Chapter5 Network Layer(7)

王昊翔 hxwang@scut.edu.cn

School of Computer Science & Engineering ,SCUT

Communication & Computer Network key-Lab of GD

Outline

- The basic idea of CIDR
- The principle of NAT/PAT
- ICMP and it's application
- Principle Address resolution protocol
  - ARP
  - RARP
- Learn assignment of IP address (RARP\Boot\pDHCP)

IP address problem

- IP is rapidly becoming a victim of its popularity: it is running out of addresses.
- In principle, over 4 billion addresses exist, but the practice of organizing the address space by classes wastes millions of them.
- For most organizations:
  - a class A network, with 16 M addresses is too big
  - a class C network, with 256 addresses is too small
  - a class B network, with 65,536 addresses, seems just right (so many organizations ask for B networks).
- In reality, more than half of all class B networks have fewer than 50 hosts !
- How about providing more (and smaller) class B addresses? Or class C networks use 10 bits instead of eight for the host number?
- Routing table explosion

CIDR –Classless InterDomain Routing

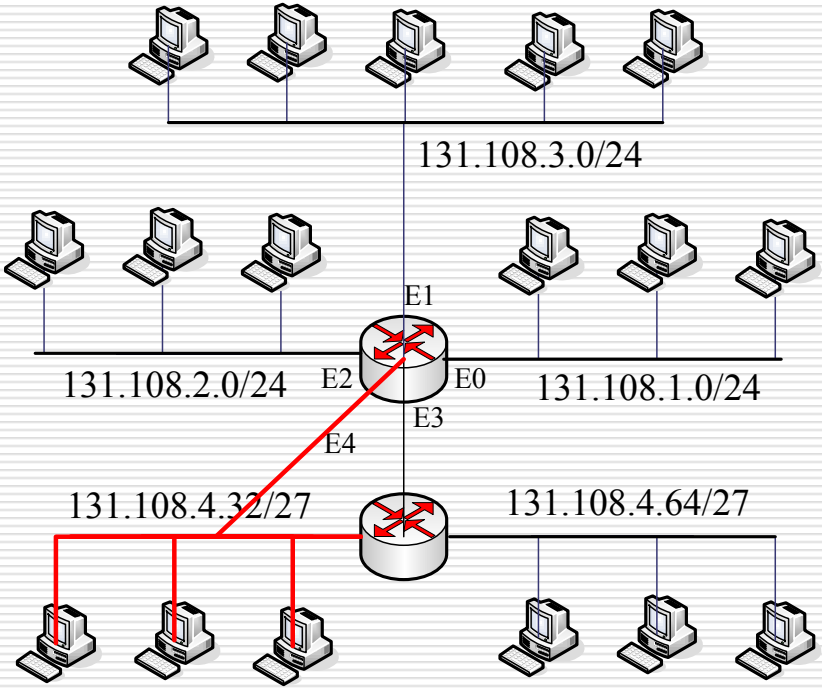
- The solution to the routing table problem and addr. problem is CIDR.
- The basic idea behind CIDR is described in RFC 1519.
  - Allocate IP addresses in variable-sized blocks as opposed to allocating them based on class.
    - F.g. need 2000 address
- CIDR can use prefix 13~27.

Routing With CIDR

- Each routing table entry is extended by giving a 32-bit mask.
- Each routing table consists of an array of (IP address, subnet mask, outgoing line) triples.
- When a packet comes in,
  - Its destination IP address is first extracted.
  - Masking the destination address and comparing it to the table entry looking for a match.
  - If multiple entries (with different subnet mask lengths) match, the longest mask is used.

The longest mask is used

- **An example: a packet with destination IP addr. is 131.108.4.33**



destination	intf
131.108.4.0/24	E3
131.108.4.32/27	E4
131.108.1.0/24	E0
131.108.2.0/24	E2

IP Address Assignment Example

University	First address	Last address	How many	Written as
Cambridge	194.24.0.0	194.24.7.255	2048	194.24.0.0/21
Edinburgh	194.24.8.0	194.24.11.255	1024	194.24.8.0/22
(Available)	194.24.12.0	194.24.15.255	1024	194.24.12/22
Oxford	194.24.16.0	194.24.31.255	4096	194.24.16.0/20

```
   Address                                 Mask
C: 11000010 00011000 00000000 00000000 11111111 11111111 11111000 00000000
E: 11000010 00011000 00001000 00000000 11111111 11111111 11111100 00000000
O: 11000010 00011000 00010000 00000000 11111111 11111111 11110000 00000000
```

CIDR example (2/2)

- A packet addressed to: 194.24.17.4
- Binary presentation: 11000010 00011000 00010001 00000100

	194.24.17.4	11000010	00011000	00010001	00000100
爱丁堡掩码	255.255.252.0	11111111	11111111	11111100	00000000
	网络号	11000010	00011000	00010000	00000000
		194.24.16.0不是爱丁堡的起始网络号			
剑桥掩码	255.255.248.0	11111111	11111111	11111000	00000000
	网络号	11000010	00011000	00010000	00000000
		194.24.16.0不是剑桥的起始网络号			
牛津掩码	255.255.240.0	11111111	11111111	11110000	00000000
	网络号	11000010	00011000	00010000	00000000
		194.24.16.0是牛津的起始网络号			

How to compute available IP addr. ?

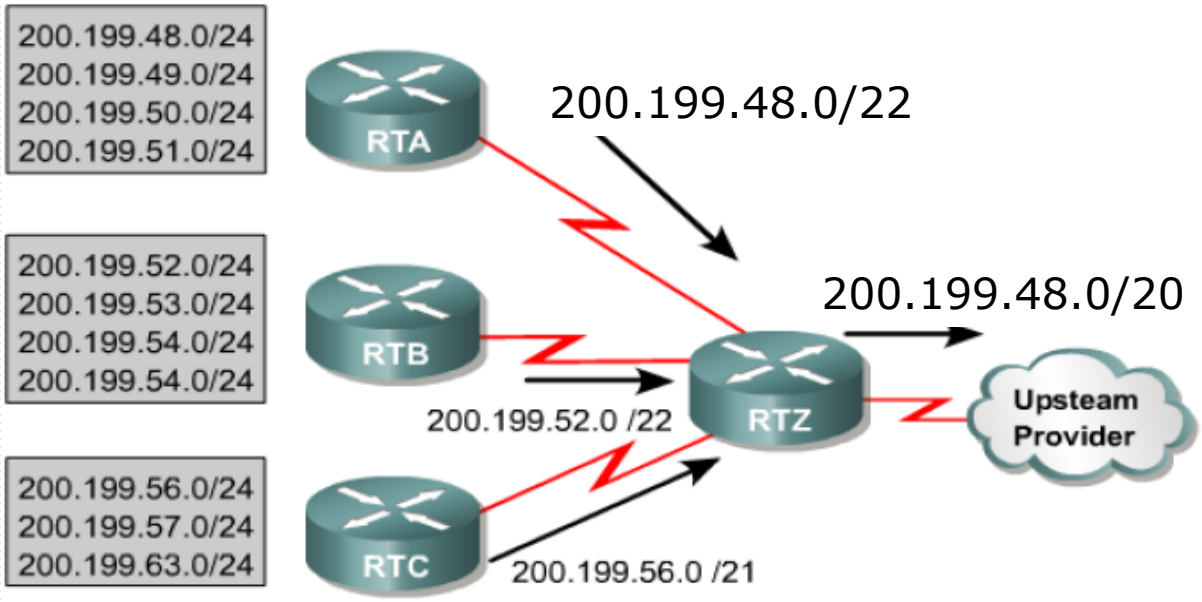
- **IP address is 194.24.6.112，it's mask is 255.255.248.0；equal to 194.24.6.112/21**
- **Corresponding host-bits 32-21=11，so host has：2048**

from: 00000000.00000000=0.0

to: 00000111.11111111=7.255

Routing cluster(路由聚合)

- Reduce routing table
- Separate up-down(隔离路由翻动)



Route summarization reduces routing table size by aggregating routes to multiple networks into one supernet.

How to Cluster

- 200.199.48.0/24
- 200.199.49.0/24
- 200.199.50.0/24
- 200.199.51.0/24
- Cluster into：

  200.199.48.0/22

- 00110000
- 00110001
- 00110010
- 00110011

第三个8位组

- Bits unchanged：

  8+8+6=22，＝mask or network length

NAT outline

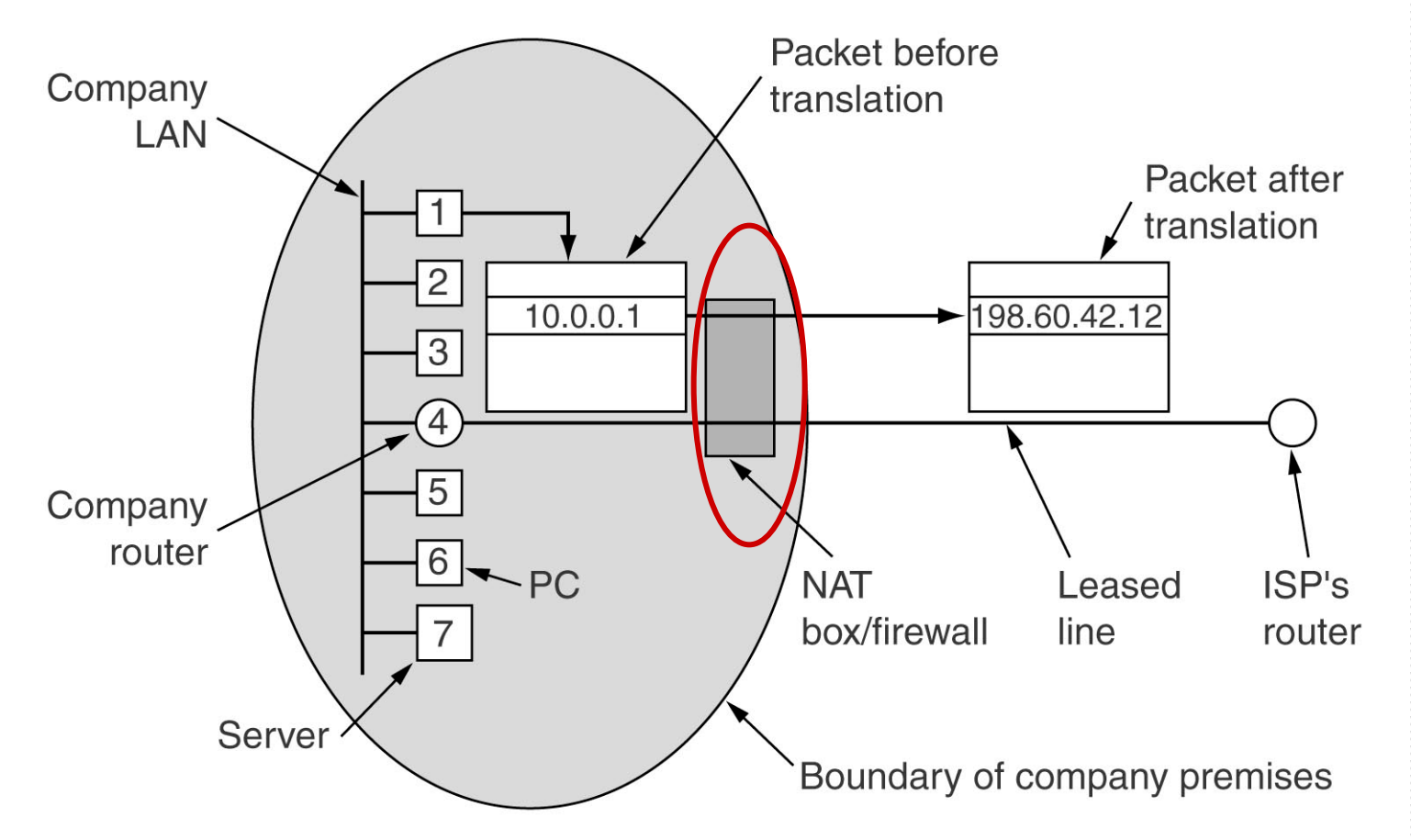
- NAT：net address translate NAT
  - Translation between private IP Addr.(私人地址) and global IP Addr.(公有地址)
- PAT：port address translate
  - Map many IP addr. to one IP addr. with different port
- Private IP addr.：non-routed Addr.

Class	RFC 1918 Internal Address Range	CIDR Prefix
A	10.0.0.0 - 10.255.255.255	10.0.0.0/8
B	172.16.0.0 - 172.31.255.255	172.16.0.0/12
C	192.168.0.0 - 192.168.255.255	192.168.0.0/16

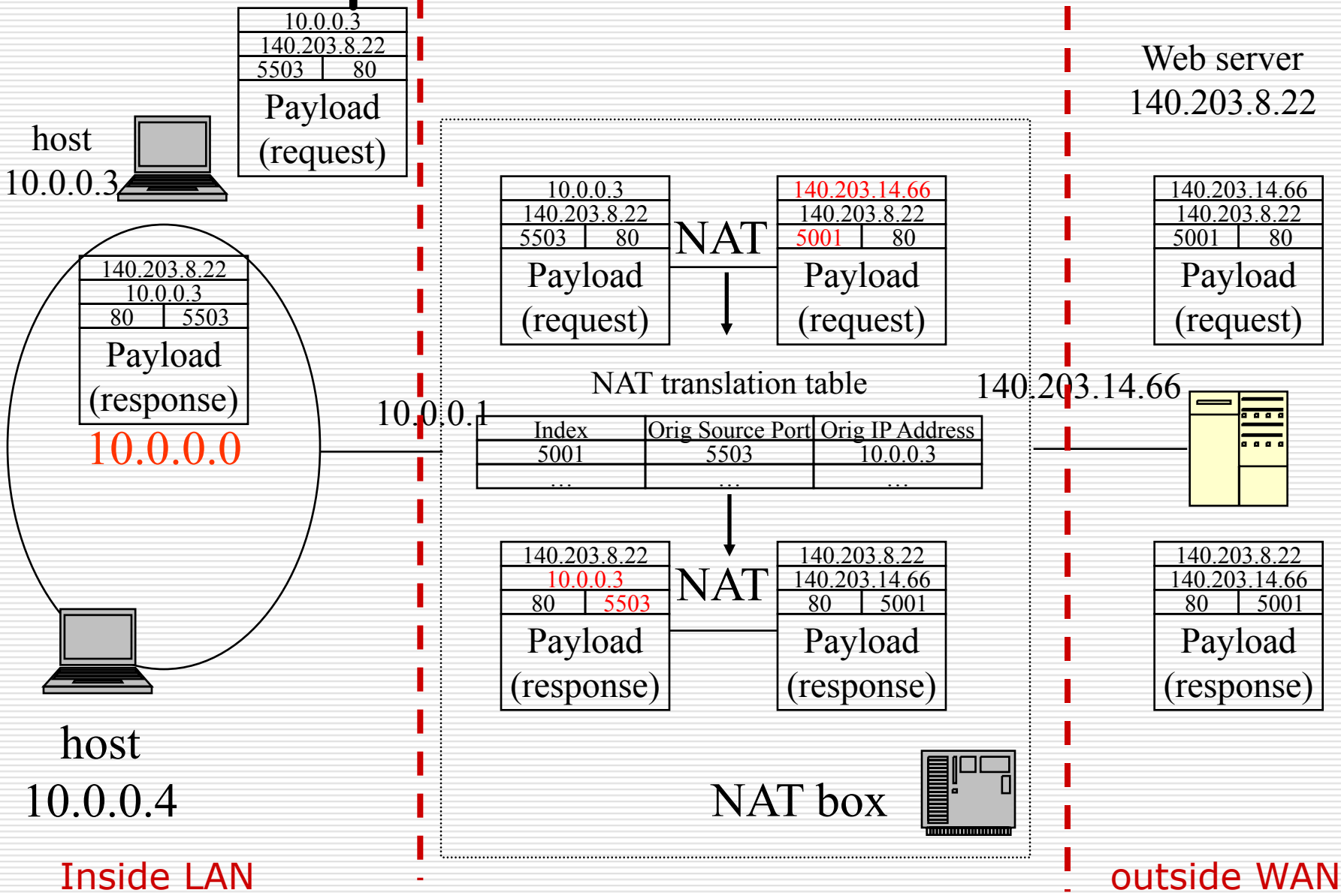
NAT—Network Address Translation

- A quick fix was needed to deal with the problem of running out of IP addresses.
- NAT (Network Address Translation) is described in RFC 3022.
- The process involves using private internal IP addresses and then translating those IP addresses to a valid IP address when leaving the LAN.
- This translation is done by a NAT box. The NAT box is able to translate and keep track of addresses by using a large translation table.
- As incoming packets arrive at the NAT box, it looks up the source port field which was used as an index to the internal IP address in the NAT table.

Placement and operation of a NAT Box



NAT Operation



NAT Issues

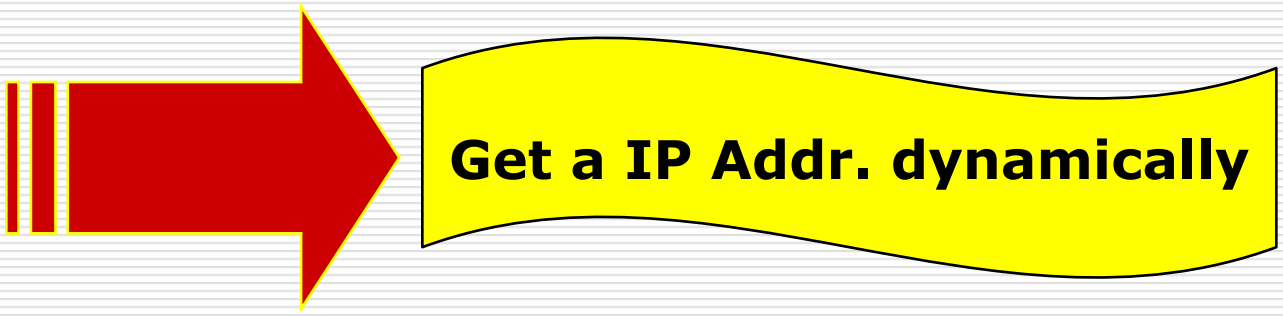
- NAT violates the architectural model of IP - every IP address uniquely identifies a single machine worldwide.
- It changes the Internet into a "connection-oriented" network. The NAT box maintains the state of the connection, and if it crashes, so does the link.
- Protocol layer k makes assumptions about what protocol layer k+1 has put in the payload, violating layer independence.

NAT Issues (cont'd)

- NAT may fail if some protocols other than TCP or UDP are used.
- If IP addresses are inserted into the payload data (i.e. text of the message), then the NAT table will not translate that information and trouble could occur.
- The limit of a NAT machine is 61,440 （65536-4096）machines.

Internet network-layer protocol

- **Besides internet protocol, there are some other accessorial protocols**
  - ICMP
  - ARP
  - RARP
  - BOOTP
  - DHCP

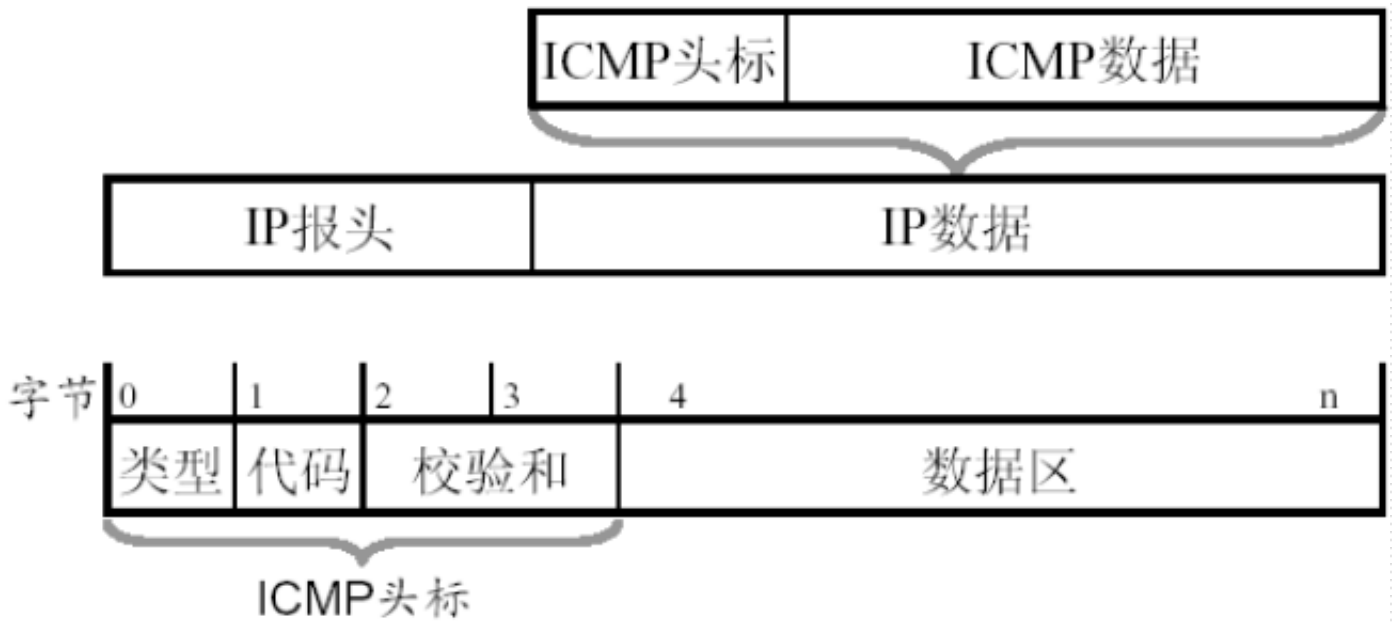


ICMP - Internet Control Message Protocol

- **Used to report unexpected events（errors） or test the Internet.**
- **More ICMP Types: http://www.iana.org/assignments/icmp-parameters**

Message type	Description
Destination unreachable	Packet could not be delivered
Time exceeded	Time to live field hit 0
Parameter problem	Invalid header field
Source quench	Choke packet
Redirect	Teach a router about geography
Echo	Ask a machine if it is alive
Echo reply	Yes, I am alive
Timestamp request	Same as Echo request, but with timestamp
Timestamp reply	Same as Echo reply, but with timestamp

ICMP message format



Address mapping（地址映射）

- **ARP （地址解析协议）：**

  Address Resolution Protocol

  IP addr. → MAC addr.

- **RARP （逆向地址解析协议）**

  Reserve Address Resolution Protocol

  MAC addr. → IP addr.

ARP — Address Resolution Protocol

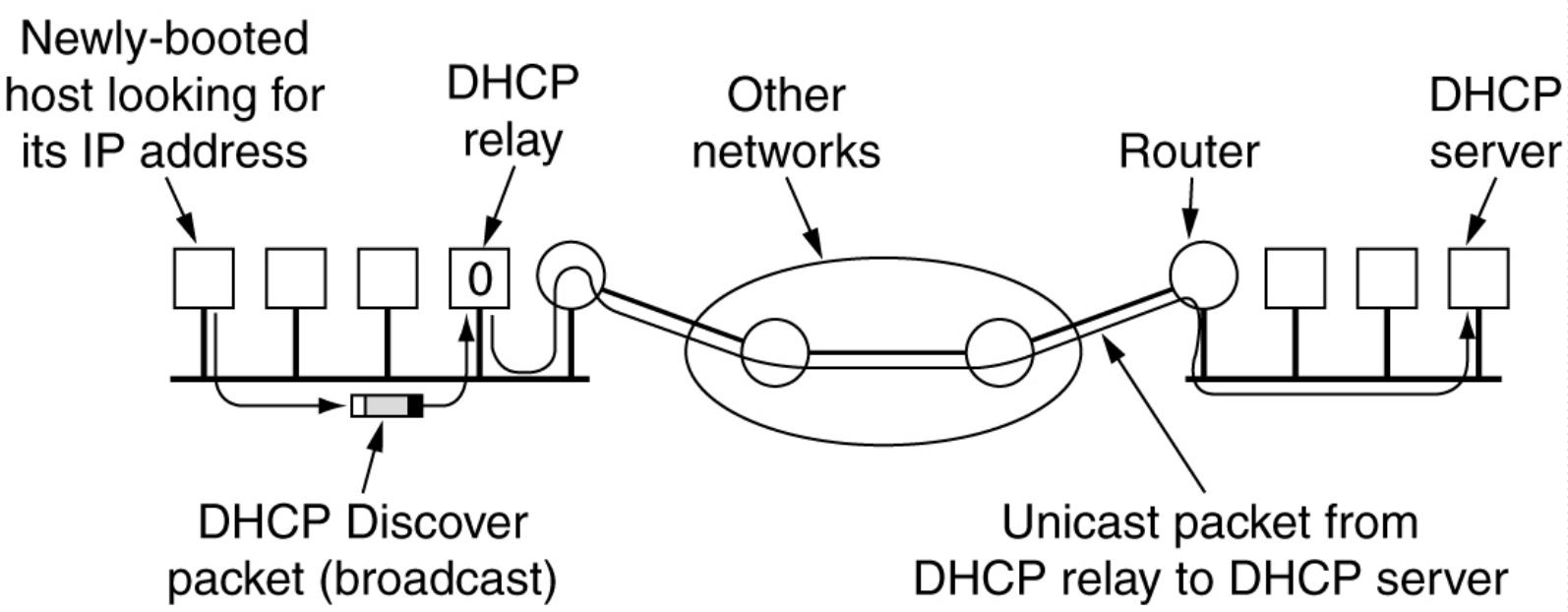
- **ARP solves the problem of finding out which physical address corresponds to a given IP address.**
- **ARP is defined in RFC 826.**

Assignment way of IP addr.

- Static assignment
- Dynamic assignment
  - Given an Ethernet address, what is the corresponding IP address?
    - RARP (Reverse Address Resolution Protocol) is defined in RFC 903. It uses a destination address of all 1s (limited broadcasting) to reach the RARP server and the RARP server sends back the corresponding IP address.
    - BOOTP is defined in RFCs 951, 1048 and 1084. It uses UDP messages, which are forwarded over routers. It can provides more information. （disadv. :manual configuration）
    - DHCP (Dynamic Host Configuration Protocol) is described in RFCs 2131 and 2132. RARP

DHCP：动态主机配置协议

- **Dynamic host configure protocol**
- **可以灵活分配IP地址，节约IP地址的使用**



Summary

- The idea of CIDR
- The principle of NAT/PAT
- ICMP and it's application
- Principle Address resolution protocol
  - ARP
  - RARP
- Learn assignment of IP address(RARP\Boot\pDHCP)

Thank you!