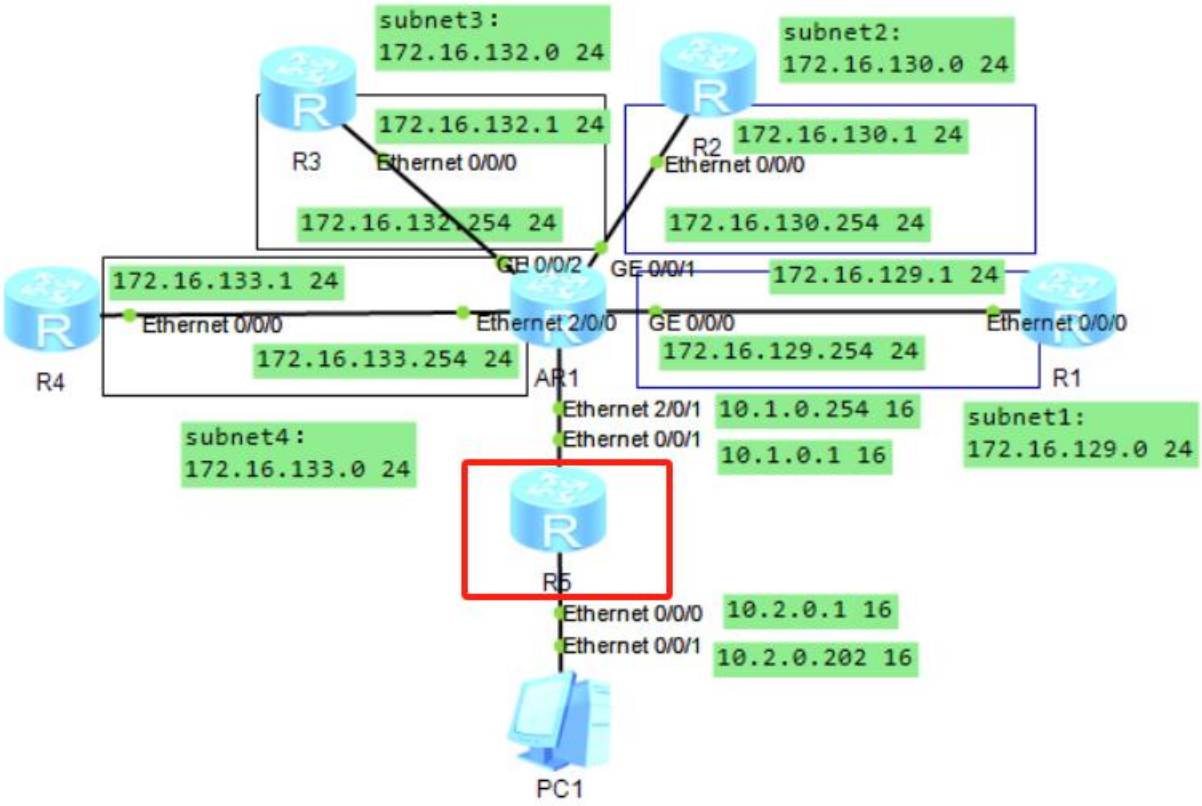
```
[Huawei]dis ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 7         Routes : 7

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

        10.1.0.0/16  Direct  0    0           D   10.1.0.1        Ethernet0/0/1
        10.1.0.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/1
        10.2.0.0/16  Direct  0    0           D   10.2.0.1        Ethernet0/0/0
        10.2.0.1/32  Direct  0    0           D   127.0.0.1       Ethernet0/0/0
       127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
       127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    172.16.128.0/21  Static  60   0          RD   10.1.0.254      Ethernet0/0/1
```

SUSTech
Southern University of Science and Technology

Router: Practice2

Build a network topology as shown in the following figure, complete the configurations to make PC1 could send/ receive PKT to/from every working interface of the Routes .

- Show the configuration on PC1
- Show the ip routing-table on each Route
  - Describe the specific role of routing table entries in PKT forwarding
  - Is there any route aggregation?
  - Is there any default rout in the routes?
- Testing by command “ping”

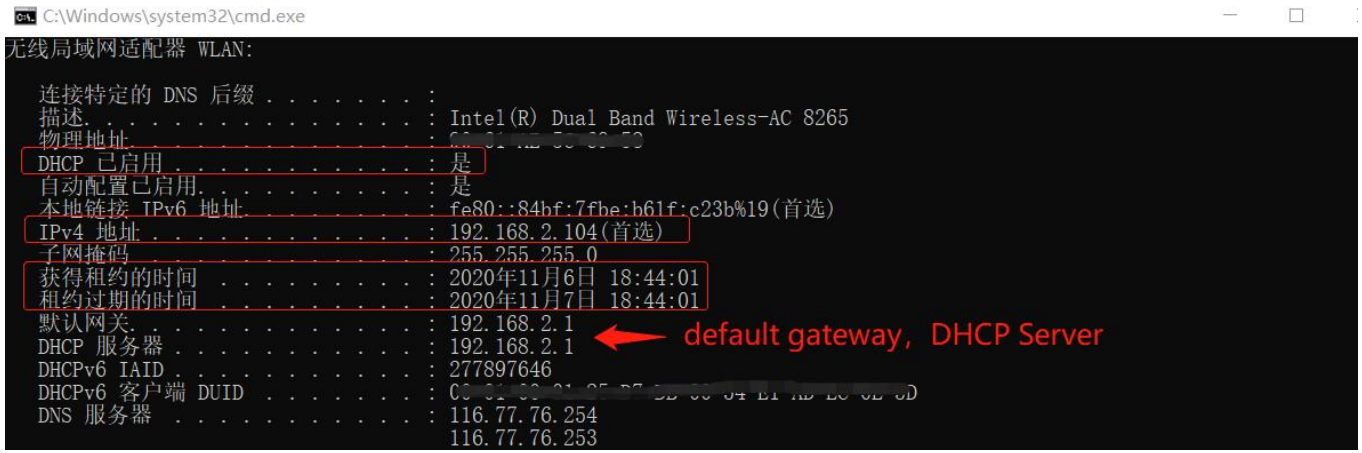


tips: undo could be help to revoke the command
e.g. undo ip route-static 10.2.0.0 24 172.16.133.254

Router: DHCP service

Route could provide DHCP service, it work as DHCP server or relay the DHCP related packet.

- DHCP is built on a Client-Server model
  - server: a host providing initialization parameters through DHCP
  - client: a host requesting initialization parameters from a DHCP server
  - designated DHCP server hosts allocate network addresses and deliver configuration parameters to dynamically configured hosts
- BOOTP is a transport mechanism for a collection of configuration information. BOOTP using port 67 AND 68 of UDP.



https://www.rfc-editor.org/rfc/rfc2131.txt

DHCP

RFC 2131 Dynamic Host Configuration Protocol March 1997

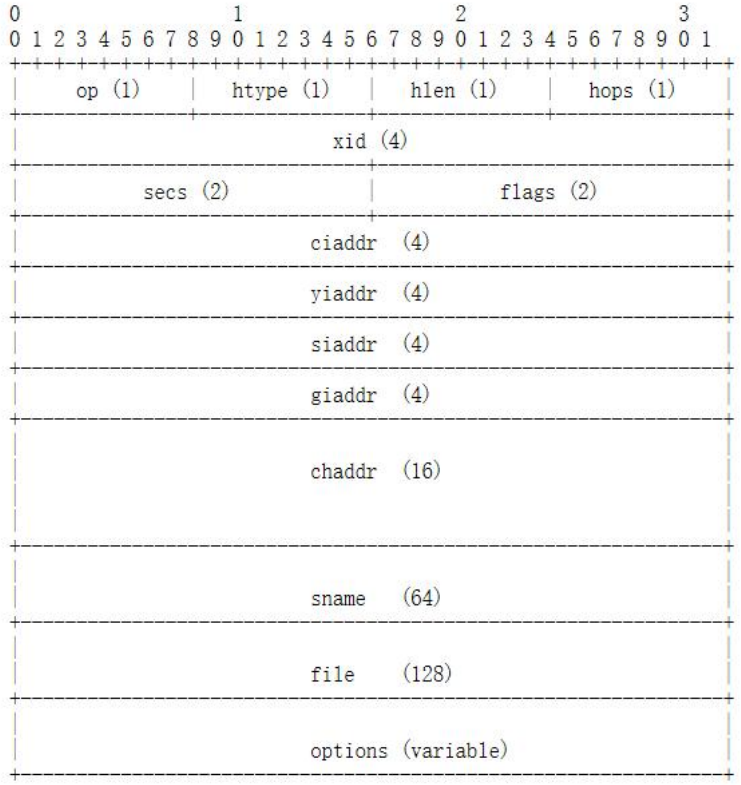


Figure 1: Format of a DHCP message

FIELD	OCTETS	DESCRIPTION
op	1	Message op code / message type. 1 = BOOTREQUEST, 2 = BOOTREPLY
htype	1	Hardware address type, see ARP section in "Assigned Numbers" RFC; e.g., '1' = 10mb ethernet.
hlen	1	Hardware address length (e.g. '6' for 10mb ethernet).
hops	1	Client sets to zero, optionally used by relay agents when booting via a relay agent.
xid	4	Transaction ID, a random number chosen by the client, used by the client and server to associate messages and responses between a client and a server.
secs	2	Filled in by client, seconds elapsed since client began address acquisition or renewal process.
flags	2	Flags (see figure 2).
ciaddr	4	Client IP address; only filled in if client is in BOUND, RENEW or REBINDING state and can respond to ARP requests.
yiaddr	4	'your' (client) IP address.
siaddr	4	IP address of next server to use in bootstrap; returned in DHCPOFFER, DHCPACK by server.
giaddr	4	Relay agent IP address, used in booting via a relay agent.
chaddr	16	Client hardware address.
sname	64	Optional server host name, null terminated string.
file	128	Boot file name, null terminated string; "generic" name or null in DHCPDISCOVER, fully qualified directory-path name in DHCPOFFER.
options	var	Optional parameters field. See the options documents for a list of defined options.

Table 1: Description of fields in a DHCP message

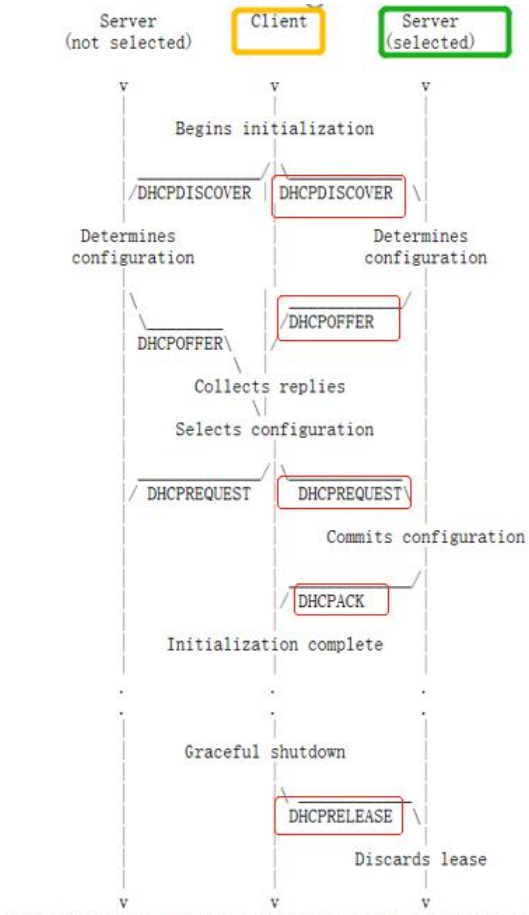
SUSTech
Southern University of Science and Technology

https://www.rfc-editor.org/rfc/rfc2131.txt

DHCP Session(1)

- Client-Server interaction when allocating a new network address

Source	Destination	Protocol	Info
0.0.0.0	255.255.255.255	DHCP	DHCP Discover - Transaction ID 0x3e5e0ce3
192.168.1.1	255.255.255.255	DHCP	DHCP Offer - Transaction ID 0x3e5e0ce3
0.0.0.0	255.255.255.255	DHCP	DHCP Request - Transaction ID 0x3e5e0ce3
192.168.1.1	255.255.255.255	DHCP	DHCP ACK - Transaction ID 0x3e5e0ce3
192.168.1.101	192.168.1.1	DHCP	DHCP Request - Transaction ID 0x257e55a3
192.168.1.1	255.255.255.255	DHCP	DHCP ACK - Transaction ID 0x257e55a3
192.168.1.101	192.168.1.1	DHCP	DHCP Release - Transaction ID 0xb7a32733



igure 3: Timeline diagram of messages exchanged between DHCP client and servers when allocating a new network address

Tips in command line:
While network interface card is set as DHCP client,
using 'ipconfig /renew' to request a dynamically assigned IP addresses.
using 'ipconfig /release' to release the dynamically assigned IP addresses.

Tips in Wireshark display filter : DHCP or
udp.port == 67 || udp.port == 68

https://tools.ietf.org/html/rfc2131

DHCP Discover

```
> Frame 2: 342 bytes on wire (2736 bits), 342 bytes captured (2736 bits)
> Ethernet II, Src: Dell_4f:36:23 (00:08:74:4f:36:23), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 0.0.0.0 (0.0.0.0), Dst: 255.255.255.255 (255.255.255.255)
> User Datagram Protocol, Src Port: bootpc (68), Dst Port: bootps (67)
v Bootstrap Protocol (Discover)
    Message type: Boot Request (1)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x3e5e0ce3
    Seconds elapsed: 0
  > Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0 (0.0.0.0)
    Your (client) IP address: 0.0.0.0 (0.0.0.0)
    Next server IP address: 0.0.0.0 (0.0.0.0)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: Dell_4f:36:23 (00:08:74:4f:36:23)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
  > Option: (53) DHCP Message Type (Discover)
  > Option: (116) DHCP Auto-Configuration
  > Option: (61) Client identifier
  > Option: (50) Requested IP Address
  > Option: (12) Host Name
  > Option: (60) Vendor class identifier
  > Option: (55) Parameter Request List
  > Option: (255) End
    Padding: 000000000000000000
```

```
v Option: (53) DHCP Message Type (Discover)
      Length: 1
      DHCP: Discover (1)
v Option: (116) DHCP Auto-Configuration
      Length: 1
      DHCP Auto-Configuration: AutoConfigure (1)
v Option: (61) Client identifier
      Length: 7
      Hardware type: Ethernet (0x01)
      Client MAC address: Dell_4f:36:23 (00:08:74:4f:36:23)
v Option: (50) Requested IP Address
      Length: 4
      Requested IP Address: 192.168.1.101 (192.168.1.101)
v Option: (12) Host Name
      Length: 4
      Host Name: Noho
v Option: (60) Vendor class identifier
      Length: 8
      Vendor class identifier: MSFT 5.0
v Option: (55) Parameter Request List
      Length: 11
      Parameter Request List Item: (1) Subnet Mask
      Parameter Request List Item: (15) Domain Name
      Parameter Request List Item: (3) Router
      Parameter Request List Item: (6) Domain Name Server
      Parameter Request List Item: (44) NetBIOS over TCP/IP Name Server
      Parameter Request List Item: (46) NetBIOS over TCP/IP Node Type
      Parameter Request List Item: (47) NetBIOS over TCP/IP Scope
      Parameter Request List Item: (31) Perform Router Discover
      Parameter Request List Item: (33) Static Route
      Parameter Request List Item: (249) Private/Classless Static Route (Microsoft)
```

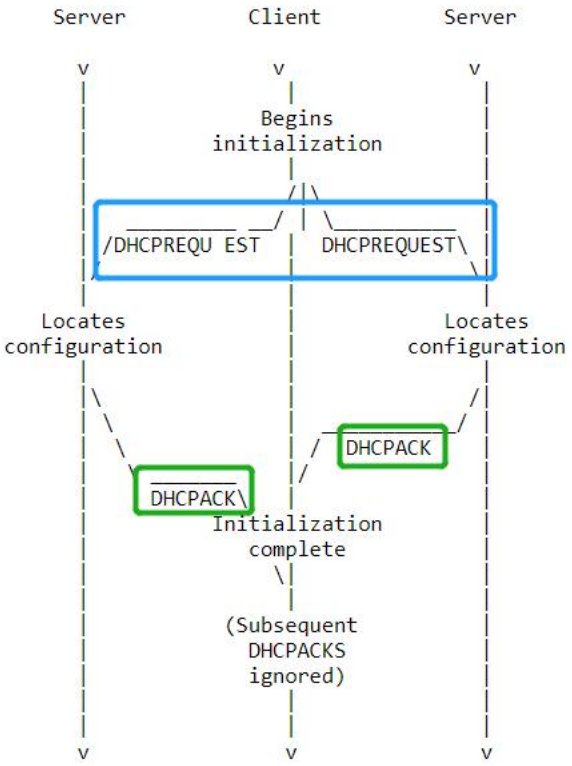
DHCP Offer

```
> User Datagram Protocol, Src Port: bootps (67), Dst Port: bootpc (68)
v Bootstrap Protocol (Offer)
    Message type: Boot Reply (2)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x3e5e0ce3
    Seconds elapsed: 0
  > Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0 (0.0.0.0)
    Your (client) IP address: 192.168.1.101 (192.168.1.101)
    Next server IP address: 0.0.0.0 (0.0.0.0)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: Dell_4f:36:23 (00:08:74:4f:36:23)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
```

```
v Option: (53) DHCP Message Type (Offer)
      Length: 1
      DHCP: Offer (2)
v Option: (1) Subnet Mask
      Length: 4
      Subnet Mask: 255.255.255.0
v Option: (3) Router
      Length: 4
      Router: 192.168.1.1 (192.168.1.1)
v Option: (6) Domain Name Server
      Length: 8
      Domain Name Server: ns10.attbi.com (63.240.76.19)
      Domain Name Server: 204.127.198.19 (204.127.198.19)
v Option: (15) Domain Name
      Length: 22
      Domain Name: ne2.client2.attbi.com
v Option: (51) IP Address Lease Time
      Length: 4
      IP Address Lease Time: (86400s) 1 day
v Option: (54) DHCP Server Identifier
      Length: 4
      DHCP Server Identifier: 192.168.1.1 (192.168.1.1)
v Option: (255) End
      Option End: 255
  Padding: 0000000000000000000000000000000000000000000000000...
```

DHCP Session(2)

- Client-Server interaction when reusing a previously allocated network address



dhcp

Source	Destination	Protocol	Info
activate.adobe.com	255.255.255.255	DHCP	DHCP Request - Transaction ID 0x98bd1be8
192.168.2.1	LAPTOP-RITC8FUU.local	DHCP	DHCP ACK - Transaction ID 0x98bd1be8

https://tools.ietf.org/html/rfc2131

DHCP Request & Ack

```
> User Datagram Protocol, Src Port: bootpc (68), Dst Port: bootps (67)
v Dynamic Host Configuration Protocol (Request)
    Message type: Boot Request (1)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x98bd1be8
    Seconds elapsed: 0
  > Bootp flags: 0x0000 (Unicast)
    Client IP address: activate.adobe.com (0.0.0.0)
    Your (client) IP address: activate.adobe.com (0.0.0.0)
    Next server IP address: activate.adobe.com (0.0.0.0)
    Relay agent IP address: activate.adobe.com (0.0.0.0)
    Client MAC address: LAPTOP-RITC8FUU.local (90:61:ae:5c:69:58)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
  > Option: (53) DHCP Message Type (Request)
  > Option: (61) Client identifier
  > Option: (50) Requested IP Address (192.168.2.104)
  > Option: (12) Host Name
  > Option: (81) Client Fully Qualified Domain Name
  > Option: (60) Vendor class identifier
  > Option: (55) Parameter Request List
  > Option: (255) End
```

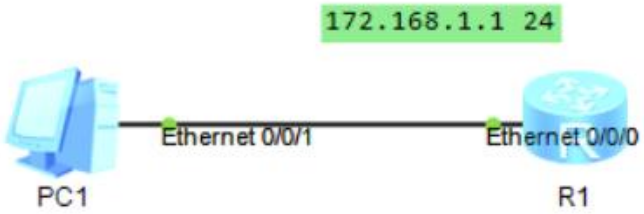
```
User Datagram Protocol, Src Port: bootps (67), Dst Port: bootpc (68)
Dynamic Host Configuration Protocol (ACK)
    Message type: Boot Reply (2)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x98bd1be8
    Seconds elapsed: 0
  > Bootp flags: 0x0000 (Unicast)
    Client IP address: activate.adobe.com (0.0.0.0)
    Your (client) IP address: LAPTOP-RITC8FUU.local (192.168.2.104)
    Next server IP address: 192.168.2.1 (192.168.2.1)
    Relay agent IP address: activate.adobe.com (0.0.0.0)
    Client MAC address: LAPTOP-RITC8FUU.local (90:61:ae:5c:69:58)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
  > Option: (53) DHCP Message Type (ACK)
  > Option: (1) Subnet Mask (255.255.255.0)
  > Option: (2) Time Offset
  > Option: (3) Router
  > Option: (23) Default IP Time-to-Live
  > Option: (51) IP Address Lease Time
  > Option: (54) DHCP Server Identifier (192.168.2.1)
  > Option: (6) Domain Name Server
  > Option: (58) Renewal Time Value
  > Option: (59) Rebinding Time Value
  > Option: (255) End
    Padding: 00
```

Router: DHCP service(1-1)

- How to make a Route provide the DHCP service
  - method1: Provide DHCP services on the interface
  - method2:Create a global address pool for routers to provide DHCP services

methode1(in the Router)

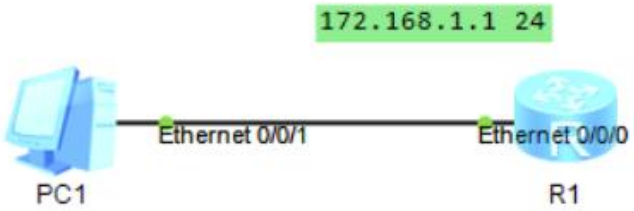
- make DHCP enable [Huawei]
  - command: **dhcp enable**
- select the interface
  - the interface is most near the DHCP client, here is "Ethe
    - the interface of the route work as the Gateway of the DHCP client
- Configure the interface, here is [Huawei-Ethernet0/0/0]
  - IP address
    - command : **ip address** 172.168.1.1 255.255.255.0
      - IP address of the interface would be the gateway
  - to detemine the DHCP service is provide by the interface
    - command : **dhcp select interface**
  - to point out the DNS-list
    - command : **dhcp server dns-list 114.114.114.114**
  - lease time ...
  - Restricted address range ...

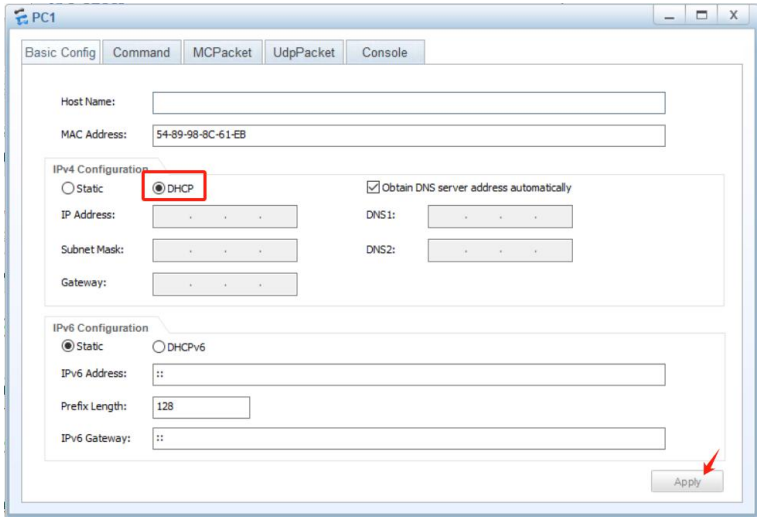


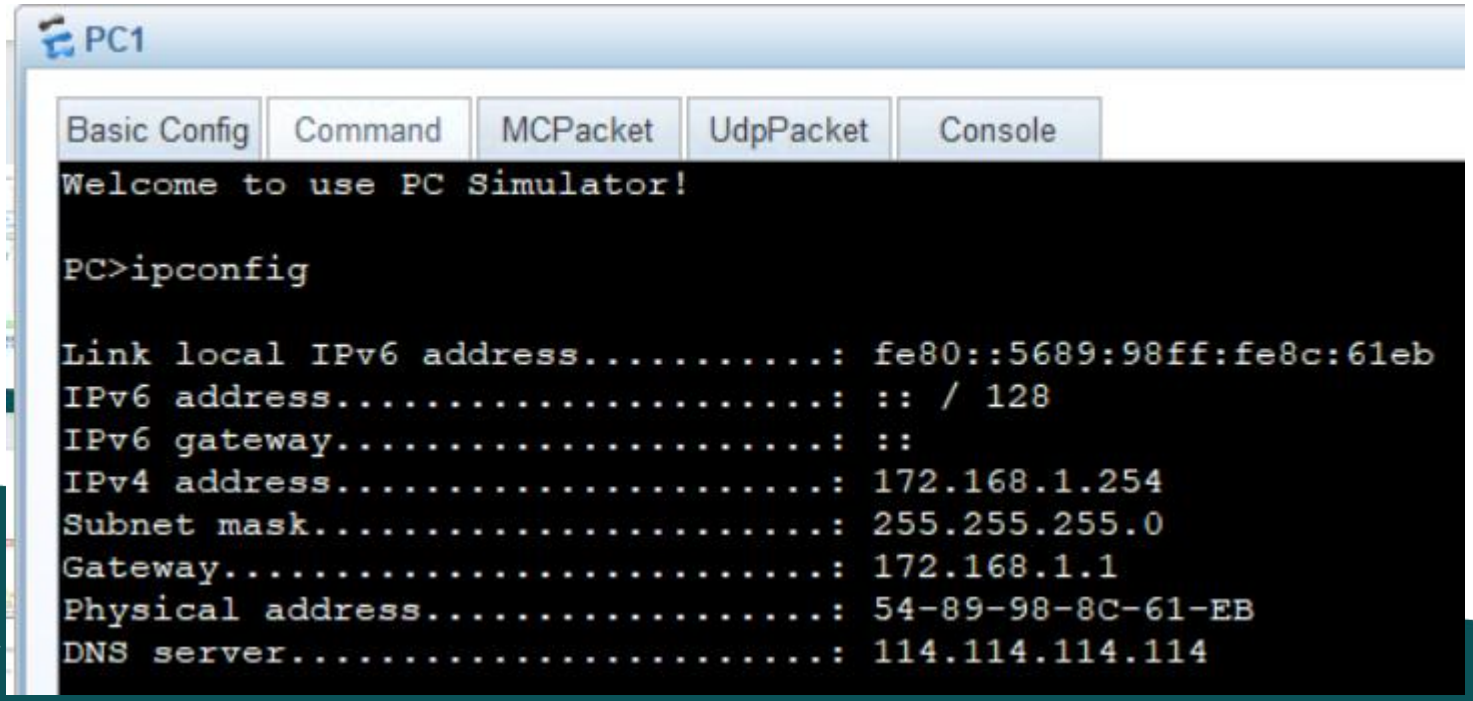
tip: Don't forget to set the PC as DHCP client

Router: DHCP service(1-2)

- Testing
  - by using command “ipconfig” on PC





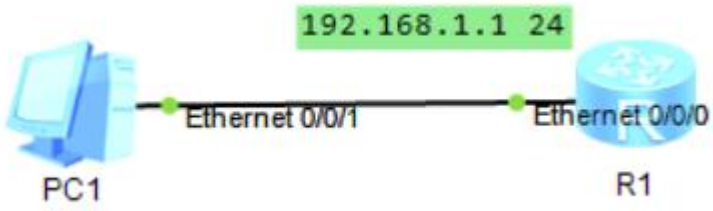


SUSTech
Southern University of Science and Technology

Router: DHCP service(2-1)

- How to make a Route provide the DHCP service
  - method2:Create a global address pool for routers to use to provide DHCP services
    - make DHCP enable [Huawei]
      - command: dhcp enable
    - make a “ip pool” [Huawei]

      command: ip pool [ip-pool-name]
      - point out network
        - command: **network 192.168.1.0**
      - point out Gateway and Mask
        - command: **gateway-list 192.168.1.1**
      - point out the DNS-list
        - command : **dns-list 114.114.114.114**
      - point out lease time and restricted address range ...
    - select the interface
      - the interface is most near the DHCP client, here is “Ethernet0/0/0”
    - Configure the interface, here is [Huawei-Ethernet0/0/0]
      - IP address
        - command : **ip address 192.168.1.1 255.255.255.0**
      - to detemine the DHCP service is provide by the ip pool
        - command : **dhcp select global**



Router: DHCP service(2-2)

```
[Huawei]dis ip pool
  ------------------------------------------------------------------------
  Pool-name      : test
  Pool-No        : 0
  Position       : Local          Status           : Unlocked
  Gateway-0      : 10.1.0.1
  Mask           : -
  VPN instance   : --


  IP address Statistic
    Total        :0
    Used         :0          Idle         :0
    Expired      :0          Conflict     :0          Disable    :0
[Huawei]
```

```
[Huawei-ip-pool-test]dis this
#
ip pool test
 gateway-list 192.168.1.1
 network 192.168.1.0 mask 255.255.255.0
 excluded-ip-address 192.168.1.200
 lease day 1 hour 12 minute 0
 dns-list 114.114.114.114
#
return
[Huawei-ip-pool-test]
```

```
[Huawei-Ethernet0/0/0]dis this
#
interface Ethernet0/0/0
 ip address 10.1.0.1 255.255.0.0
 dhcp select global
#
return
[Huawei-Ethernet0/0/0]
```

```
PC>ipconfig /renew

IP Configuration


Link local IPv6 address.....: fe80::5689:98ff:fee8:4d85
IPv6 address.....: :: / 128
IPv6 gateway.....: ::
IPv4 address.....: 192.168.1.254
Subnet mask.....: 255.255.255.0
Gateway.....: 192.168.1.1
Physical address.....: 54-89-98-E8-4D-85
DNS server.....: 114.114.114.114


PC>ping 192.168.1.1

Ping 192.168.1.1: 32 data bytes, Press Ctrl_C to break
From 192.168.1.1: bytes=32 seq=1 ttl=255 time=32 ms
```

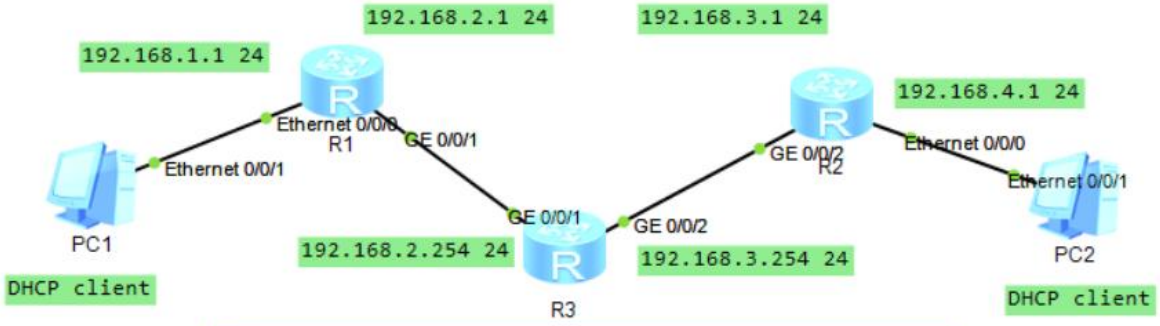
Router: practic3(optional)

- Set up the DHCP service on the Router in the existing network topology(practice 1), set the PC as the DHCP client

- test whether the PC has obtained relevant configurations, and test network connectivity

```
R1:
ip route-static d-network-id d-network-mask  next-hop-ip
?
```

```
R2:
ip route-static d-network-id d-network-mask  next-hop-ip
?
```




```
R3:
ip route-static d-network-id d-network-mask  next-hop-ip
?
```