

IP : Internet Protocol

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Agenda

- **IP functions**
- **IP header format**
- **Routing architecture**

IP layer

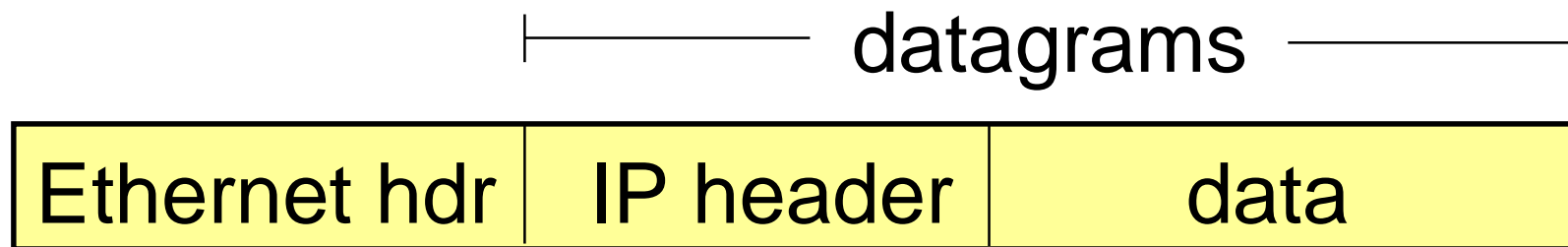
- **defines a single virtual network on top of different kinds of hardware platform using IP address**
- **functions of IP**
 - route packet
 - fragmentation
 - handle type of services
 - send and receive error and control message using ICMP

IP attributes

- **handle data unit called IP datagrams**
- **connectionless protocol - doesn't promise reliable delivery**
- **best effort delivery**
- **packets may be lost, out of sequence, or duplicated due to various reasons**

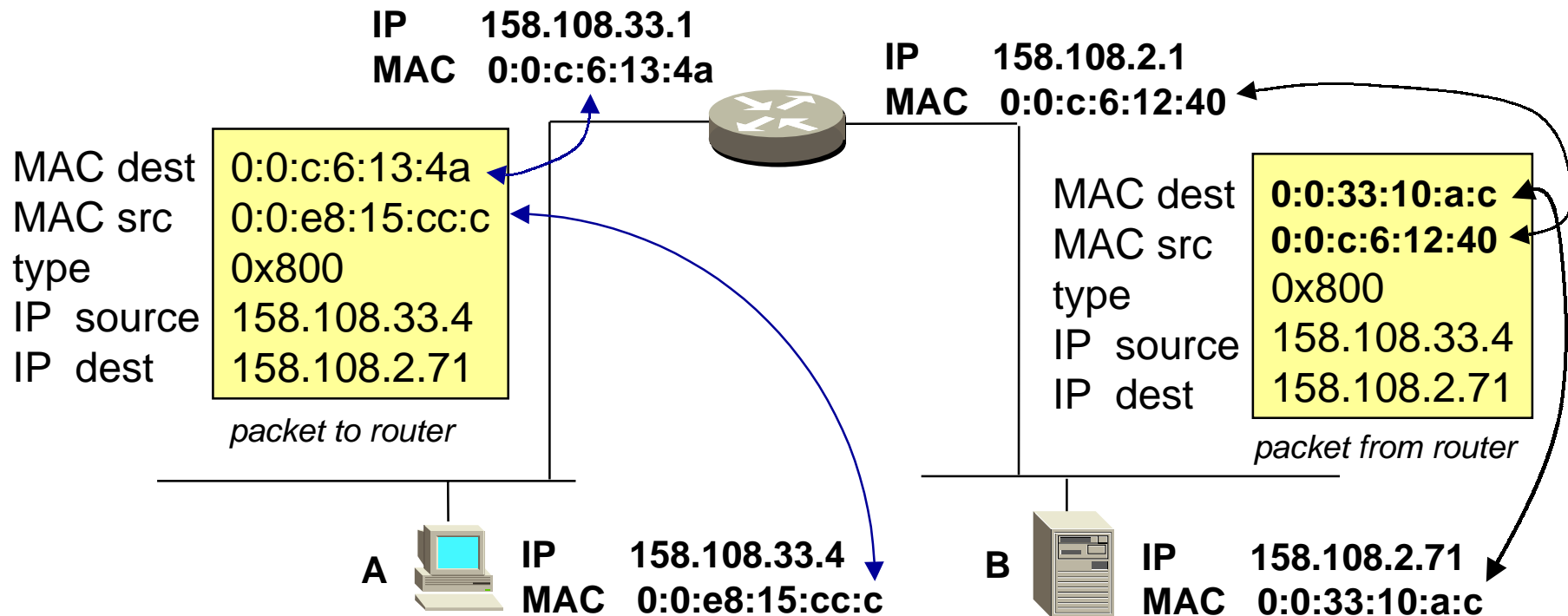
IP encapsulation

- with Ethernet frame



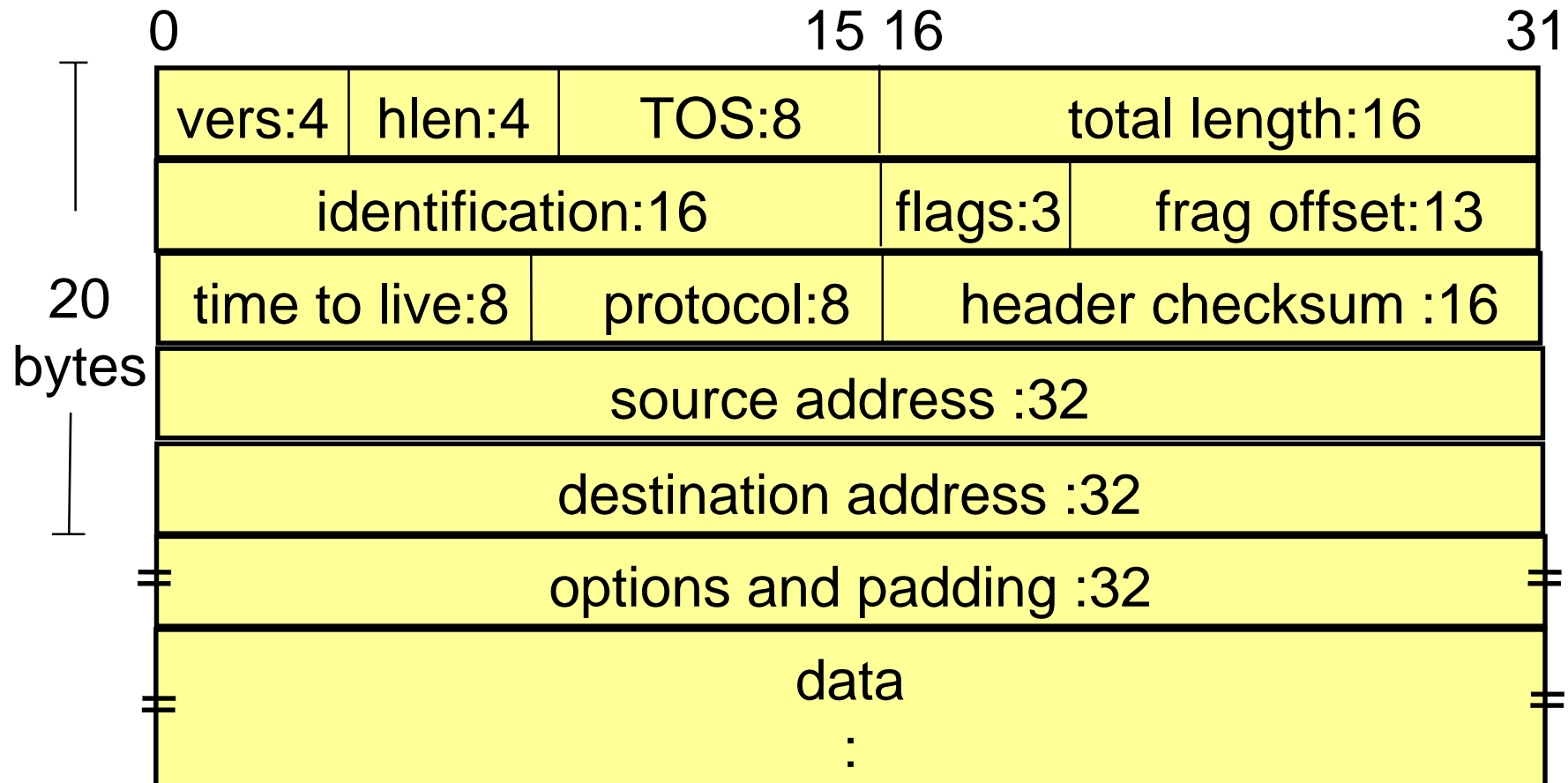
IP reframing

- IP will reframe the packet when A send data to B



Change MAC address, IP address be the same

IP datagrams



IP header details (1)

- **vers** - version = 4
- **hlen** - header length in 32-bit words, hlen =5 with no options
- **TOS** - type of service, desired quality of services

0	1	2	3	4	5	6	7
Prec.			D	T	R	0	0
bits			if 0		if 1		
0-2			Precedence				
3			Normal delay		low delay		
4			Normal throughput		High throughput		
5			Normal Reliability		High reliability		
6-7			Reserved				

IP header details (2)

- **Total length** - max datagrams (including header) is 64K
- **identification, flags, fragmentation** - use to segmentation and reassembly packet
- **TTL** - Time to live, max number of routers through which the datagrams may pass (hop count)
 - decrease at each router to prevent looping
 - normally set to 30
 - if ttl == 0 discard and send ICMP TTL exceeded to source IP
- **Protocol** - higher-level protocol that provide data
 - 1 = datagrams carries an ICMP messages
 - 6 = datagrams carries an TCP segments
 - 17 = datagrams carries an UDP datagrams

IP header details (3)

- **header checksum** - 16 bit one's compliment, note that there is no data checksum
- **source address** - 32 bit IP source address
- **destination address** - 32 bit IP destination address
- **option and padding** - additional info to control functions such as routing and security

Routing

- **process of choosing a path over which to send datagrams**
- **IP routes packet by looking at the IP network number**
- **routing components**
 - determine what path are available
 - selecting the best path for a particular purpose
 - using those paths to reach other networks
- **devices which perform routing are routers (historically call IP gateways)**

Routing Table

- **Every router contains a routing table of the network numbers**
- **The table records**
 - which connection can be used to reach a particular network
 - plus some indication of the performance or cost of using connection

Routing Table form

- **Routing Table form**
 - <network, gateways, others>

```
% netstat -rn
```

Destination	Gateway	Flags	Refcnt	Use	Interf
127.0.0.1	127.0.0.1	UH	4	72705	lo0
default	158.108.33.1	UG	14	10265	le0
158.108.33.0	158.108.33.3	U	4	1702	le0

How to create routing Table

- **static route - by hand**
 - **# route add 158.108.20.0 158.108.33.1**
- **dynamic routes - via routing protocol**
- **via ICMP redirect**

Routing Protocol

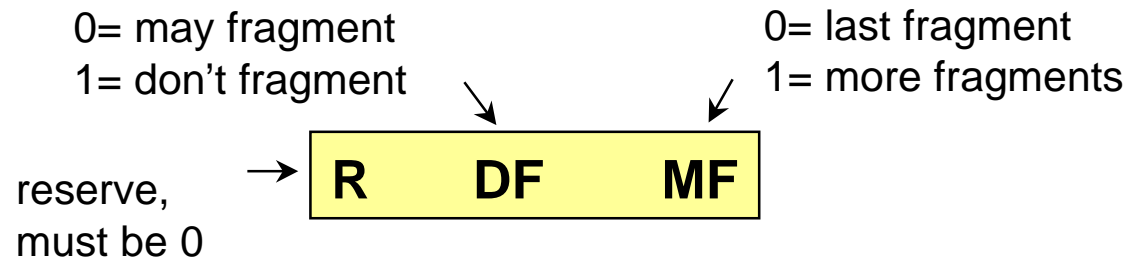
- **Routing protocol manages and updates routing table on each network node**
- **Unix often implemented using one of the two daemons:**
 - **routed** : basic routing daemon for interior routing, normally with RIP
 - **gated** : sophisticated daemon for interior and exterior routing, with additional protocol such as OSPF, BGP

Fragmentation

- **fragmentation** = processed used by IP to reduced size of datagram that are too big for network interface MTU e.g. fragment 2000 bytes to Ethernet (MTU=1500)
- fragments should be **reassembled** at the *final destination* (expensive process)
- **How ?**
 - each fragment has its own header
 - each fragment carries the same 16 bit identification number
 - Each fragment must be aligned with an eight-octet boundary

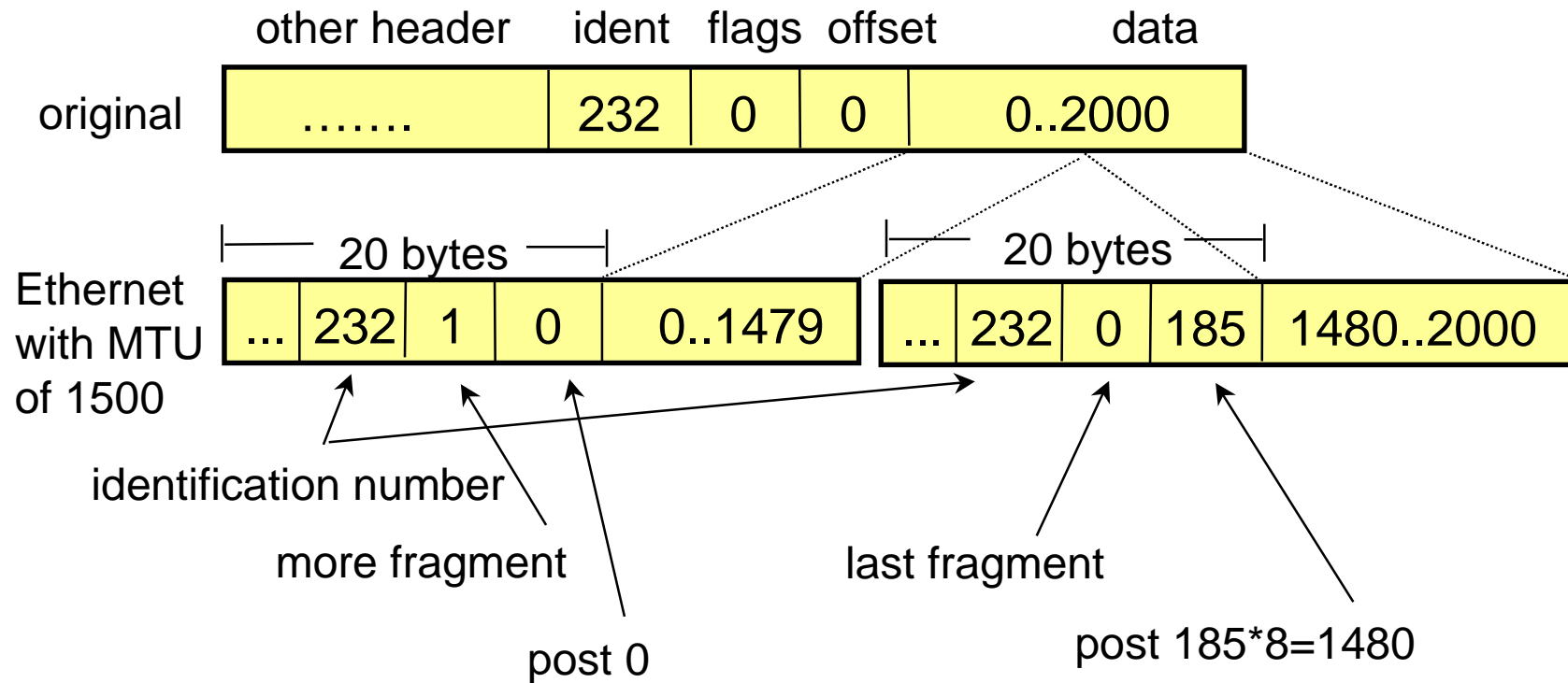
Fragmentation flag

- **Identification number**
 - 16 bits integer value used to identify all fragments
 - This id is not a sequence number!
- **flags - 3 bits control fragmentation**



- **fragment offset** - indicate the distance of fragment data from the start of the original datagram, measure in 8 octets unit

Fragmentation sample



Problem in fragmentation

- **The end node has no way of knowing how many fragments there be. The end node** has to manage enough buffer space to handle reassembly process.
- **If any** fragments lost, all datagram must be discarded
- **End node starts a timer when received the first fragment**, if any fragments fails to arrive(usually 30 secs), all datagrams must be discarded
- **Since the IP service is connectionless. No attempt is made by IP to recover these situations, though ICMP error message may be generated**

Avoiding fragmentation

- For datagrams within the same physical network, the MTU is known. TCP/UDP then use the MTU to limit the message size pass to IP; messages will never be fragmented.
- For datagrams passed to diff net, **unknown MTU!**
- **standard recommend that all networks supporting TCP/IP have an MTU of at least 576 bytes**
512 bytes data+20 bytes TCP hdr + 20 bytes IP hdr with options

TO GUARANTEED THAT A PACKET OF 576 BYTES OR LESS IS NEVER FRAGMENTED