Chapter5 Network Layer(6)

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Content of the second part

- **Internet protocol**
  - **Packet**
  - **IP address**
- **Other protocol**
  - **Arp**
  - **Dhcp**
  - **Rarp**
  - **ICMP**
  - **CIDR**

Outline

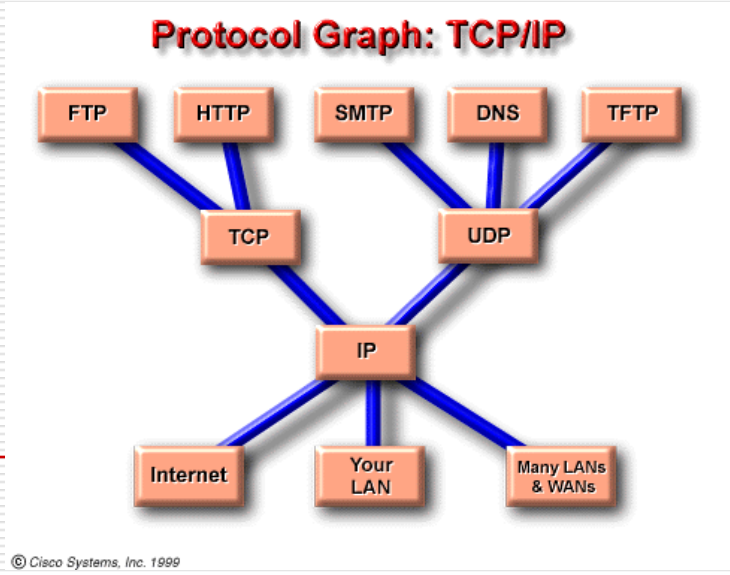
- Main function of router
- Learn IP
  - IP packet format
  - IP address and it's classification
- Reserved IPv4 address
- Subnet and subnetting

Network Layer in the Internet

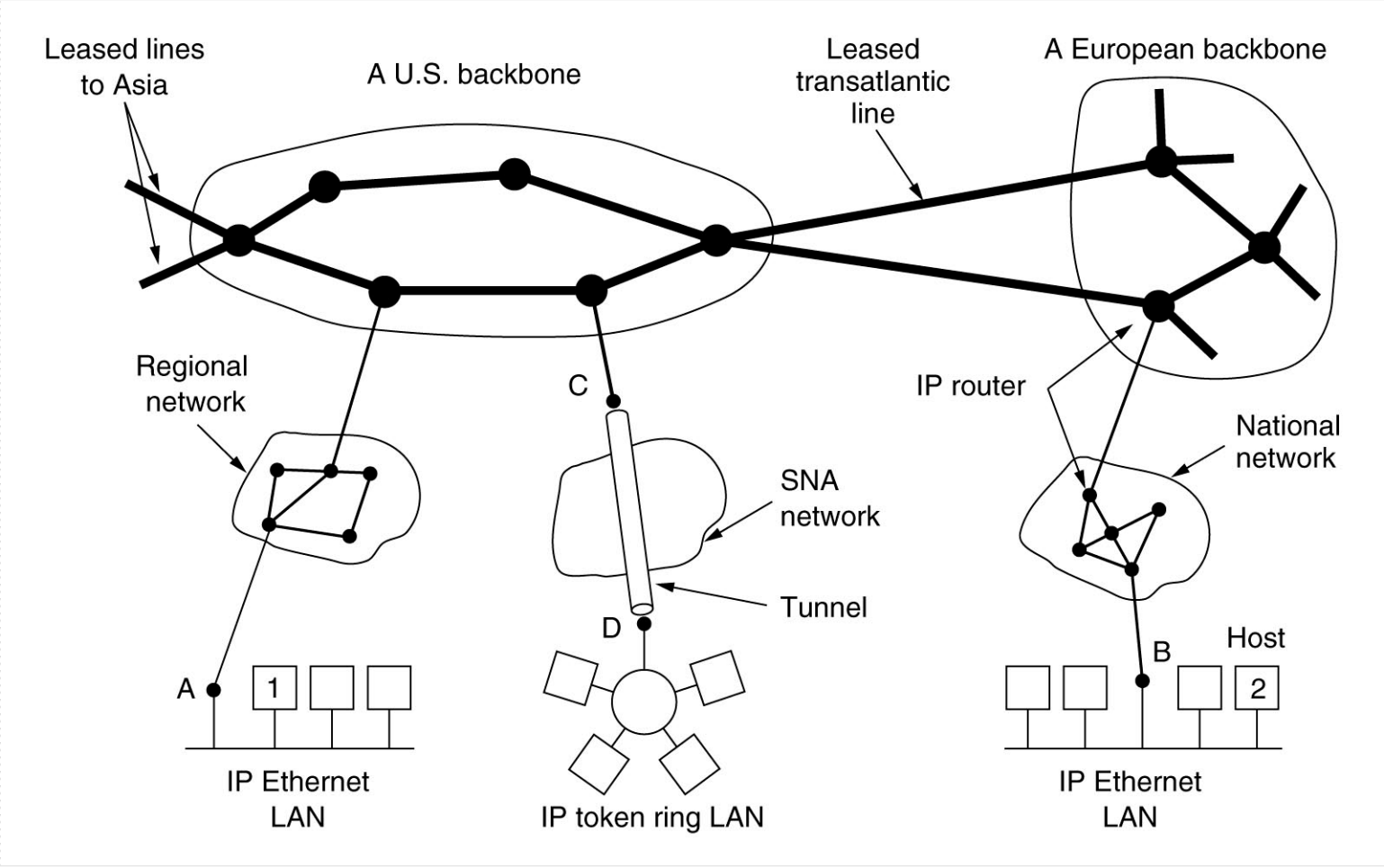
- **Design Principles for Internet (RFC 1958)**
  1. **Make sure it works.**
  2. **Keep it simple.**
  3. **Make clear choices.**
  4. **Exploit modularity.**
  5. **Expect heterogeneity.**
  6. **Avoid static options and parameters.**
  7. **Look for a good design; it need not be perfect.**
  8. **Be strict when sending and tolerant when receiving.**
  9. **Think about scalability.**
  10. **Consider performance and cost.**

Internet and Its Network Layer

- The Internet can be viewed as a collection of subnetworks or Autonomous Systems (ASes) that are interconnected.
- The glue that holds the whole Internet together is the network layer protocol, IP (Internet Protocol).
- Its job is to provide a best-efforts (i.e., not guaranteed) way to transport datagrams from source to destination.



Internet - Collection of Subnetworks

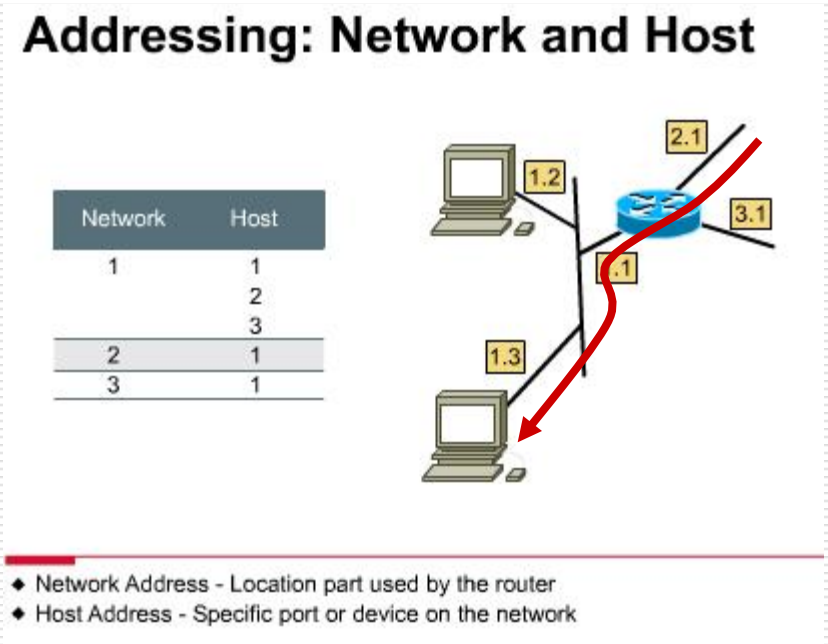


Addressing(寻址)

- 寻址：连网的目的是共享资源、与远端节点通信，要做到这一点，首先必须找到目的节点，寻找目的节点（设备）的过程叫做寻址。
- **Two type of addressing**
  - **MAC addressing：locate destination according to MAC address**
  - **IP addressing： locate destination according to IP address**

IP addressing

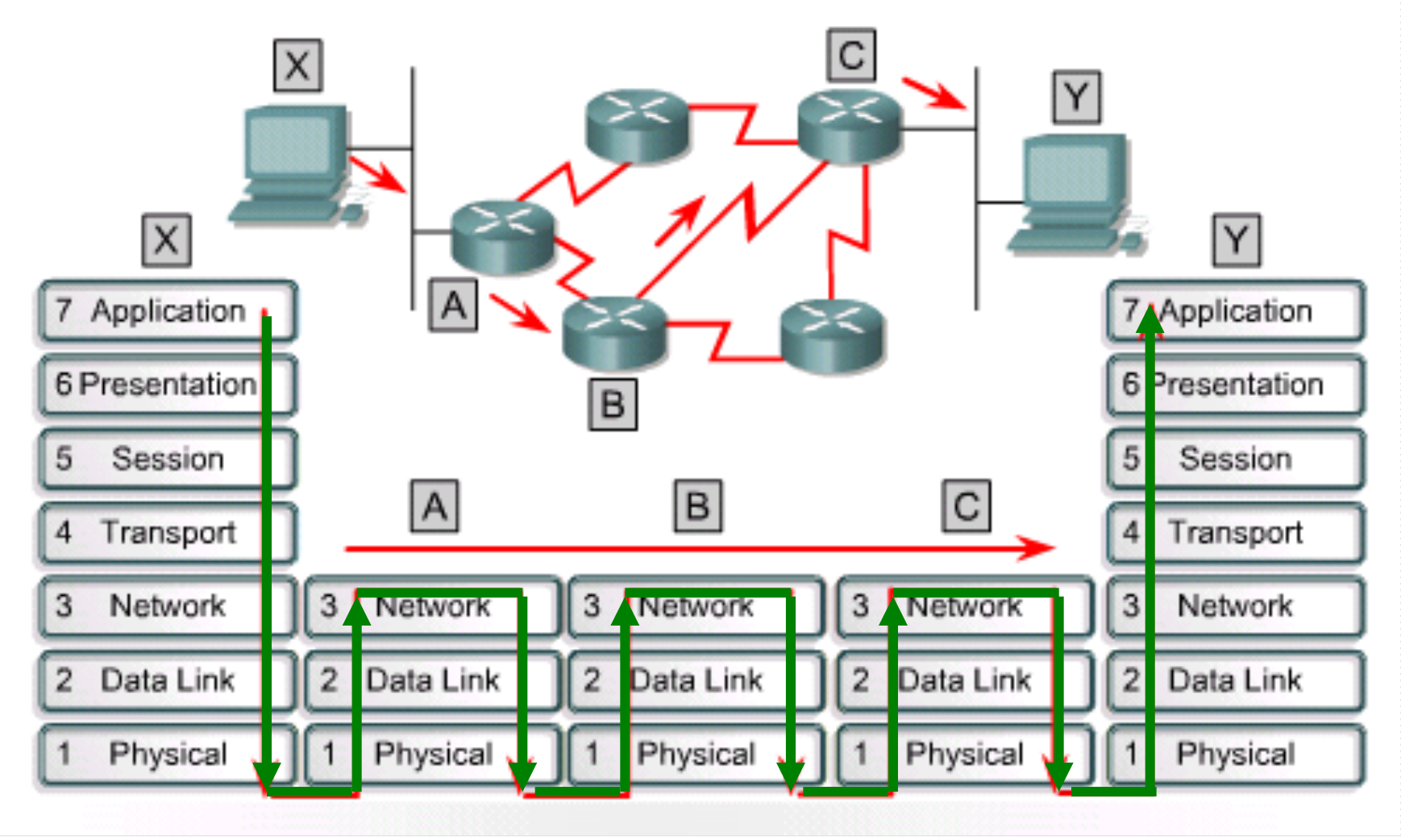
- Step
  - Packet arrive a router
  - The router forward the packet
  - Locate the destination
- Analogy: mailing



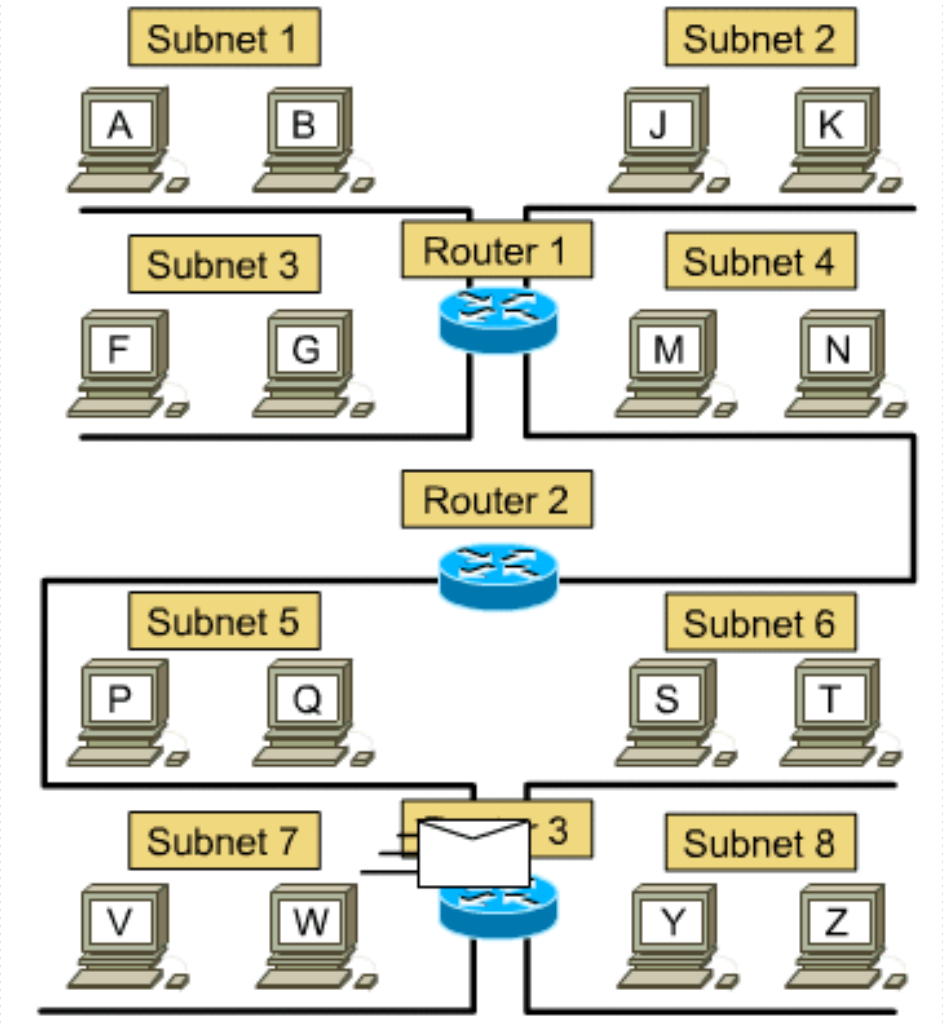
Main function of router

- **Process of router**
  - **Open packet（de-encapsulation）**
  - **Decide destination network**
  - **Look up routing-table ，re-encapsulation and forward**
- **Main function**
  - **Routing**
  - **Forward**
  - **other**

Data go through routers



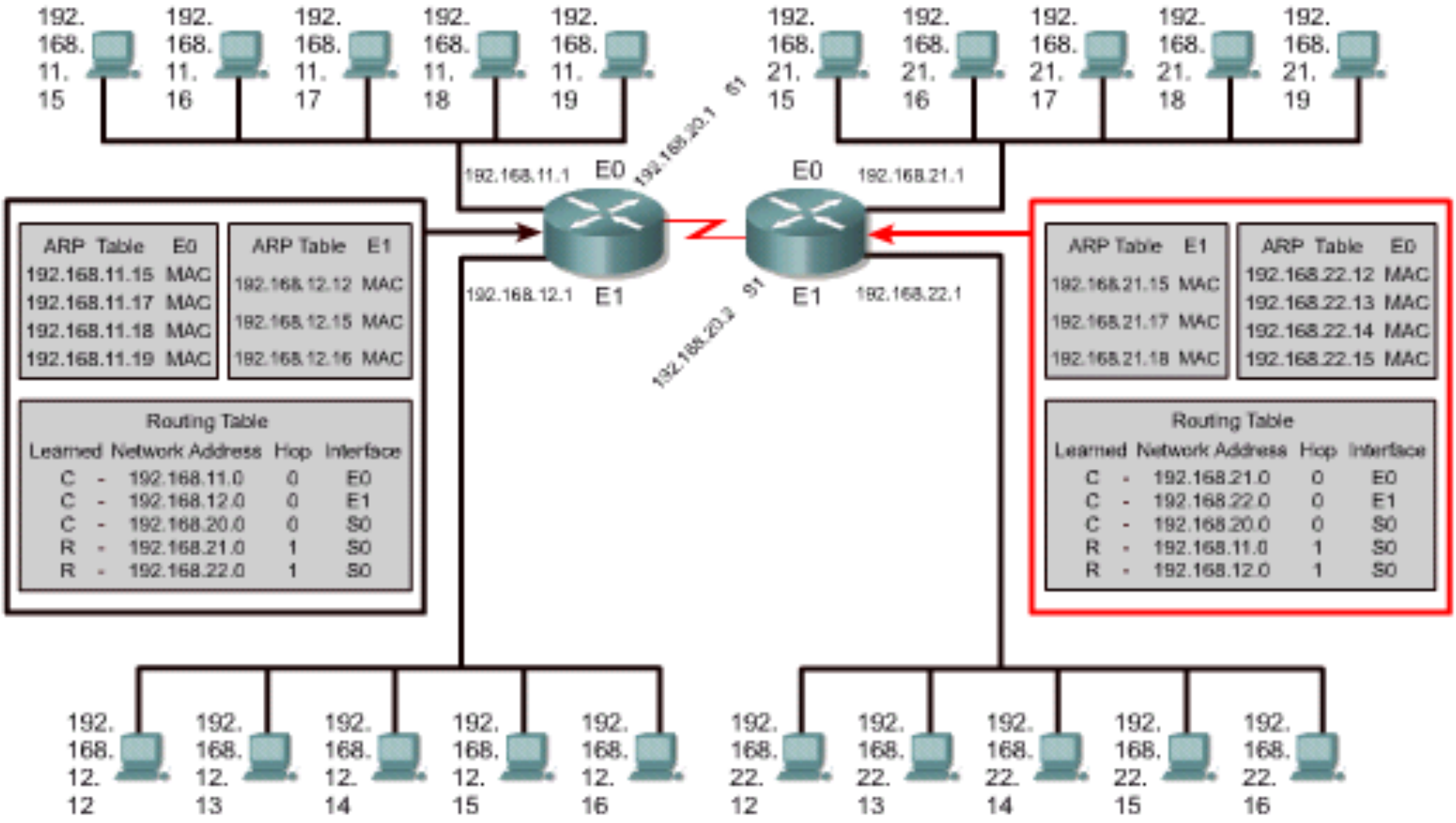
How a packet go from A to Z ?

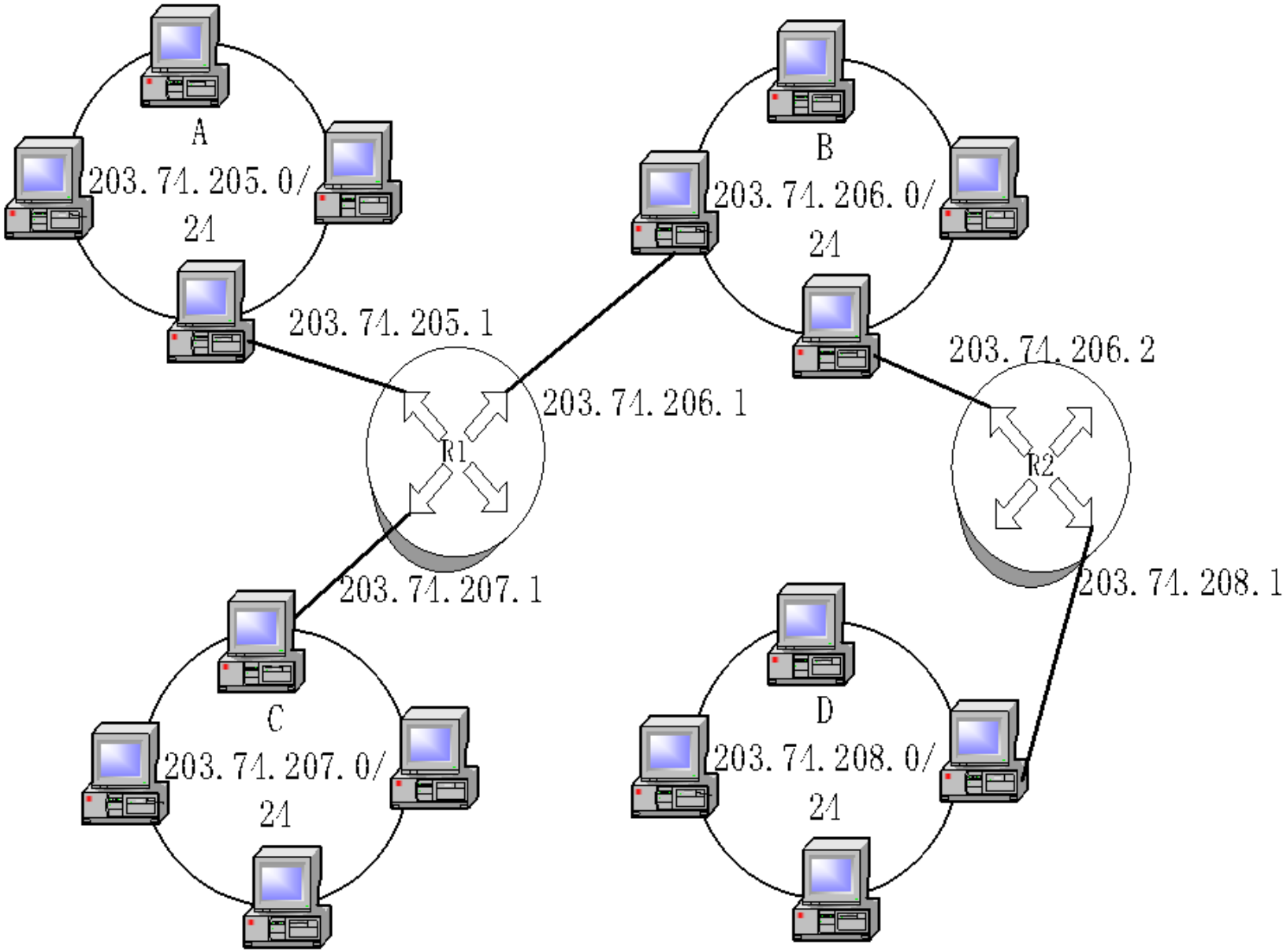


Routing table

- Including network address, interface, metric (f.g. hop), subnet mask, gateway, and so on。
- Besides IP and MAC address of connected-devices, router has IP and MAC address of it's neighbor router（arp table）
- May be somewhat different, because of different factory

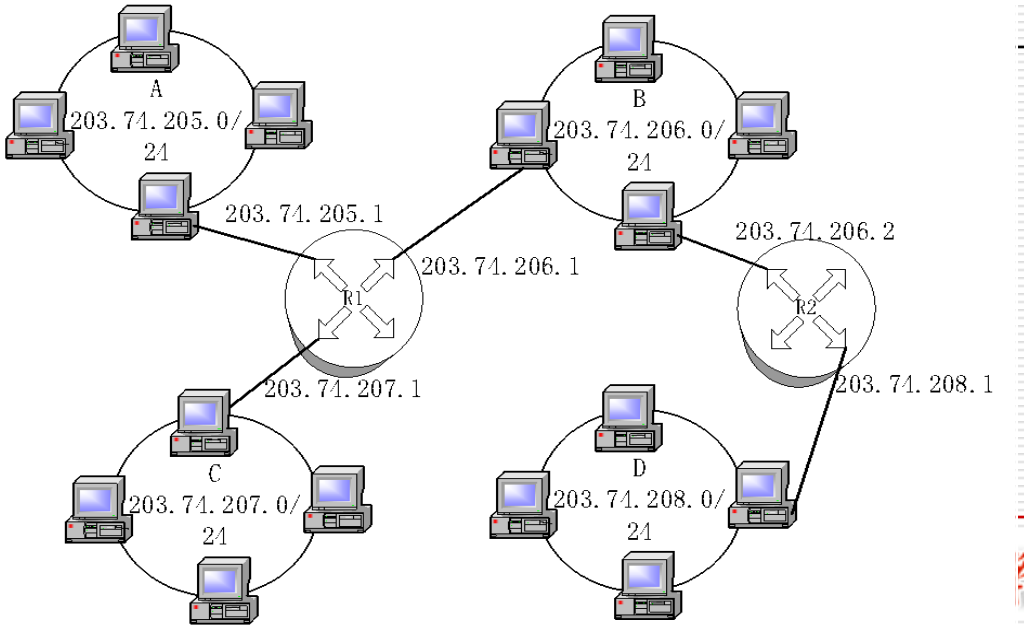
ARP table and routing table




A
203.74.205.0/24
B
203.74.206.0/24
C
203.74.207.0/24
D
203.74.208.0/24
R1
R2
203.74.205.1
203.74.206.1
203.74.206.2
203.74.207.1
203.74.208.1

Routing of router R1

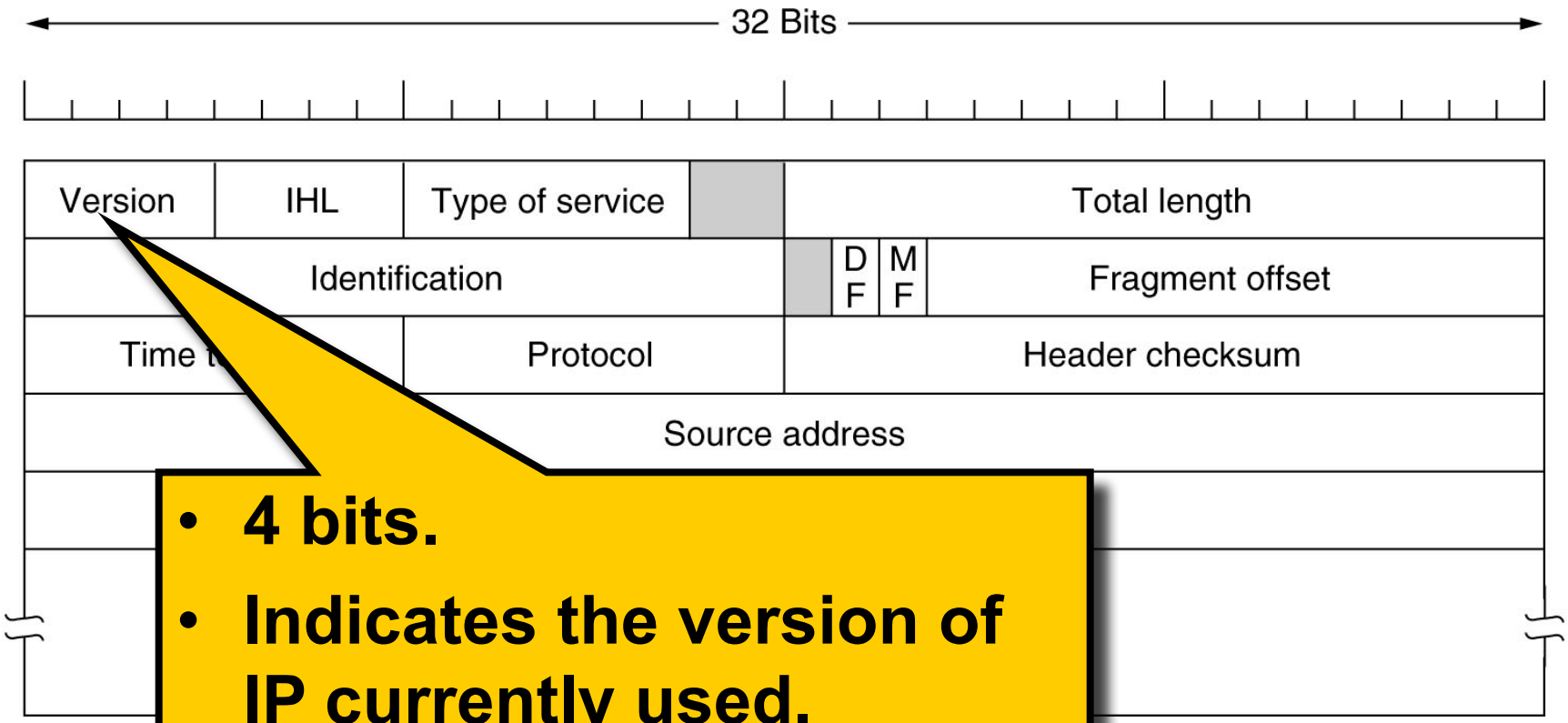
网络	网络地址	网络掩码	网关	接口	跳数
A	203.74.205.0	255.255.255.0	203.74.205.1	203.74.205.1	0
B	203.74.206.0	255.255.255.0	203.74.206.1	203.74.206.1	0
C	203.74.207.0	255.255.255.0	203.74.207.1	203.74.207.1	0
D	203.74.208.0	255.255.255.0	203.74.206.2	203.74.206.1	1



Internet protocol

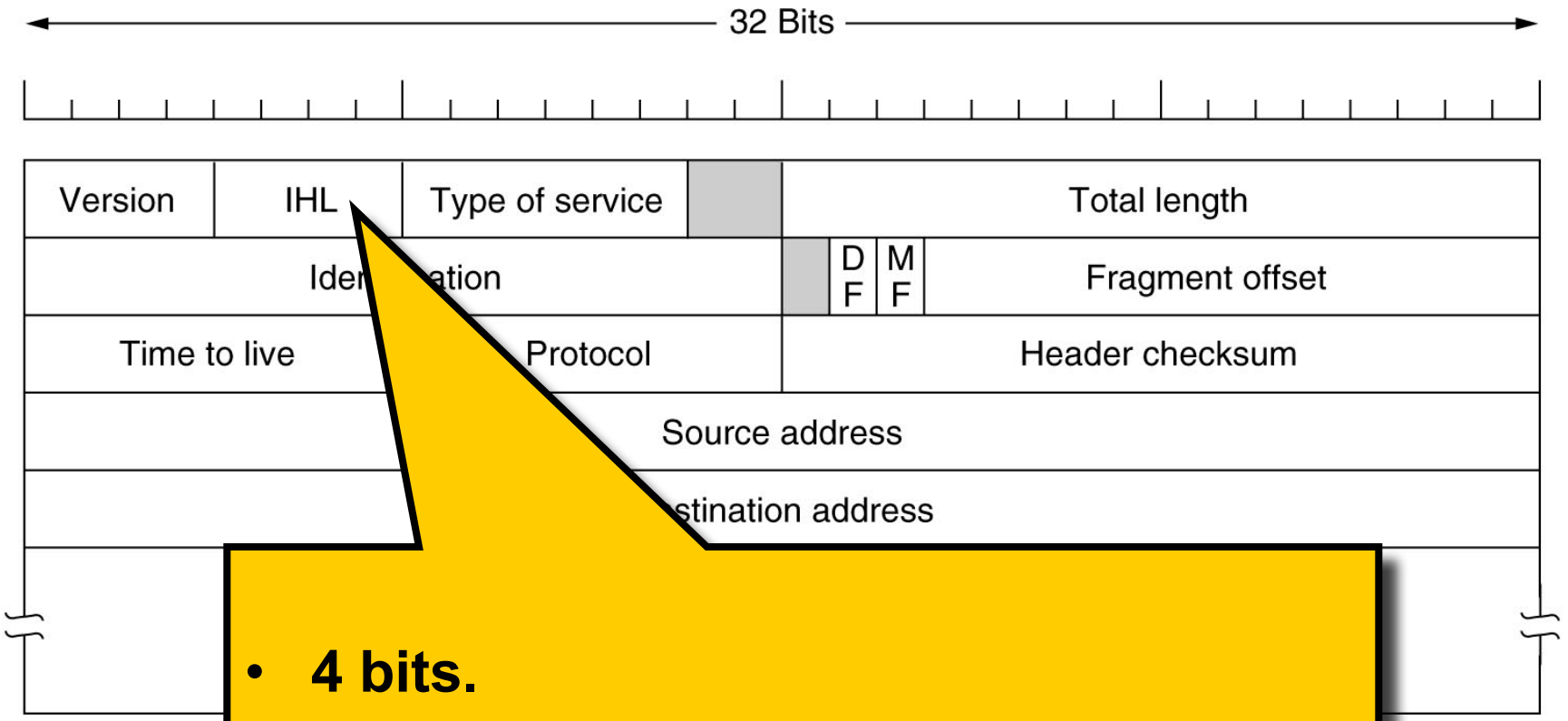
- IP is to provide a best-efforts (i.e., not guaranteed) way to transport datagrams (packet) from source to destination
  - A routed protocol
- Internet protocol
  - Packet format
  - Addressing

IP packet format



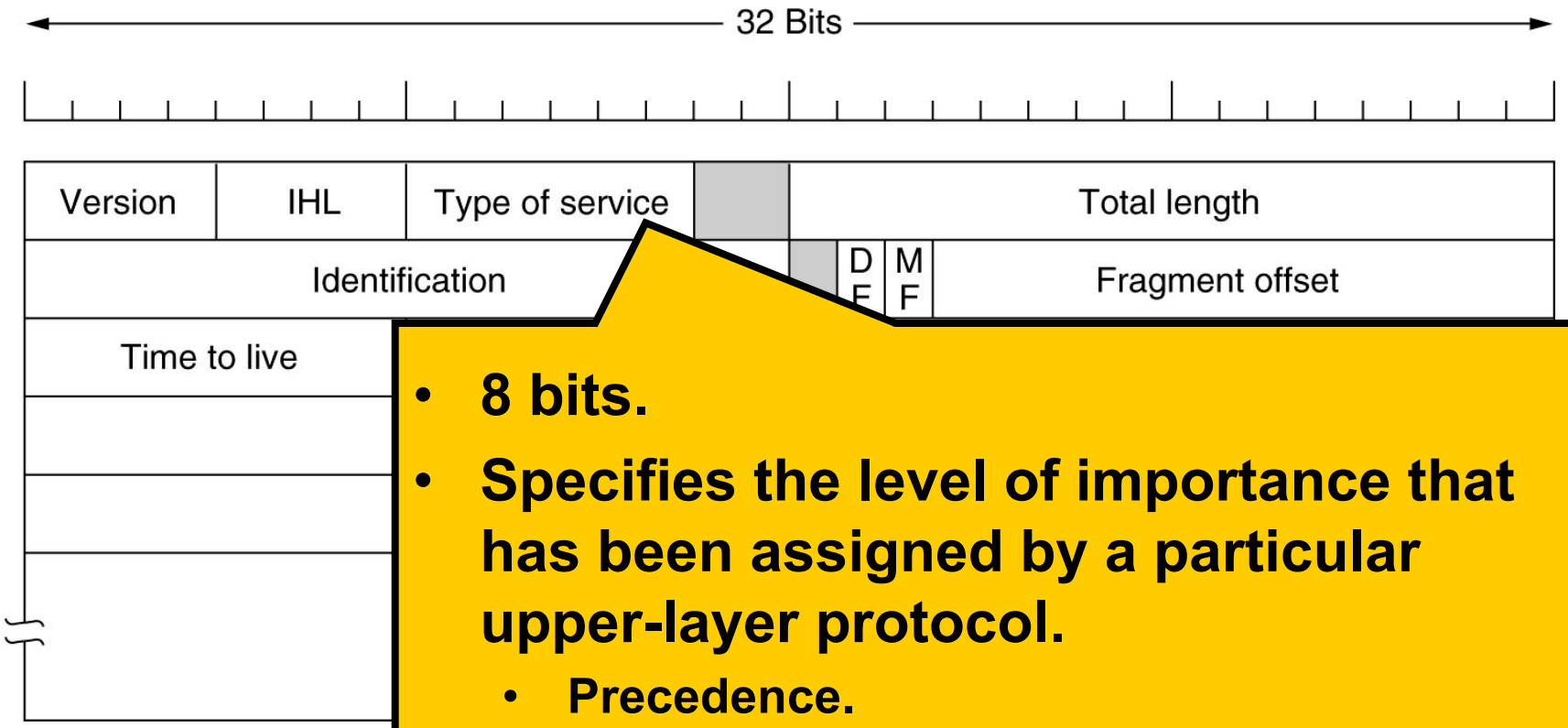
- **4 bits.**
- **Indicates the version of IP currently used.**
  - **IPv4 : 0100**
  - **IPv6 : 0110**

IP packet format



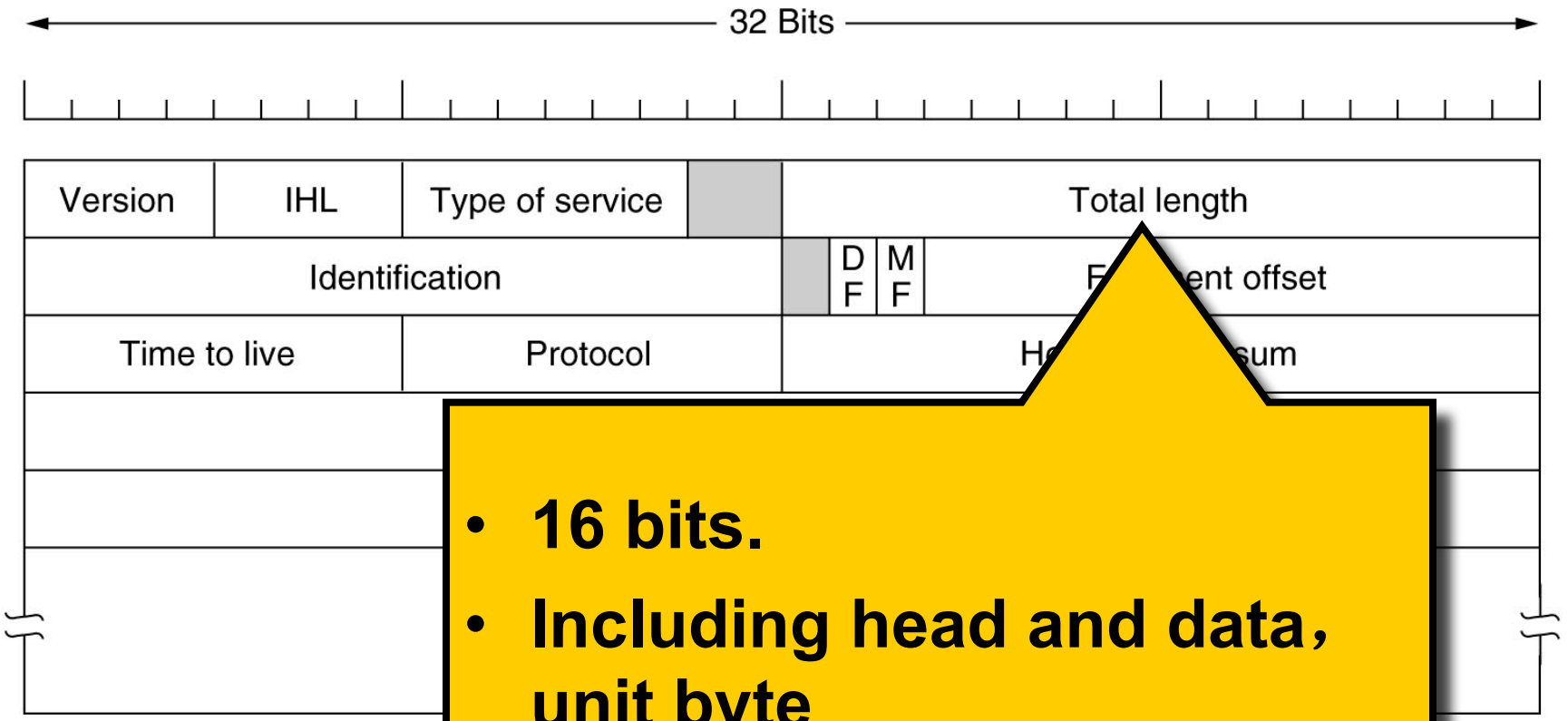
- **4 bits.**
- **IP Head lenght：32bits a unit**

IP packet format



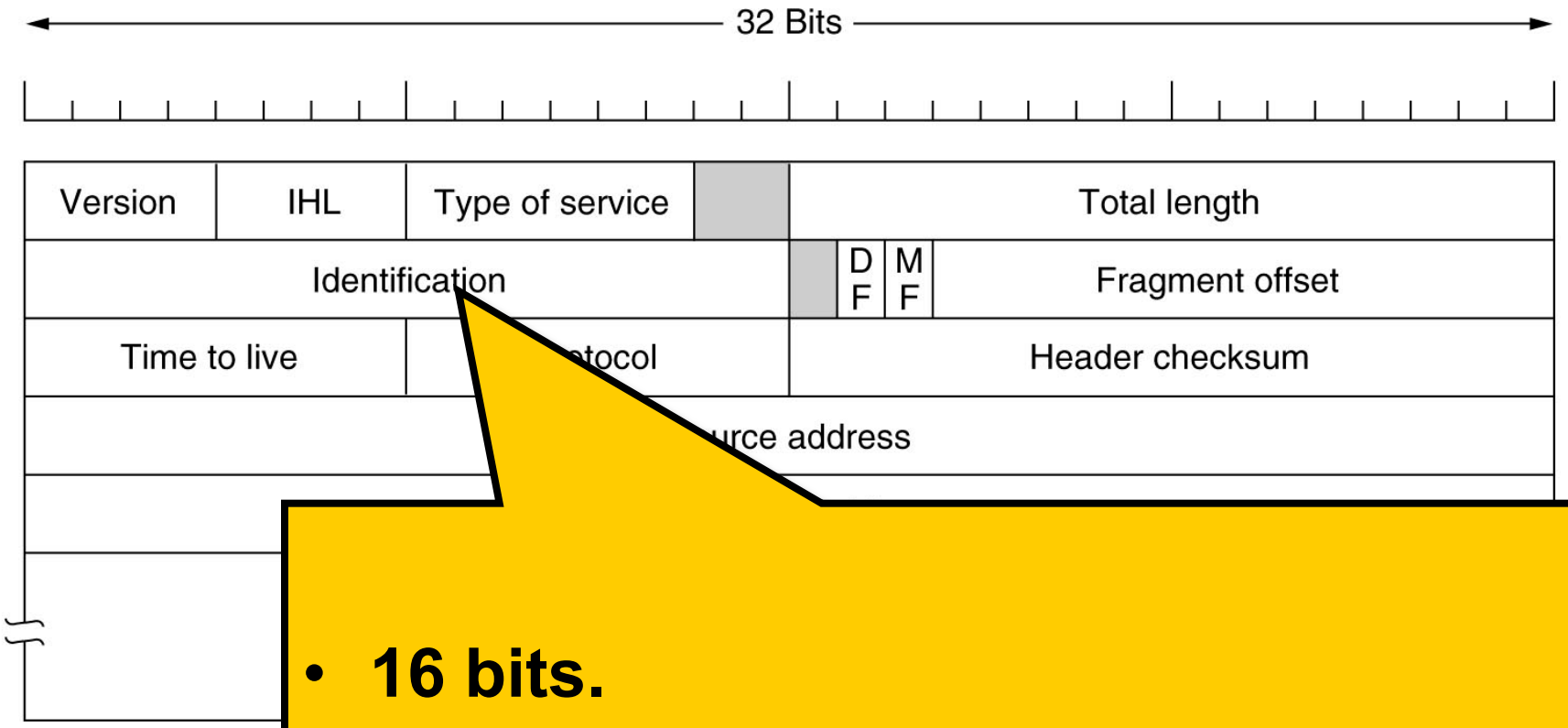
- **8 bits.**
- **Specifies the level of importance that has been assigned by a particular upper-layer protocol.**
  - **Precedence.**
  - **Reliability.**
  - **Speed.**

IP packet format ..



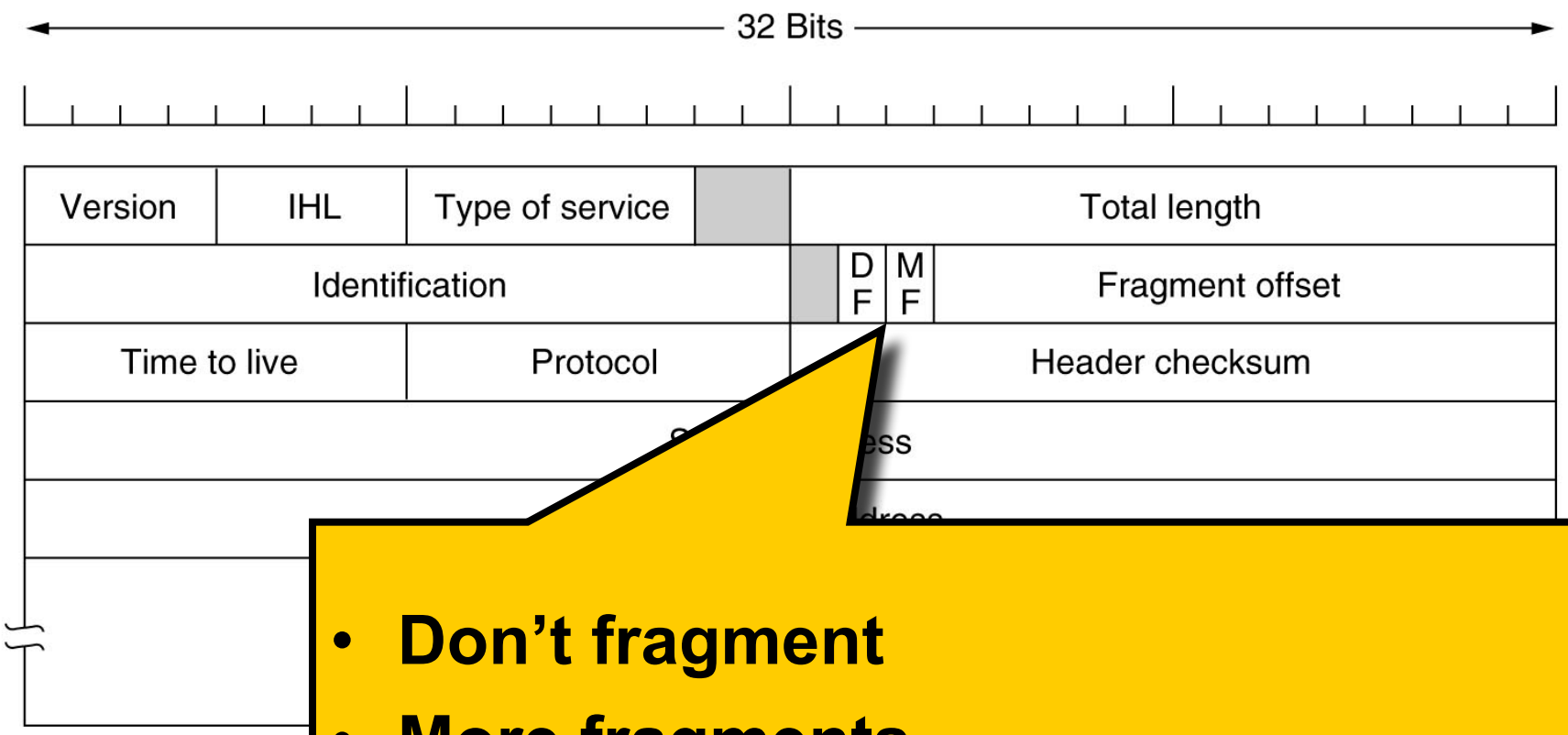
- **16 bits.**
- **Including head and data，unit byte**

IP packet format



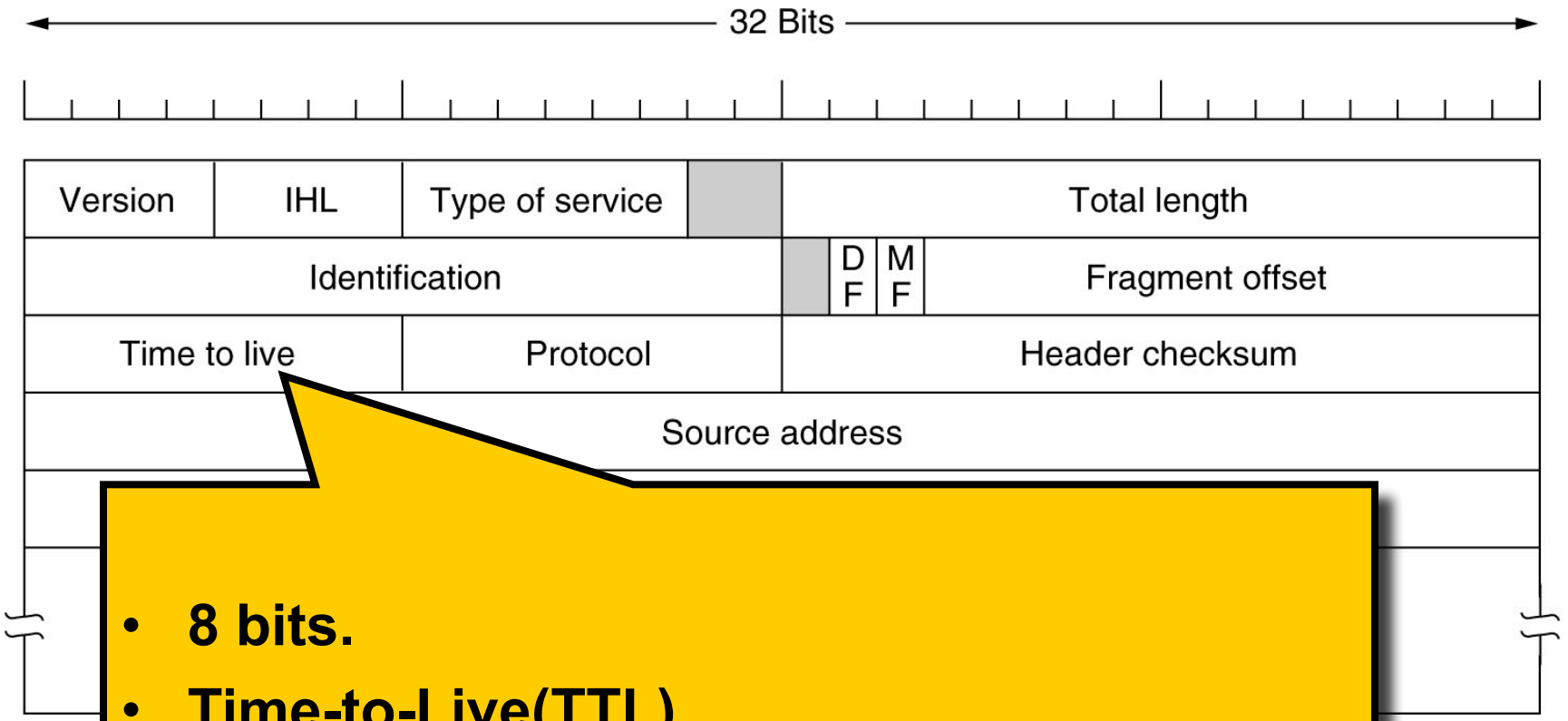
- **16 bits.**
- **Sequence number**

IP packet format



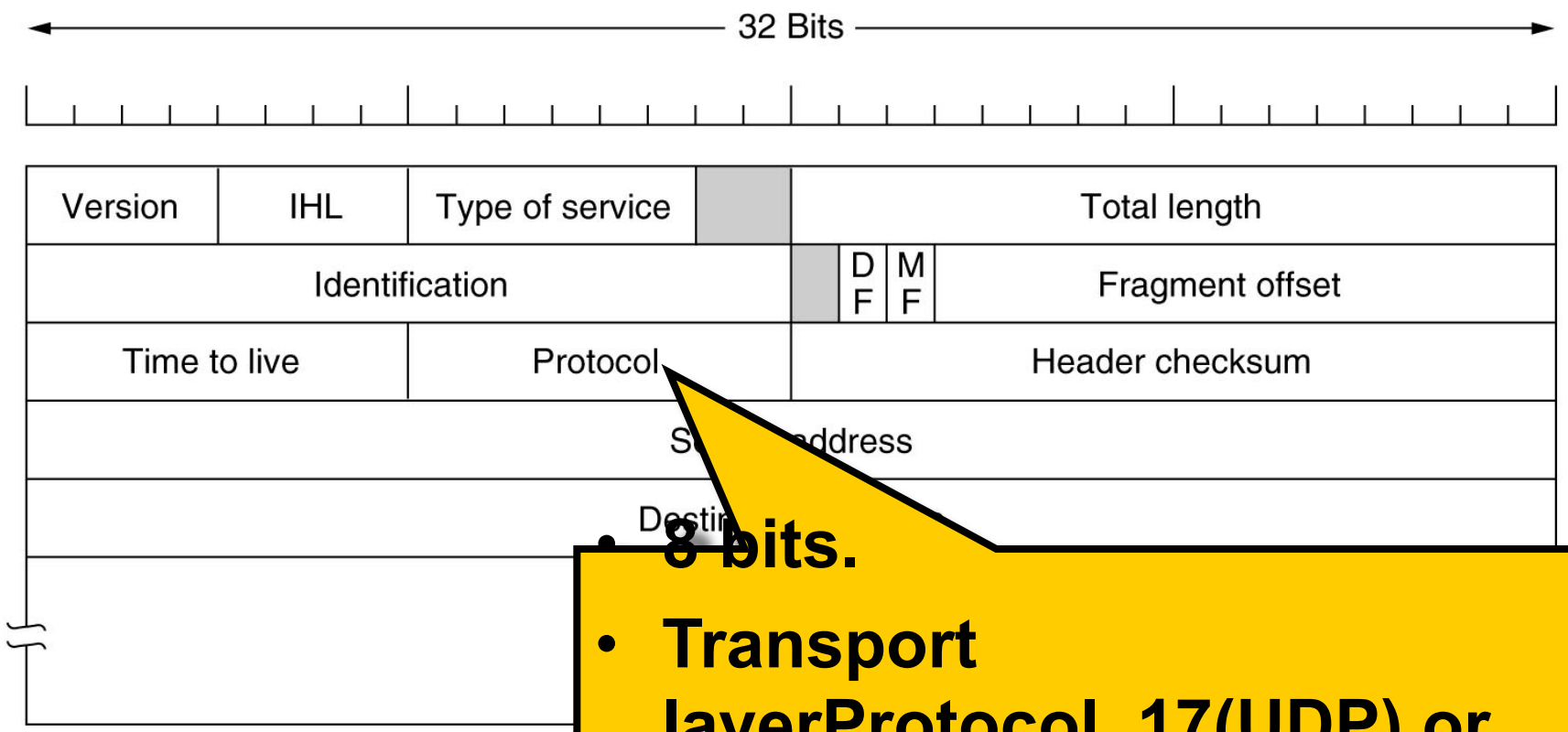
- **Don’t fragment**
- **More fragments**

IP packet format



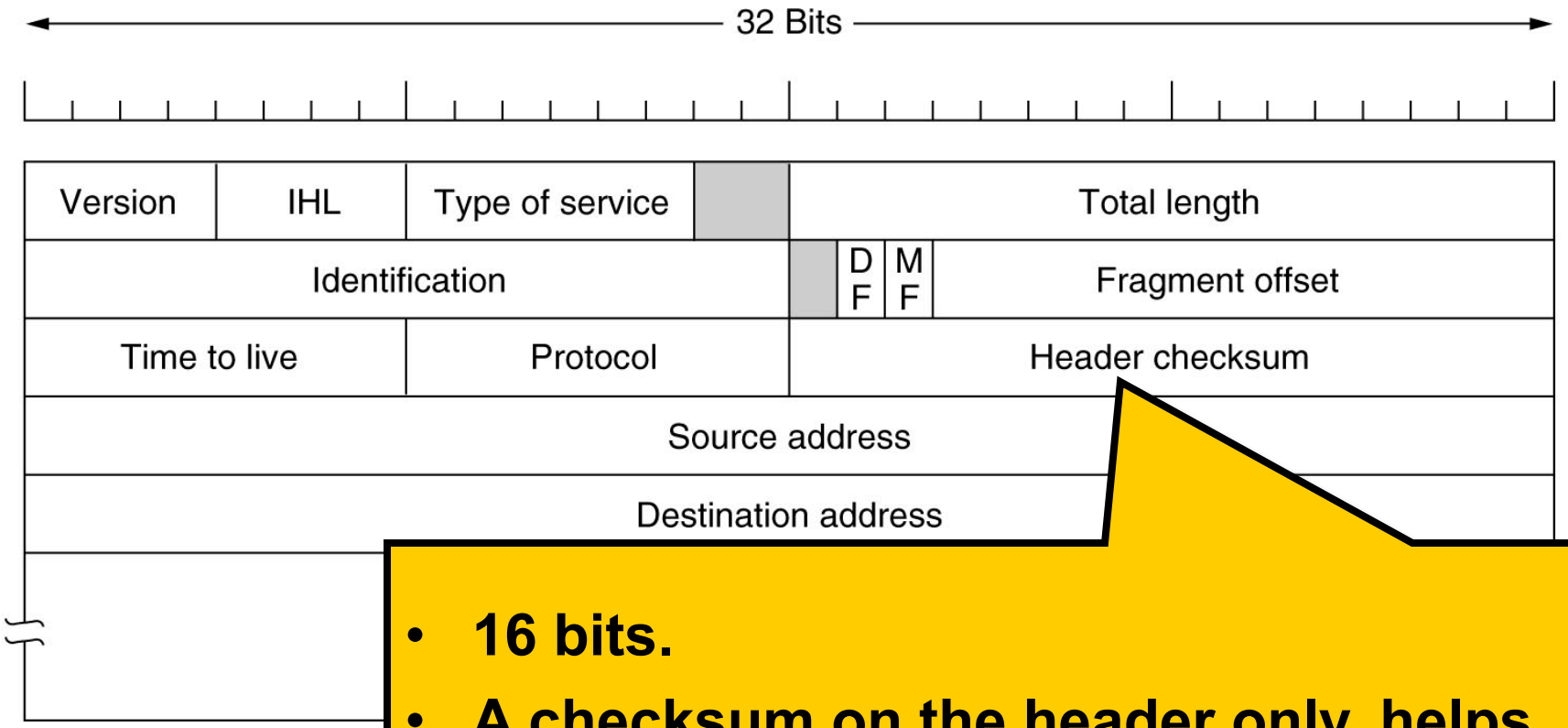
- **8 bits.**
- **Time-to-Live(TTL)**

IP packet format ..



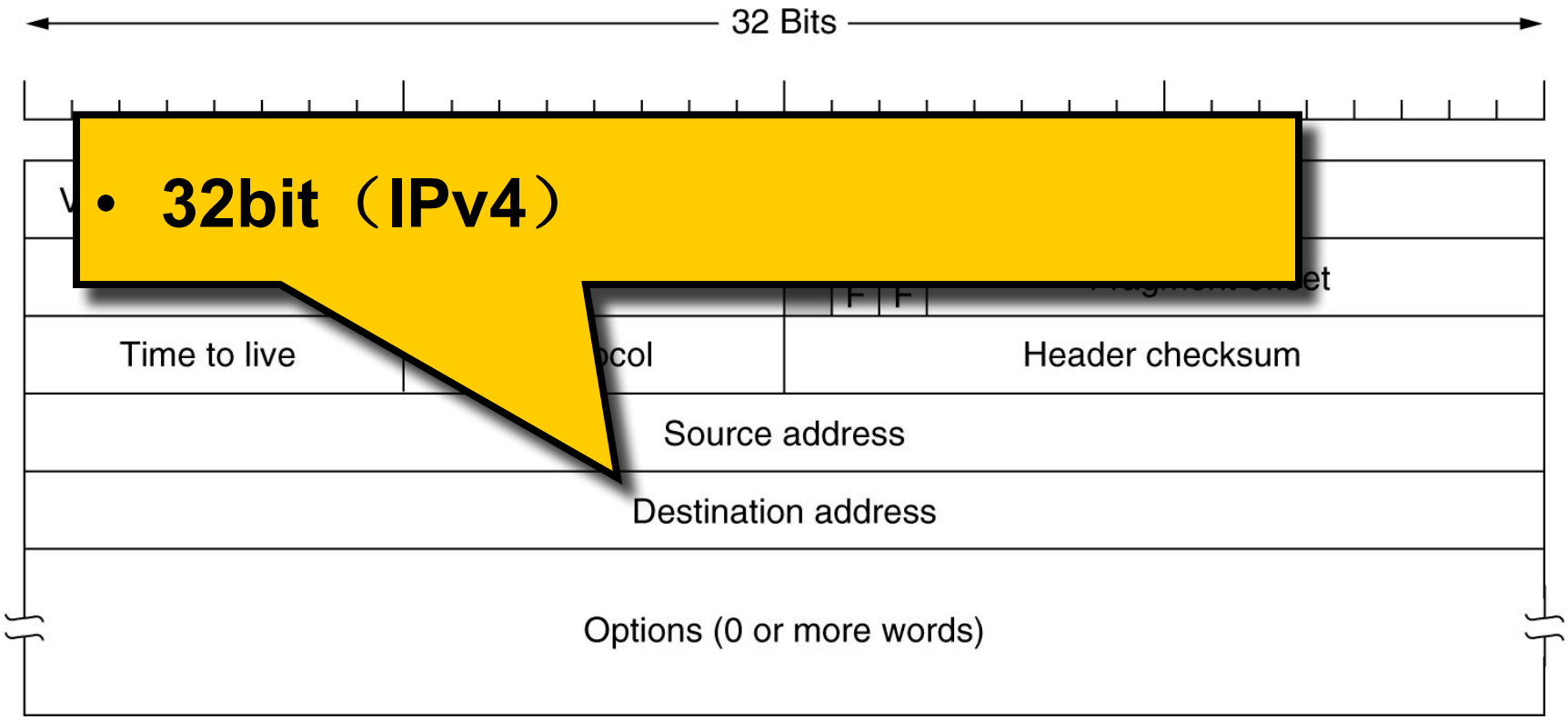
- **8 bits.**
- **Transport layerProtocol .17(UDP) or 6(TCP)**

IP packet format

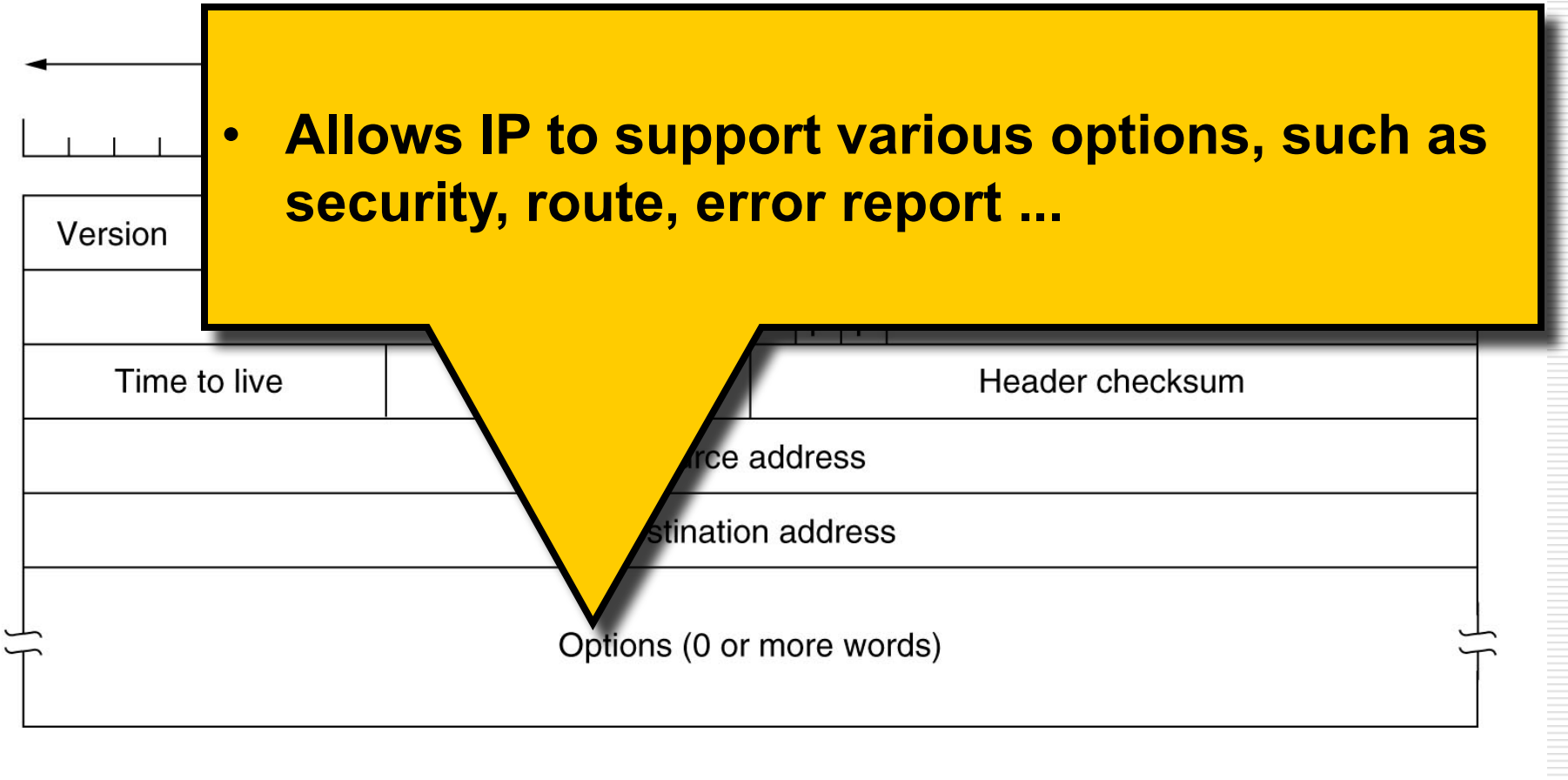


- **16 bits.**
- **A checksum on the header only, helps ensure IP header integrity.**

IP packet format

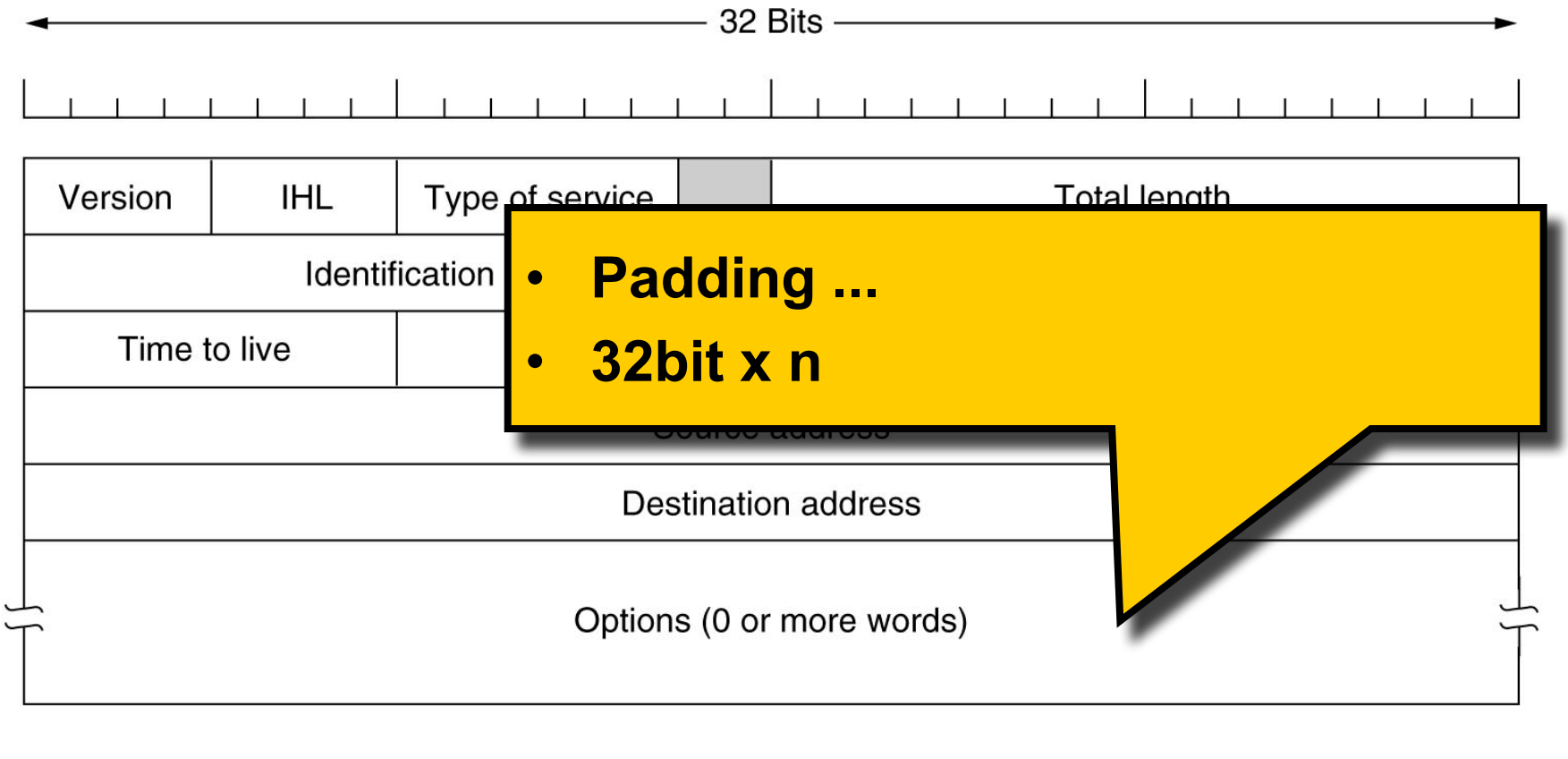


IP packet format



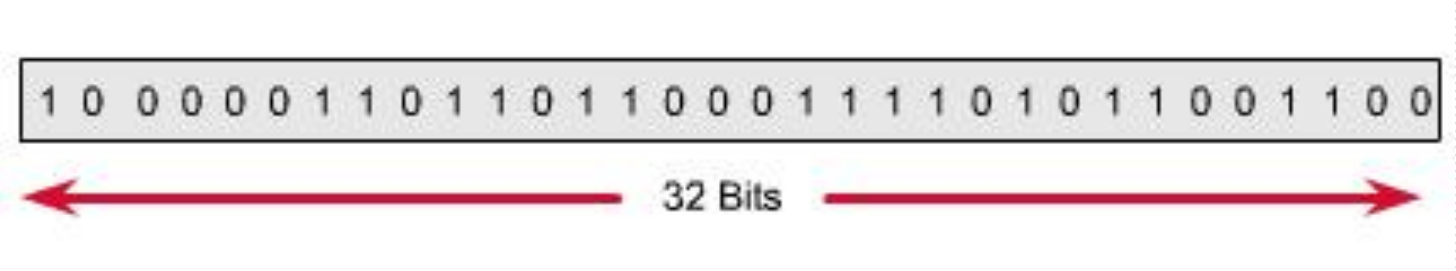
- **Allows IP to support various options, such as security, route, error report ...**

IP packet format



IP address

- IP address：network number and host number
- Binary figure of IP address

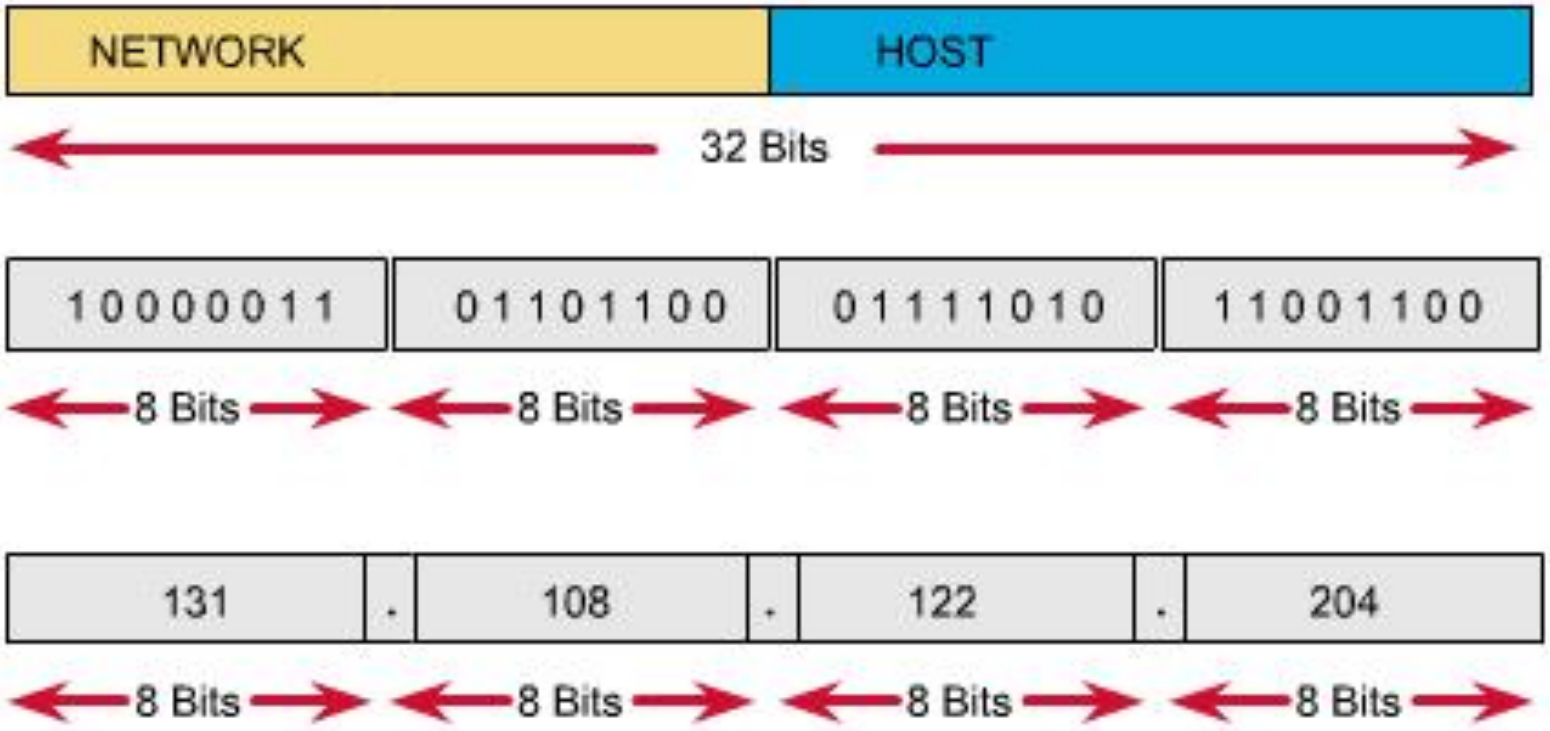


- Disadvantage: difficult to remember

Dotted decimal notation of IP address

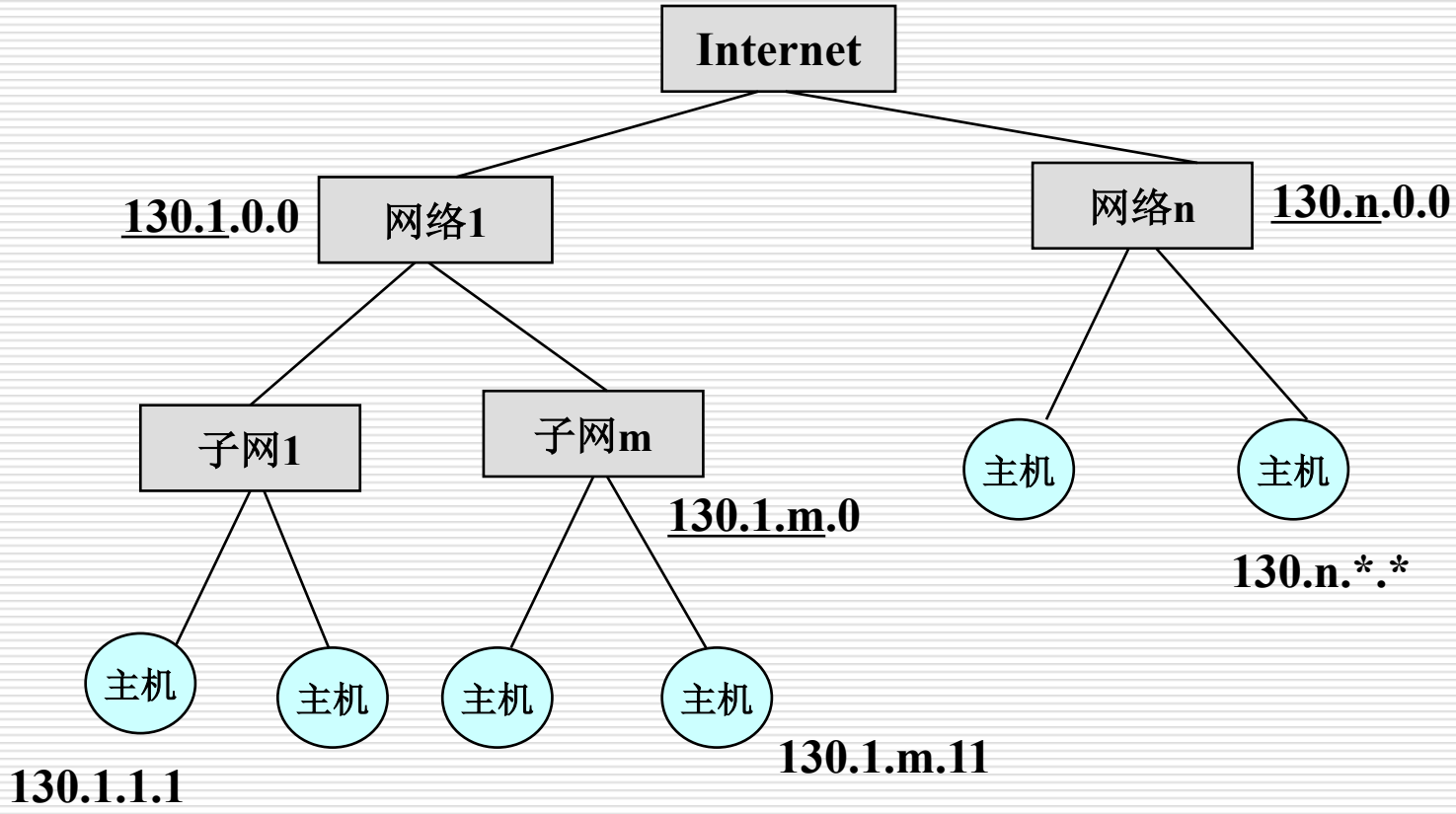
- **Binary IP is difficult to remember**
- **Dotted decimal notation：**
  - **32 bits is parted into 4 8-bits group**
  - **“.” is used to separate the 8-bits groups**
  - **Each 8-bits group is written in decimal, from 0 to 255**

IP Addressing Format

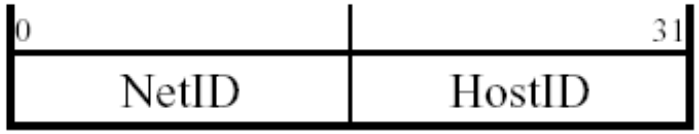


An IP address is thirty-two bits long. It consists of two main parts, a network number, and a host number. Because thirty-two bits are nearly impossible for most people to remember, IP addresses are grouped eight bits at a time, separated by dots, and represented in decimal, not in binary format. This is known as "Dotted Decimal" format.

Hierachical property of IP addr.



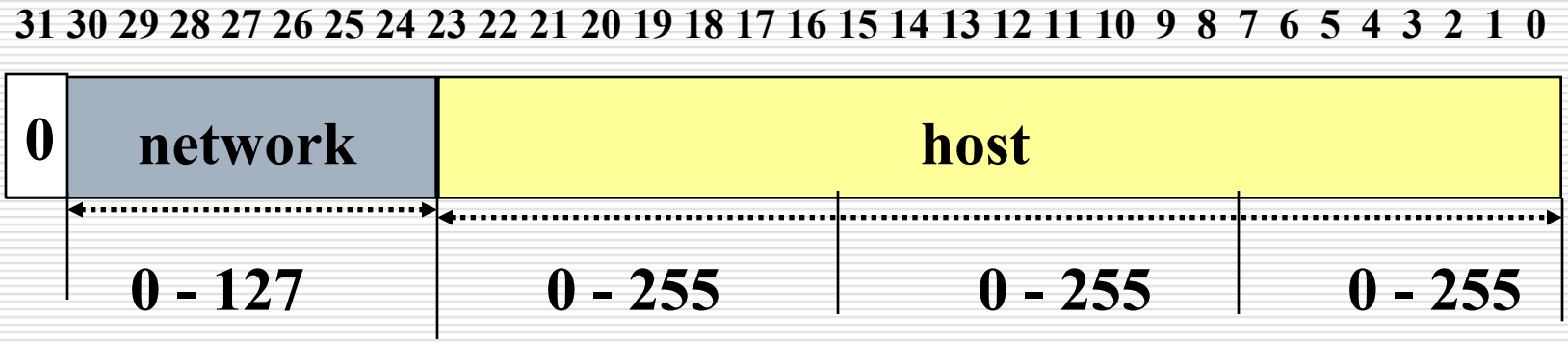
Classification of IP address



IP地址分为A、B、C、D、E类

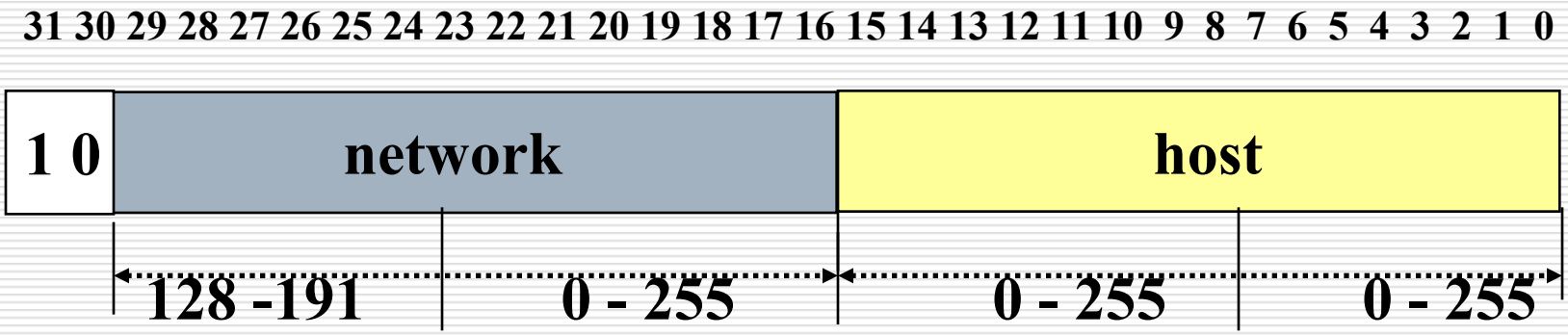
地址类别	网络数	主机数
A	0~127（128）	16777216
B	128~191（16384）	65536
C	192~223（2097152）	256

A class



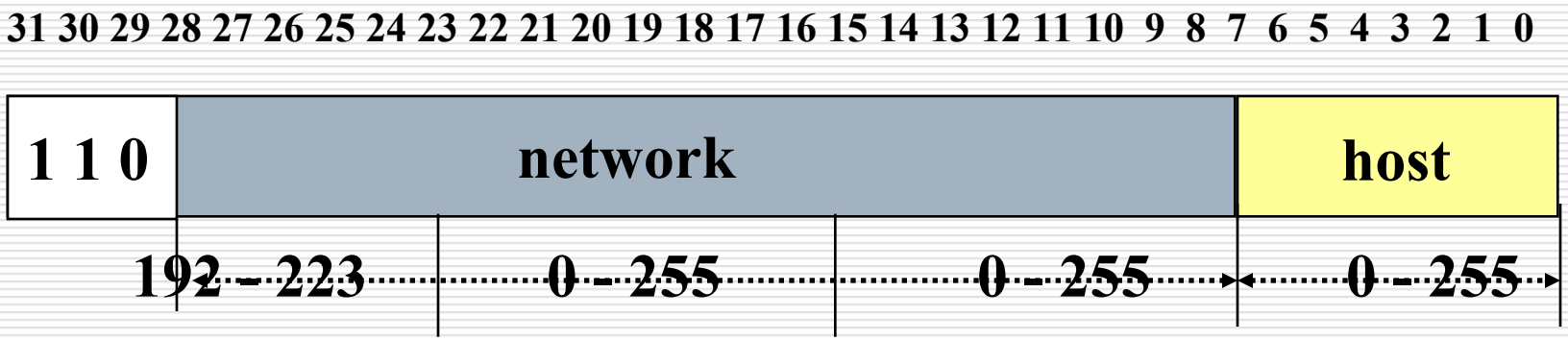
- The first byte is identified to network，the last three bytes are identified to host
- Each net can include （2^{24} -2）host at most
- The highest bit is “0”
- The first byte range “0—127” , so number of net is 128

B class



- The first two bytes are network bits, the last two bytes are host bits.
- Each net can include（2^{16}-2）host at most
- The highest two bits are “10”
- The first byte range “128－191”
- Number of net is 2^{14}

C class

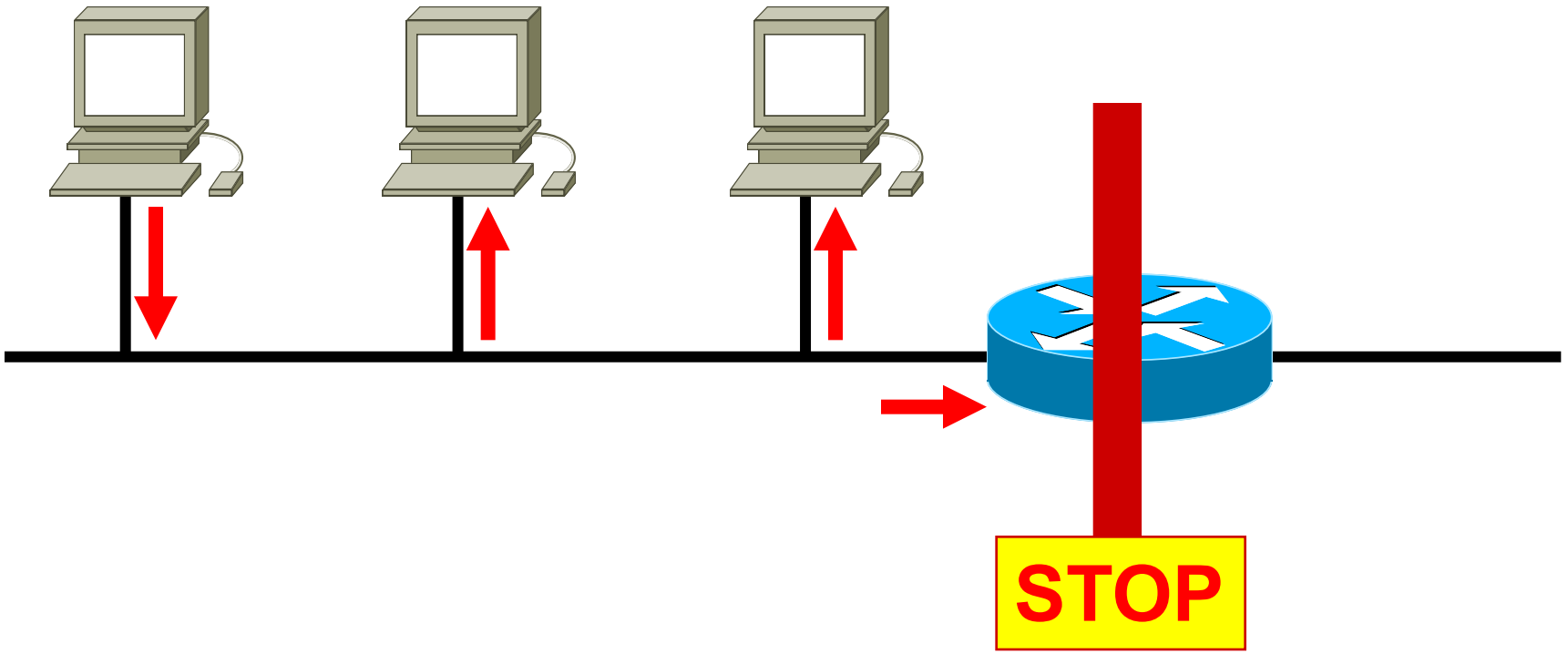


- The first three bytes are network bits, the last byte is host bits
- Each net can include 254 host at most
- The highest three bits are“110”
- The first byte range “192－223”
- number of net is 2^{21}

Special IP address

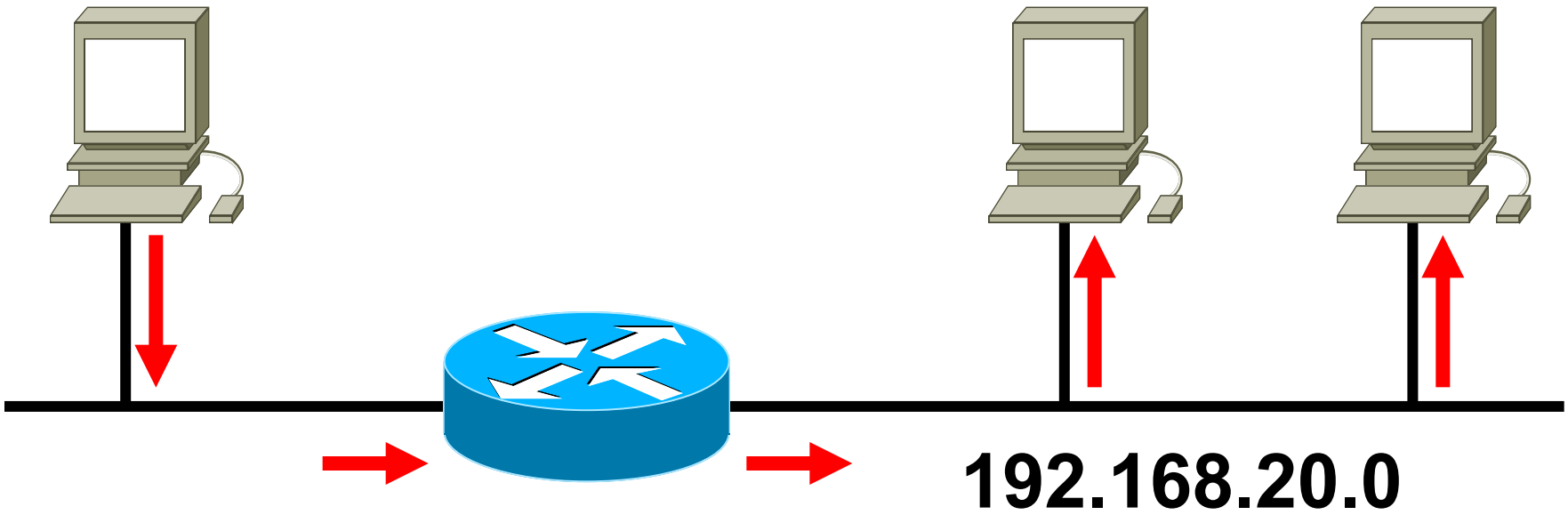
- 32 bit all 0, 0.0.0.0 Cisco default routing
- 32 all 1, 255.255.255.255 Flood Broadcast
- Host id all 0, network address 172.16.0.0
- Host id all 1, 172.16.255.255 Direct Broadcast
- 127.0.0.0 Lookback Network
- 127.0.0.1 Lookback test

Flood Broadcast = Local Broadcast



255.255.255.255

Direct Broadcast



192.168.20.255

Example: analyze 172.16.20.200

- **172.16.20.200 is Class B address**
  - **Network portion: 172.16**
  - **Host portion: 20.200**
  - **Network address: 172.16.0.0**
  - **Broadcast address: 172.16.255.255**

Public and private address

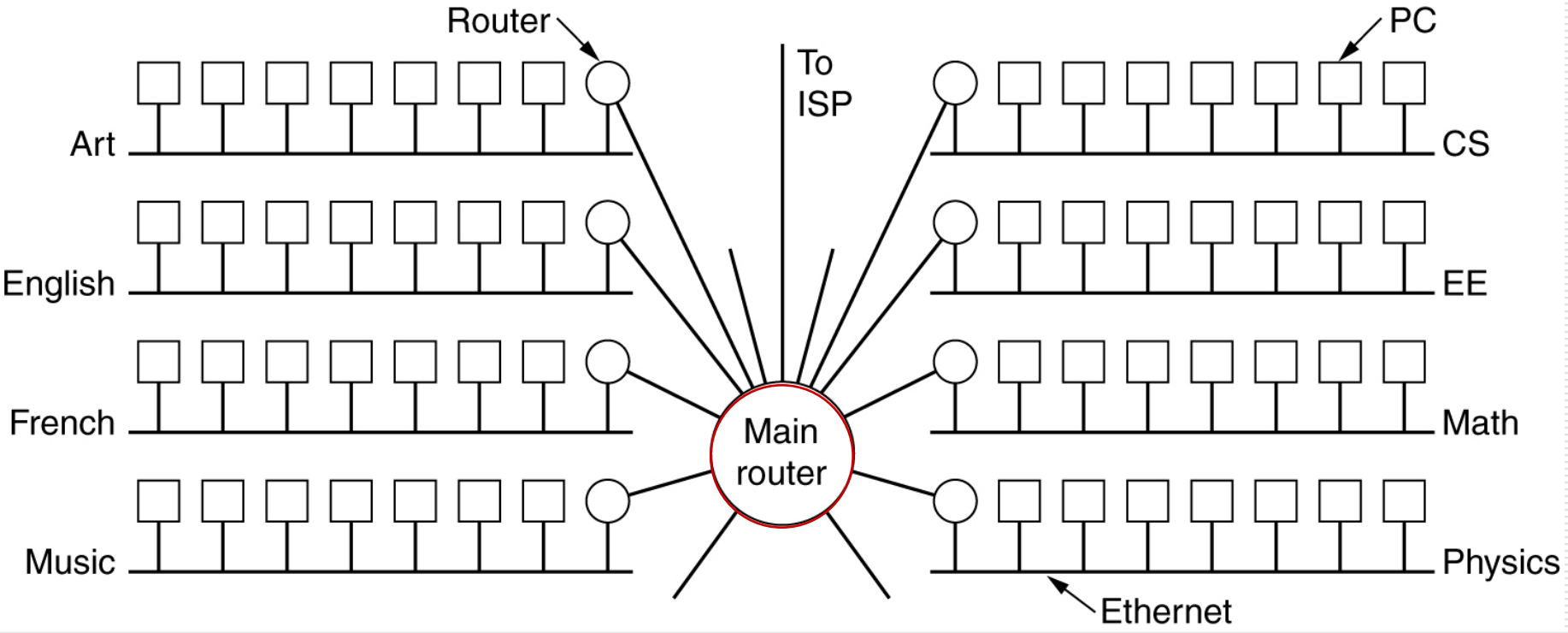
- Global IP
- IP地址枯竭
  - CIDR
  - IPv6
  - subnetting
  - private
    - A: 10.0.0.0- 10.0.255.255（1个A）
    - B: 172.16.0.0-172.31.255.255（16个B），
    - C: 192.168.0.0- 192.168.255.255（256个C）

地址类别	地　　址
A类	10.0.0.0 - 10.255.255.255
B类	172.16.0.0 - 172.31.255.255
C类	192.168.0.0 - 192.168.255.255

Subnet(子网)

- A LAN may grow to be too large to handle and must be split into subnets.
- Subsets allow a network to be split into several parts for internal use but still act like a single network (i.e., a single routing table entry) to the outside world.
- This allows different subnets to be connected within an organization.

A Subnet Examples



What function of main router?

- Communication with outside
- Main router forwards packets from outside, but how to know inside intranet structure?
  - A table?
  - A mechanism, subnet mask

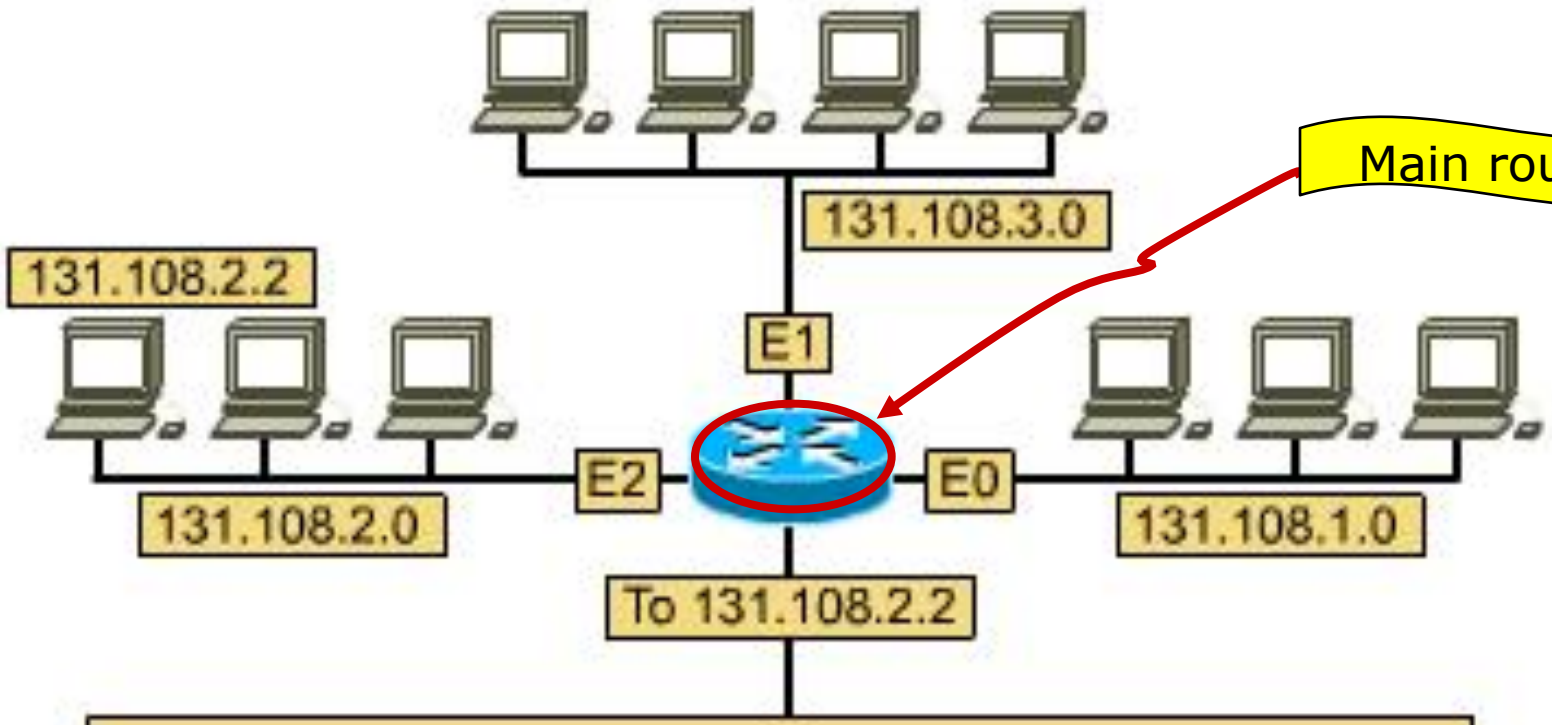
Subnet Masks

- A mask is used by the router to determine which subnet the packet should travel to.
- Subnet masks can be specified in dotted decimal notation, with the addition of a slash followed by the number of bits in the network + subnet part.
  - 255.255.255.224
  - 202.10.23.102/27
- Routers will AND the destination address with the subnet mask in order to get the address of the router where the packet should go.
- Using this method reduces the number of individual addresses that each router must store, resulting in smaller router tables.

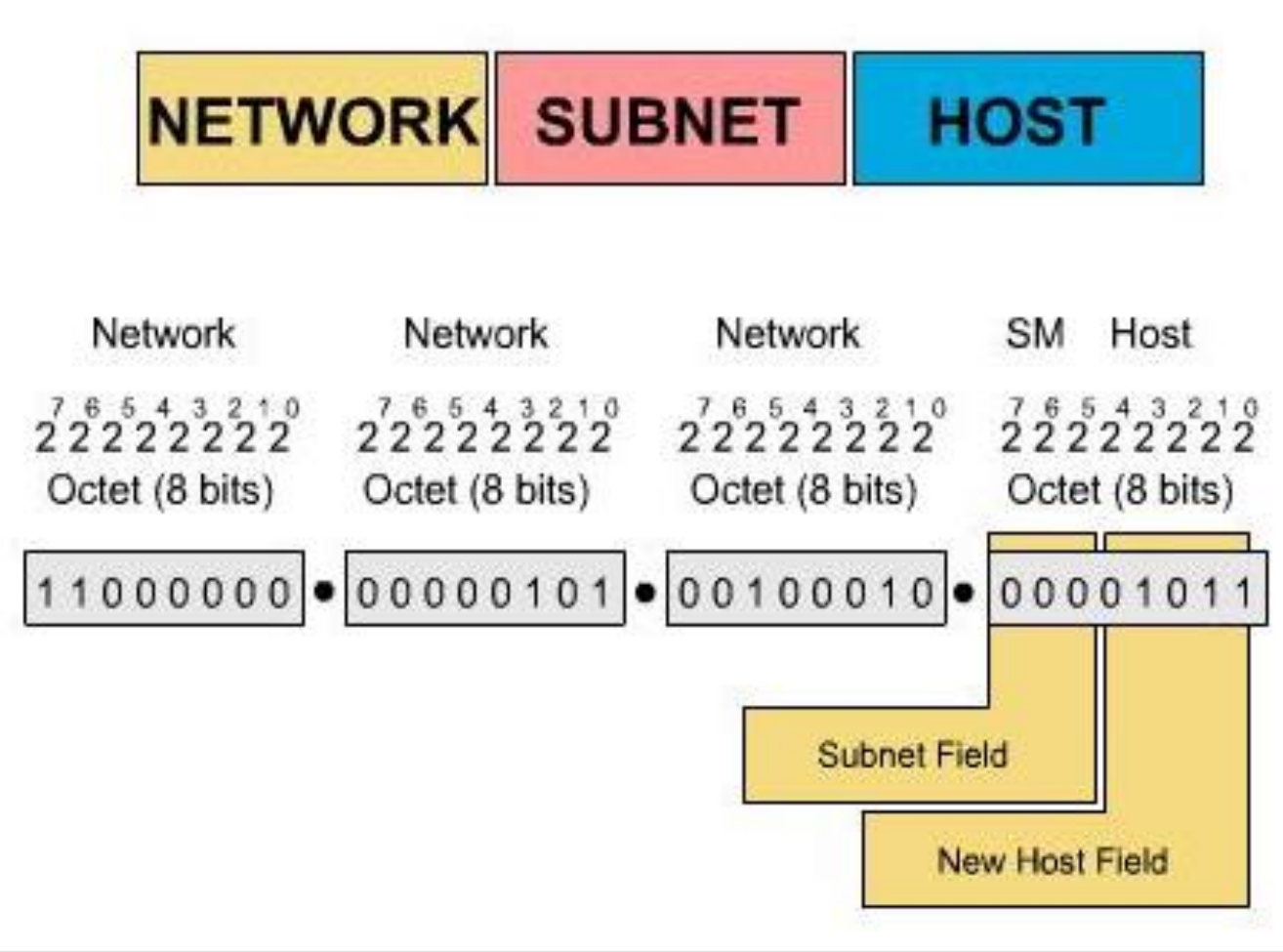
Subnet Masks

- **Default subnet mask**
  - **A：255.0.0.0**
  - **B：255.255.0.0**
  - **C：255.255.255.0**

The AND Function



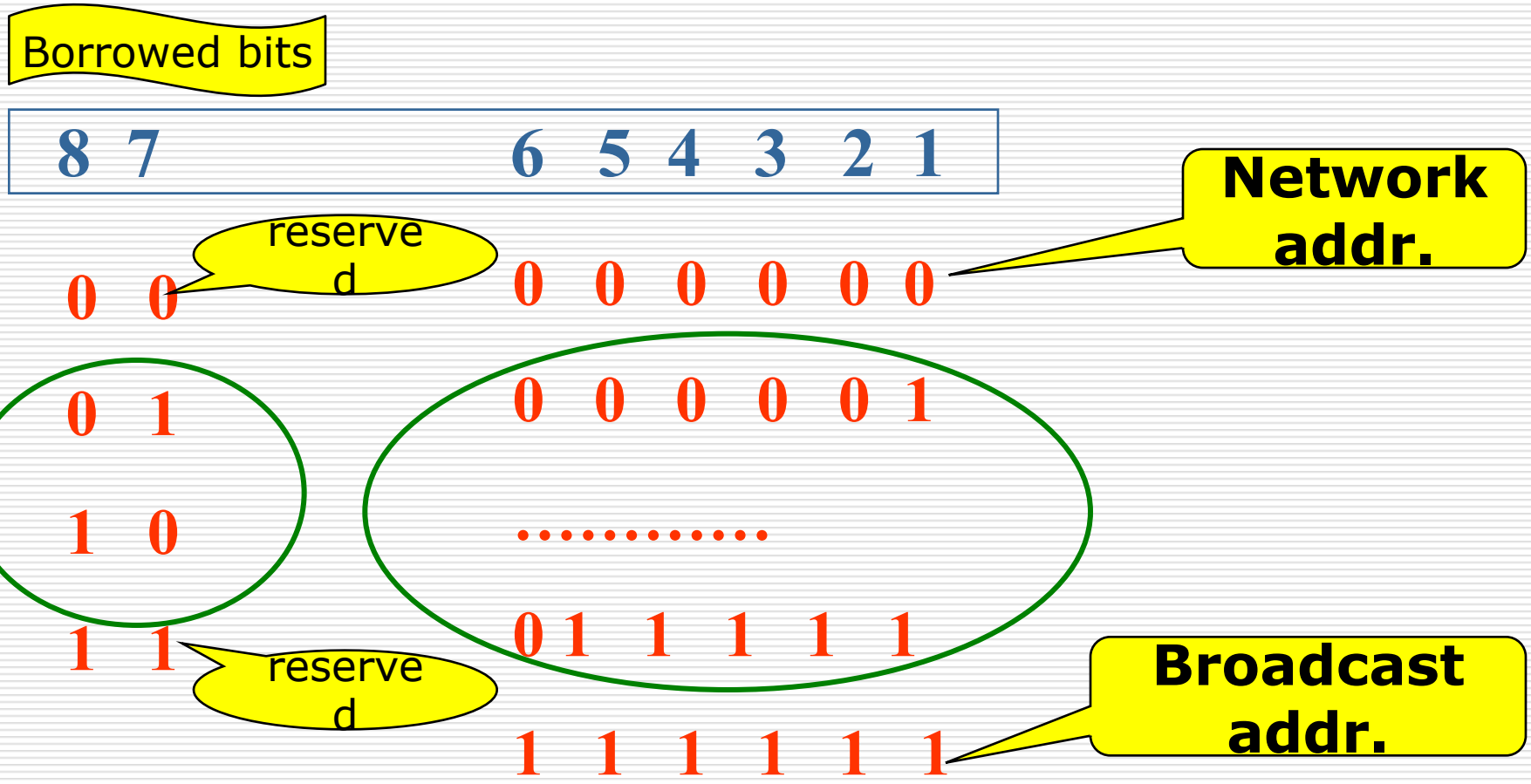
Addr. Of subnet



Using subnet to show network addr.

- A network addr.: 10.0.0.0 10/8
  broadcast addr.: 10.255.255.255
  host addr.: 10.0.0.1～10.255.255.254
- B network addr.: 166.111.0.0 166.111/16
  broadcast adr.: 166.111.255.255
  host addr.: 166.111.0.1～166.111.255.254
- C network addr.: 212.111.1.0 212.111.1/24
  broadcast addr.: 212.111.1.255
  host addr.: 212.111.1.1～212.111.1.254

How to subnet? An example



Subnet address space

- Subnet is construct via borrowing bits from host part of a IP address
- Subnetting results in loss of IP address space
  - For example：C class IP 202.38.197.0，256 Ipaddresses，254valid IP.
  - 4 subnets，total IP addresses，2*62=124。

subnetting

- **subnetting：divide a big network into small subnet**
- **Borrowing rule**

Address Class	Size of Default Host Field	Maximum Number of Subnet Bits
A	24	22
B	16	14
C	8	6

summary

- Router's main function
- Internetprotocol
  - Packet fromat
  - IP address
- IPv4 address reserved space
- Subnetting

Thank you!