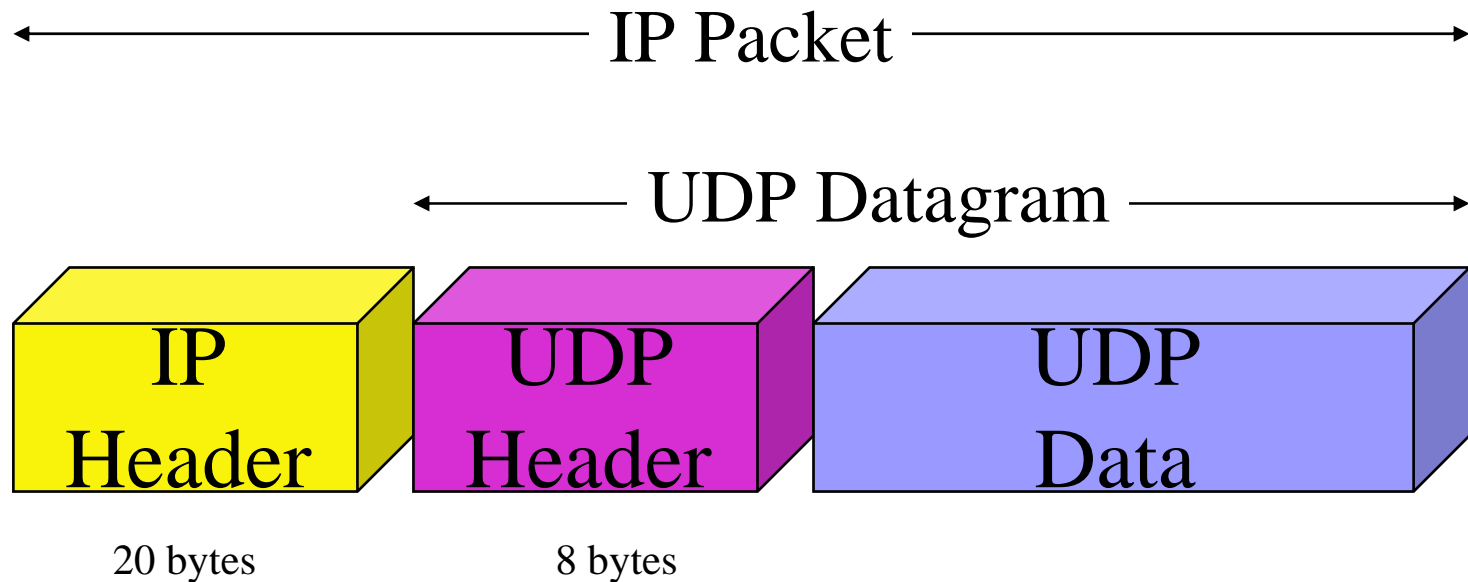
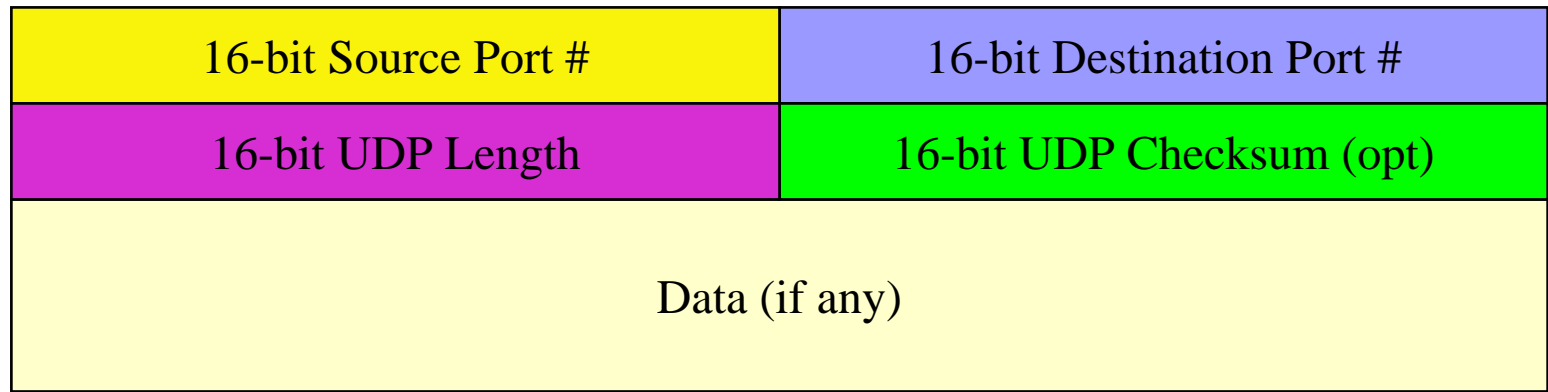


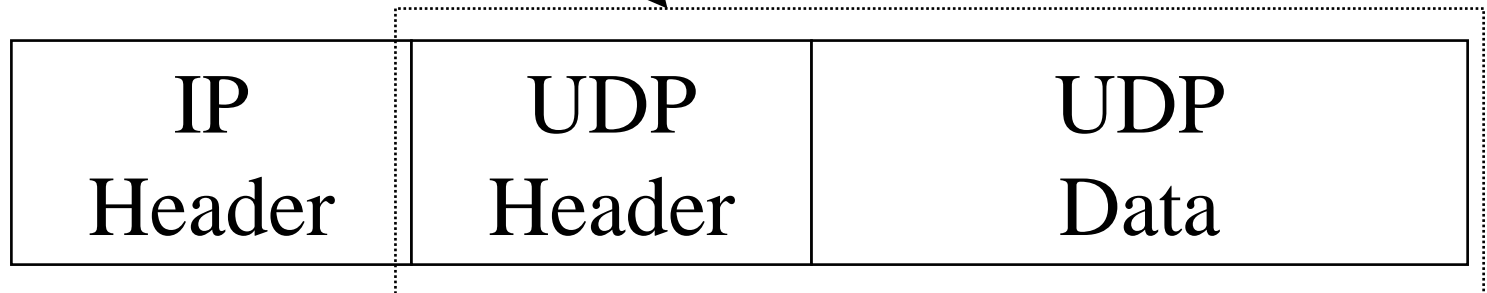
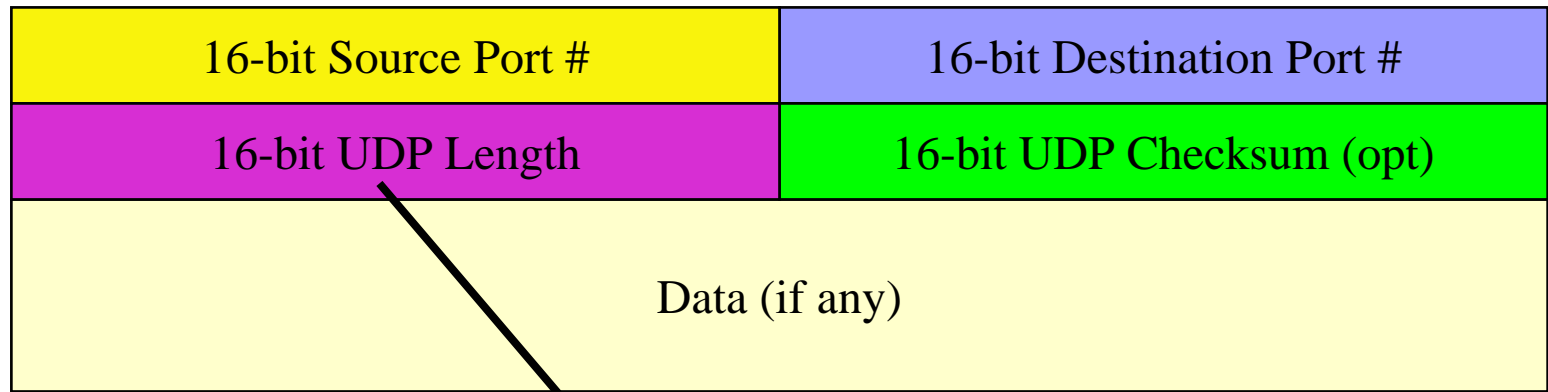
User Datagram Protocol (UDP)



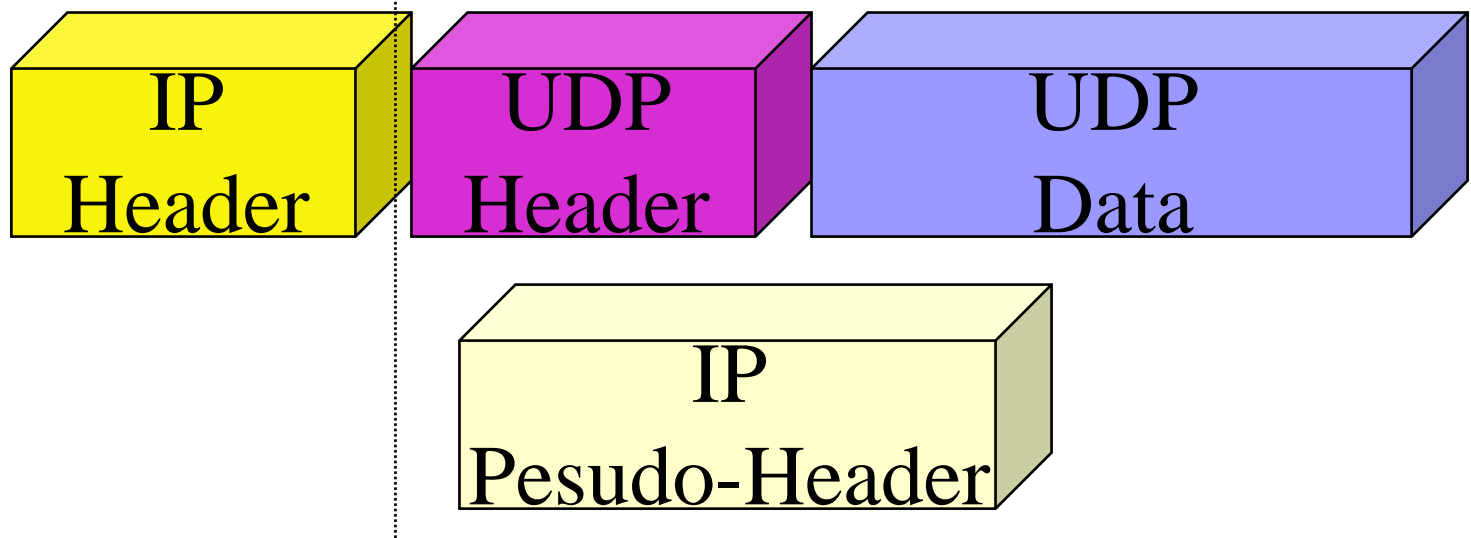
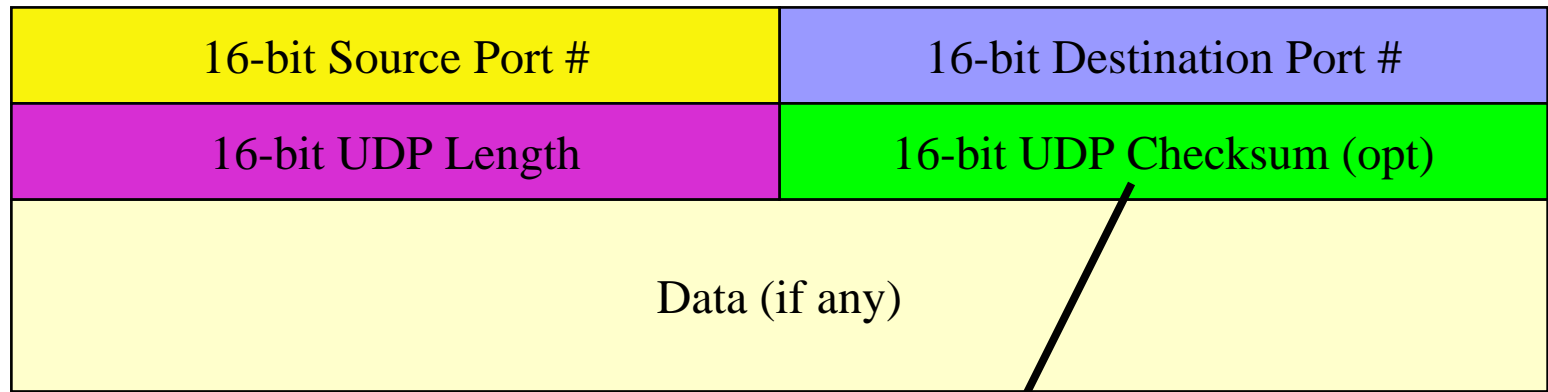
UDP Header



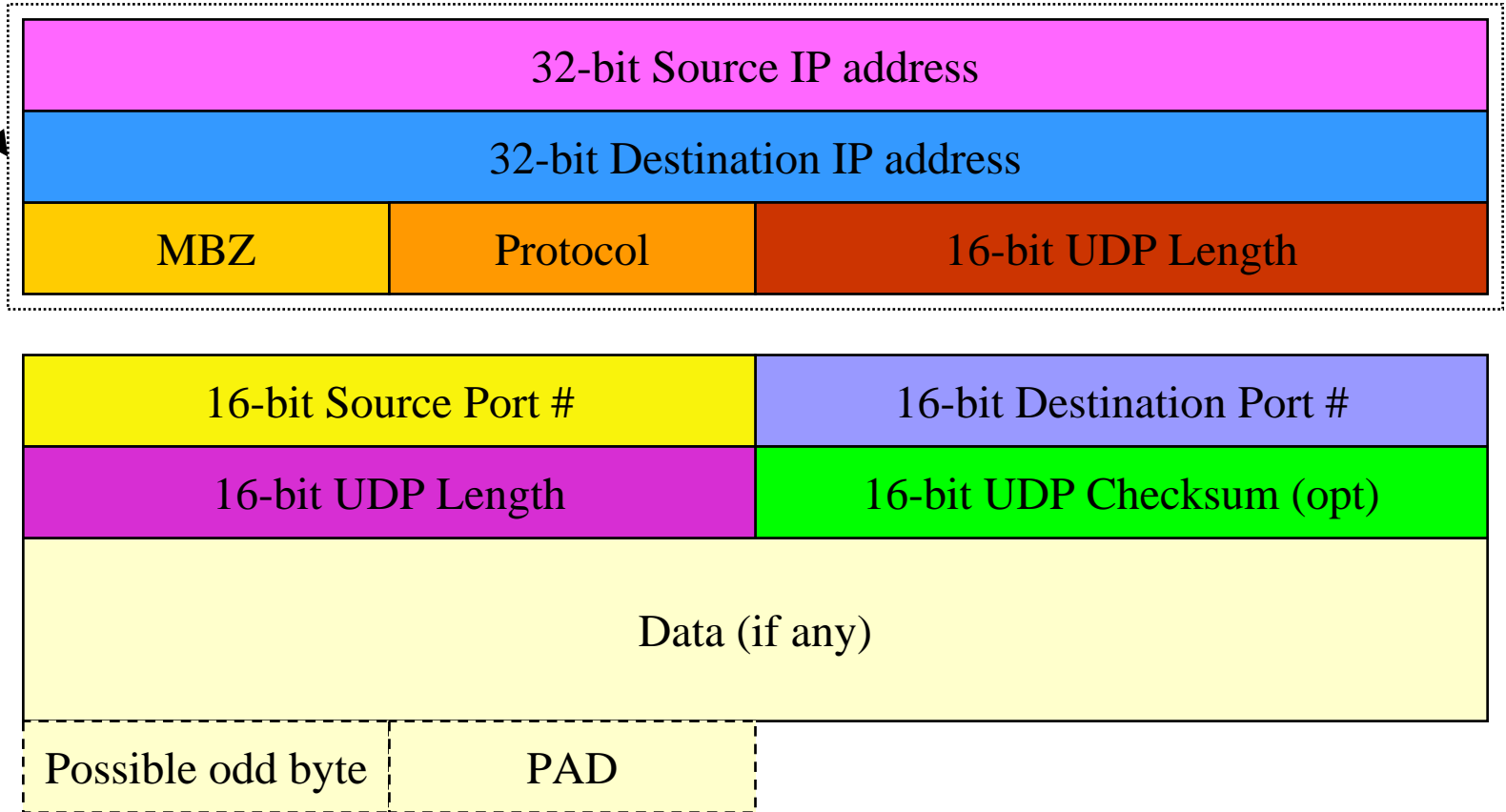
UDP Length



UDP Checksum



IP Pseudo-Header



UDP Checksum

- Checksum calculated like IP checksum, but use pseudo IP header to insure packet arrived at proper host
- If transmitted checksum field is zero, it means sender didn't compute the checksum.
- If the computed checksum would be zero, it's represented as 65535
- Packets with checksum errors are not reported

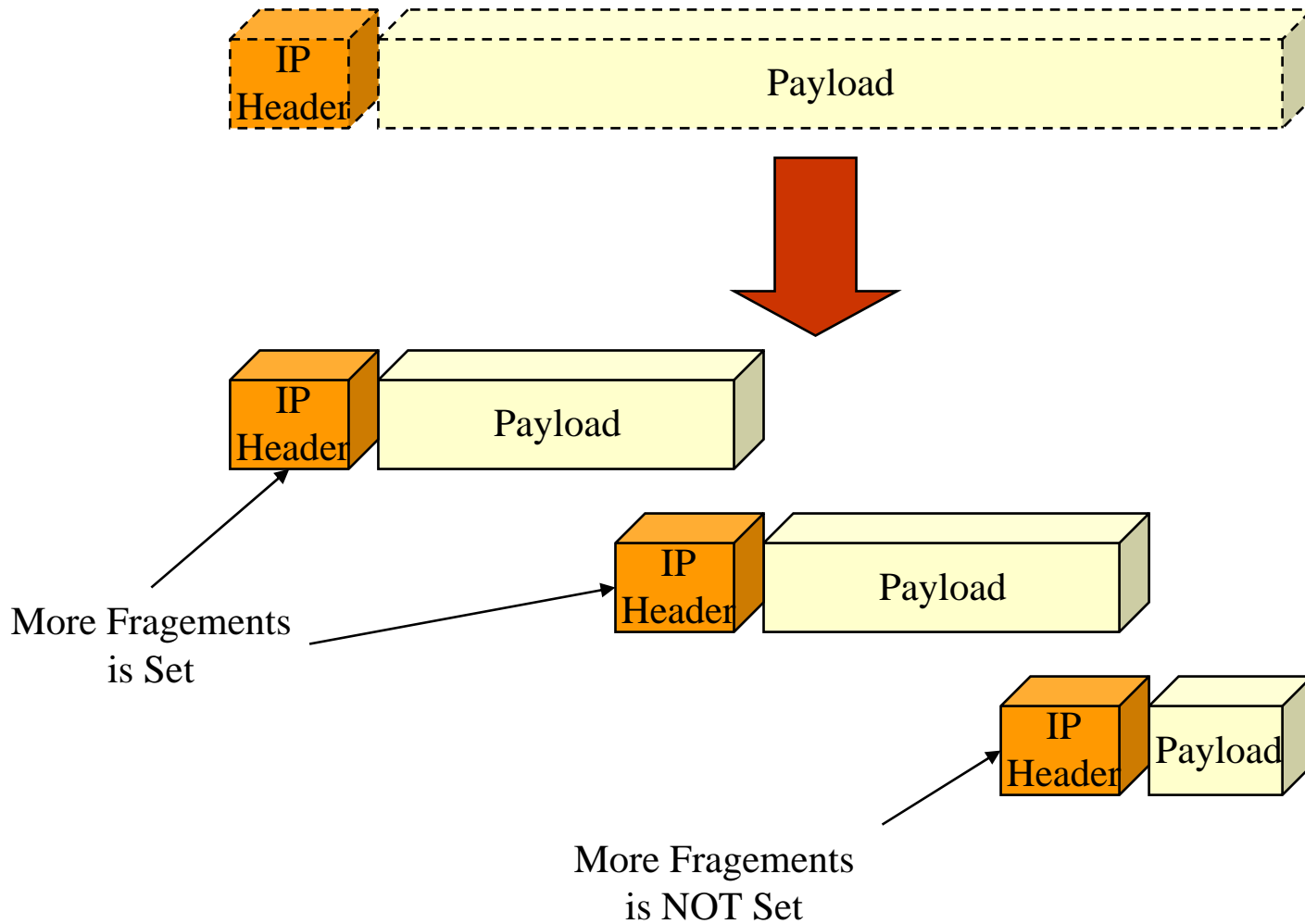
IP Fragmentation

- When a router transmits a packet that is too large for the MTU of the outgoing link, the packet is *fragmented*
- Fragmented packets are not reassembled until they reach their final destination
- Fragments may also be fragmented
- Fragments are identified using packet ID and fragment offset
- Typically, if any fragment is lost, a router will discard all fragments. Routers usually only discover fragment loss if they drop the fragment themselves.
- The endpoint assumes fragments are lost after 30-60 seconds

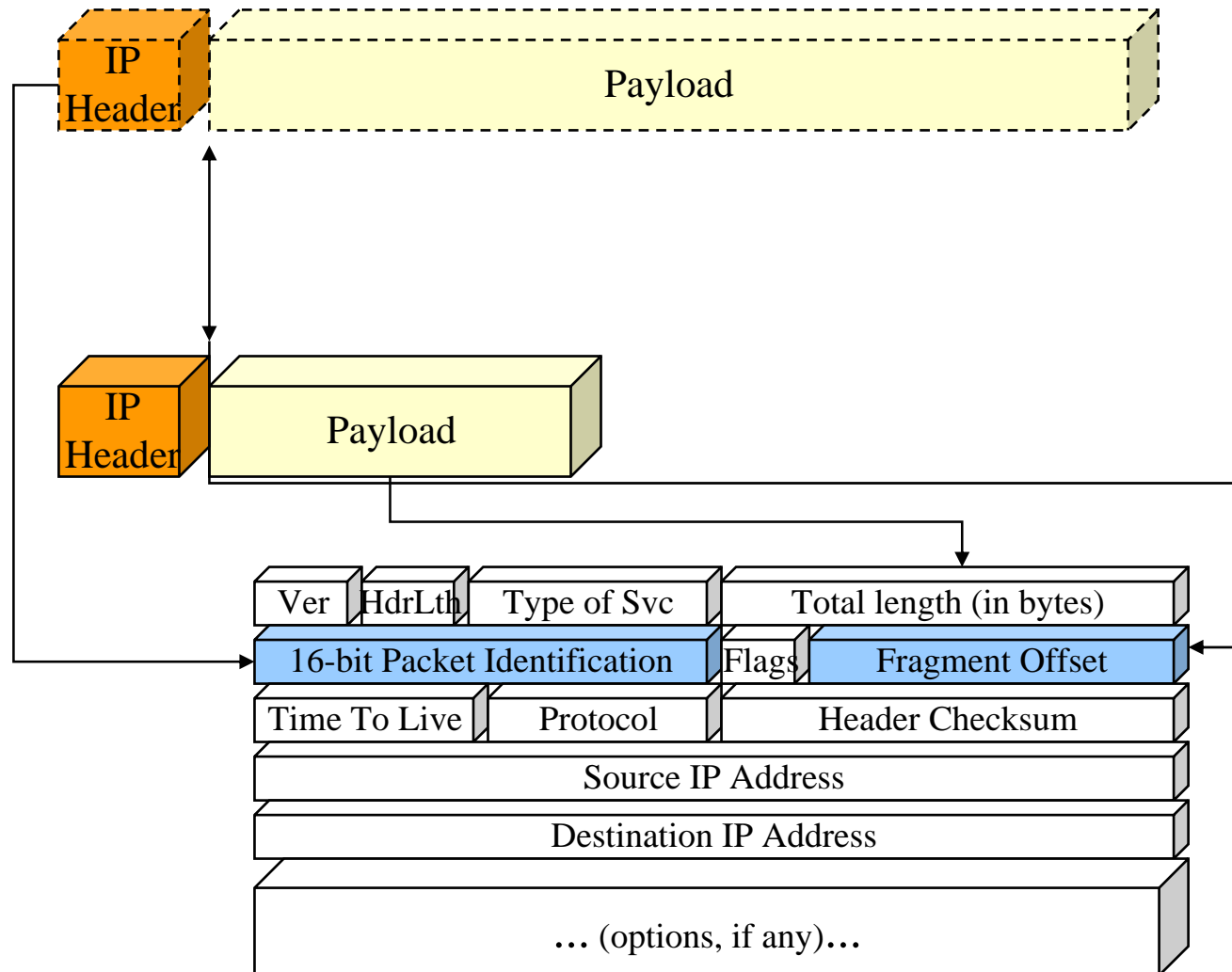
Packets vs. Datagrams

- An IP datagram is the unit of end-to-end transmission at the IP layer (before fragmentation & after reassembly)
- A packet is the unit of data passed between the IP layer and the link layer.
- A packet can be a complete IP datagram or a fragment

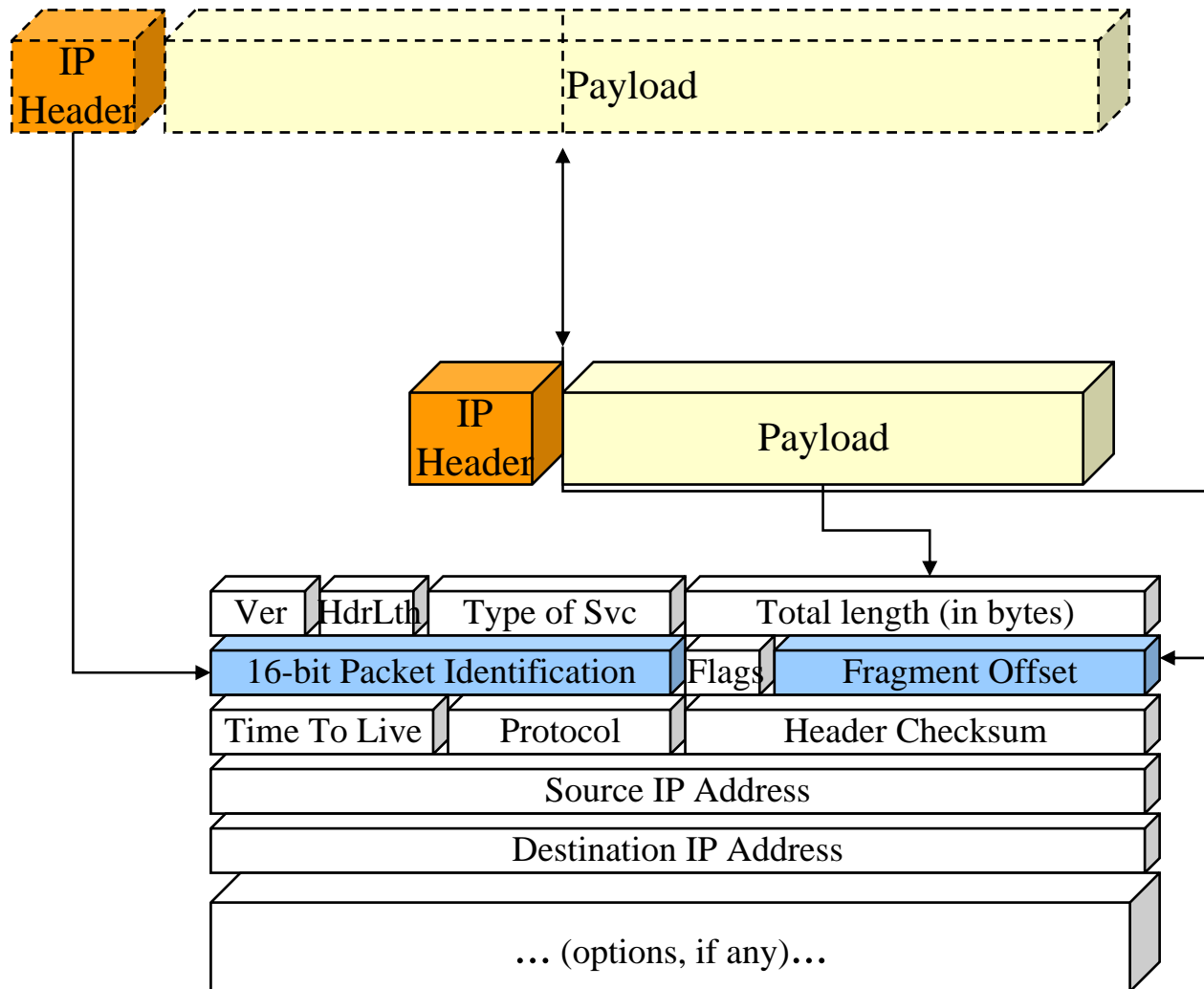
IP Fragmentation



IP Fragmentation – Identifying Fields

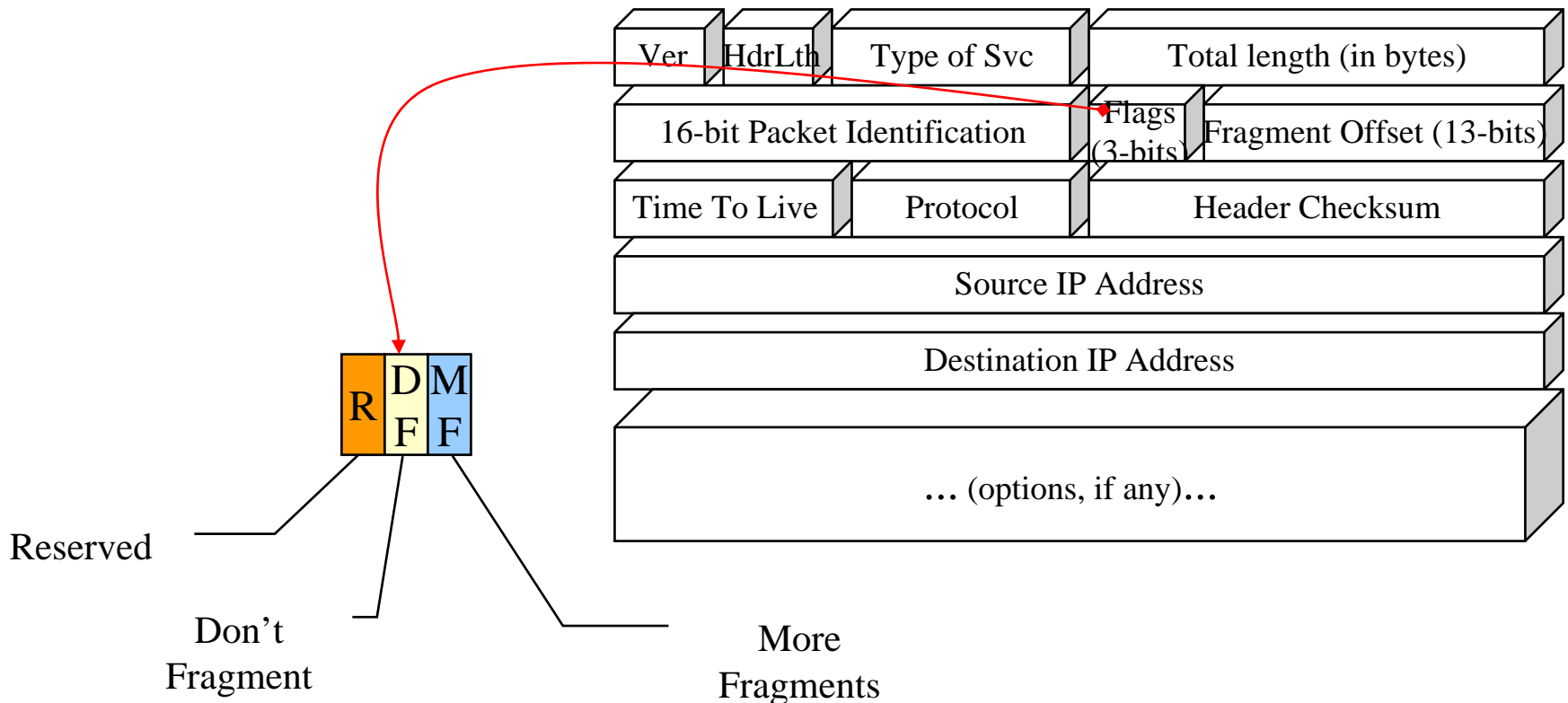


IP Fragmentation



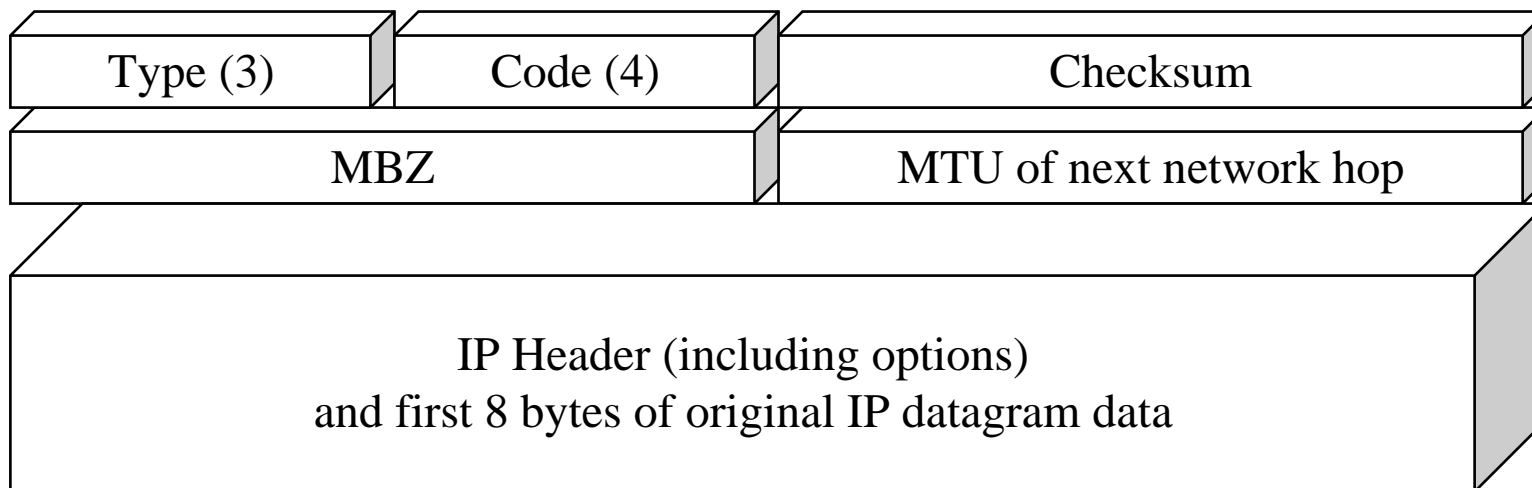
Don't Fragment

One of the IPv4 header flags specifies that this packet should not be fragmented

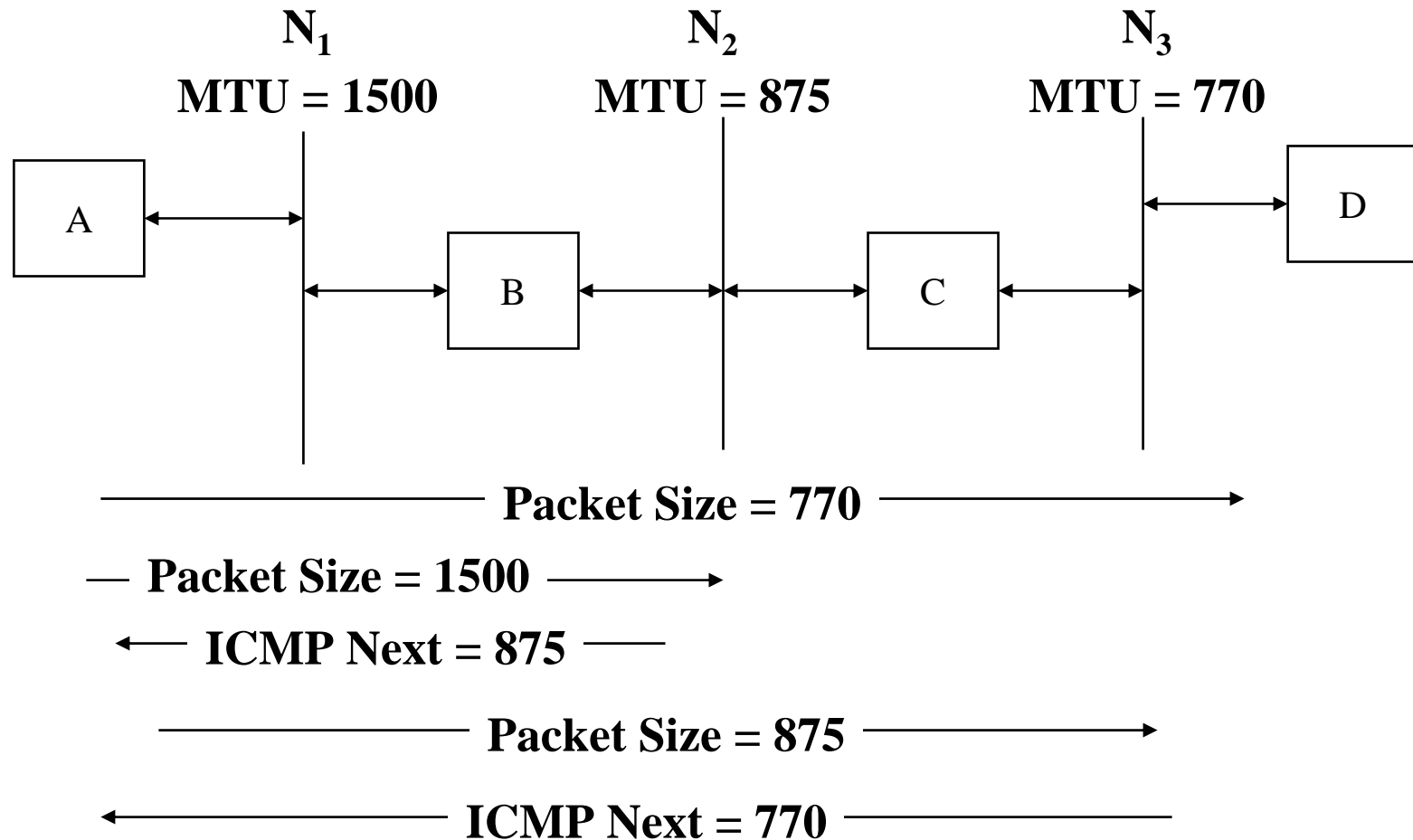


ICMP Unreachable Error

- Attempting to fragment a fragment with don't fragment flag set generates an ICMP error packet
 - ICMP type "destination unreachable" (type 3)
 - code "fragmentation required but don't fragment set" (code 4)



MTU Discovery Using Don't Fragment Packets



ICMP Source Quench

- If a router / host discards datagrams due to buffer overflows, it may send a ICMP *source quench* message
- Can be used to slow down transmission rate

UDP Ports

- UDP port and TCP ports are separate name spaces
 - UDP port 80 doesn't mean the same thing as TCP port 80
- UDP ports are unique to a specific interface
 - port 80 on loopback is not the same as port 80 on eth0
- Most POSIX/UNIX systems let you specify “wildcards”
 - IPADDR_ANY is a special address (0.0.0.0) that is a wild card interface address

Using netstat to see ports

```
$ netstat -a -n
```

Active Connections

Proto	Local Address	Foreign Address	State
TCP	0.0.0.0:7	0.0.0.0:0	LISTENING
TCP	0.0.0.0:9	0.0.0.0:0	LISTENING
TCP	0.0.0.0:13	0.0.0.0:0	LISTENING
TCP	0.0.0.0:17	0.0.0.0:0	LISTENING
TCP	0.0.0.0:19	0.0.0.0:0	LISTENING
TCP	0.0.0.0:21	0.0.0.0:0	LISTENING
TCP	0.0.0.0:23	0.0.0.0:0	LISTENING
TCP	0.0.0.0:25	0.0.0.0:0	LISTENING
TCP	0.0.0.0:80	0.0.0.0:0	LISTENING
TCP	0.0.0.0:135	0.0.0.0:0	LISTENING
TCP	0.0.0.0:443	0.0.0.0:0	LISTENING
TCP	0.0.0.0:445	0.0.0.0:0	LISTENING
TCP	127.0.0.1:1169	0.0.0.0:0	LISTENING
TCP	141.218.143.76:1167	141.210.180.18:80	CLOSE_WAIT
TCP	141.218.143.76:1328	141.218.143.215:22	ESTABLISHED
TCP	141.218.143.76:1331	64.233.167.99:80	ESTABLISHED
TCP	:::2107	:::0	LISTENING
UDP	0.0.0.0:7	*:*	
UDP	0.0.0.0:9	*:*	
UDP	0.0.0.0:13	*:*	
UDP	0.0.0.0:17	*:*	
UDP	0.0.0.0:19	*:*	
UDP	0.0.0.0:161	*:*	
UDP	0.0.0.0:162	*:*	
UDP	0.0.0.0:445	*:*	
UDP	0.0.0.0:500	*:*	
UDP	0.0.0.0:3456	*:*	
UDP	:::19	*:*	

Using netstat to see interfaces

```
bash-2.05$ netstat -in
```

Name	Mtu	Net/Dest	Address	Ipkts	Ierrs	Opkts	Oerrs	Collis
lo0	8232	127.0.0.0	127.0.0.1	2888944	0	2888944	0	0
hme0	1500	141.218.143.0	141.218.143.215	148045535	33690	14290468	0	0

References

- Cisco Networking Academy Program (CCNA), Cisco Press.
- CSCI-5273 : Computer Networks, Dirk Grunwald, University of Colorado-Boulder
- CSCI-4220: Network Programming, Dave Hollinger, Rensselaer Polytechnic Institute.
- TCP/IP Illustrated, Volume 1, Stevens.
- Java Network Programming and Distributed Computing, Reilly & Reilly.
- Computer Networks: A Systems Approach, Peterson & Davie.
- <http://www.firewall.cx>
- <http://www.javasoft.com>