Module 7
Addressing Schemes and TCP/IP Protocol Stack: Overview

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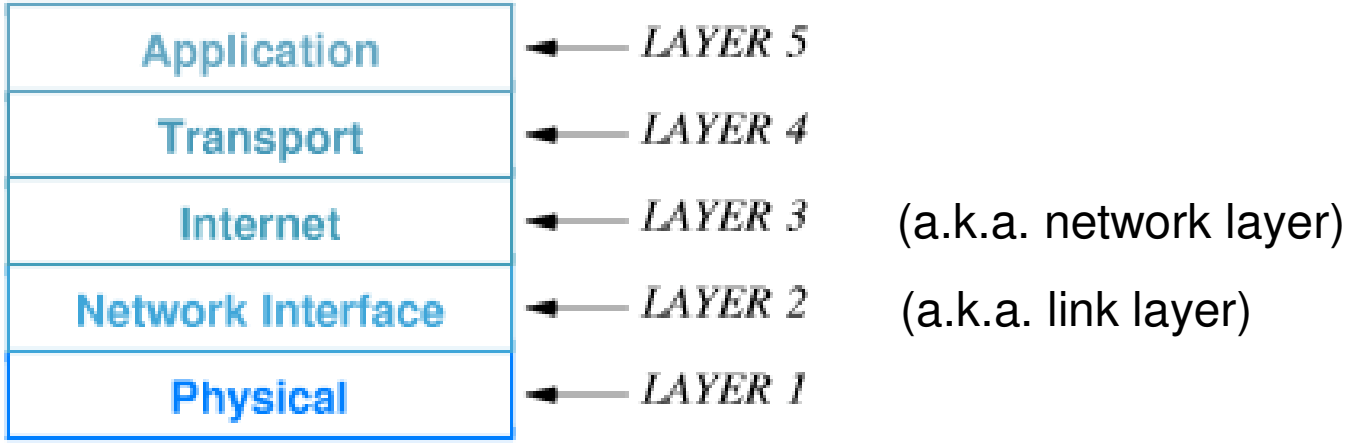
Unicast, Multicast and Broadcast

- There are three possible types of communication within a Local Area Network (LAN) as well as in the Internet.
  - Unicast – message sent from one source to one destination.
  - Multicast – message sent from one source to multiple destinations (receivers).
  - Broadcast – message sent from one source to all the other hosts in the network.

TCP/IP Protocol Stack



MAC Address, IP Address and Port #s

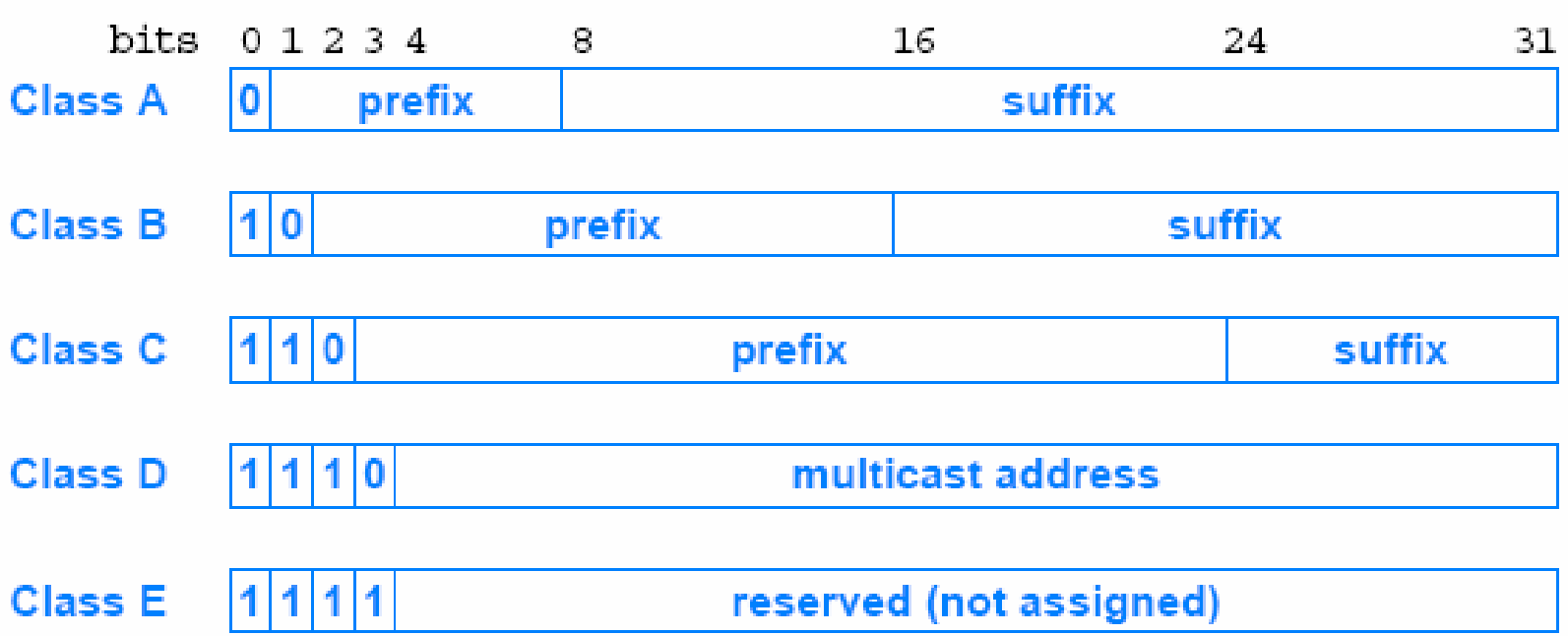
- Unless every pair of hosts in the LAN/Internet are connected directly to each other, we need to have some addressing scheme to uniquely identify the receiving machine as well as the sending machine.

- We use MAC address (48-bits) to uniquely identify hosts at the link layer (hardware address – remains the same irrespective of the network to which the host is attached to.)
  - Example: 0A:5F:BC:AD:23:10

- We use IP addresses (32-bits) to uniquely identify hosts at the network layer / Internet layer (logical address – changes on the basis of the network to which the host is attached to.)
  - Example: 143.132.8.23

- To distinguish the different applications running on a particular host, we assign a unique port number (16-bits) for each process running on a host so that the destination process can be delivered the message

Classes of Networks



Class	Range of Integer Values for the 1st 8 bits
A	1 through 126
B	128 through 191
C	192 through 223
D	224 through 239
E	240 through 255

Networks and # Hosts per Network

Address Class	Bits in Network Part	Max. # Networks	Bits in Host Part	Max. # Hosts per Network
A	7	126	24	$2^{24} - 2$
B	14	2^{14}	16	$2^{16} - 2$
C	21	2^{21}	8	$2^{8} - 2$

Special IP Address Forms

Prefix	Suffix	Type Of Address	Purpose
all-0s	all-0s	this computer	used during bootstrap
network	all-0s	network	identifies a network
network	all-1s	directed broadcast	broadcast on specified net
all-1s	all-1s	limited broadcast	broadcast on local net
127	any	loopback	testing

Class A Network: Example

- Network Address: 14.0.0.0
- Broadcast Address: 14.255.255.255
- IP Address Range: 14.0.0.1 – 14.255.255.254

Class B Network: Example

- Network Address: 143.132.0.0
- Broadcast Address: 143.132.255.255
- IP Address Range: 143.132.0.1 – 143.132.255.254

Class C Network: Example

- Network Address: 214.132.56.0
- Broadcast Address: 214.132.56.255
- IP Address Range: 214.132.56.1 – 214.132.56.254

Private IP Addresses

- Internet Assigned Numbers Authority (IANA) reserves certain blocks of IP addresses (called private IP address) for use by the private internets. The **private ip address blocks are:**

  10.0.0.0 - 10.255.255.255
  172.16.0.0 - 172.31.255.255
  192.168.0.0 - 192.168.255.255

- The same set of private IP addresses can be used at different organizations (i.e., a private IP address has to be only locally unique); where as a public IP address (all IP addresses other than the above blocks of private IP addresses) has to be globally unique.
- Private IP addressing is one of the solutions to reduce the exhaustion of IP address space.
- **The private ip addresses are not routable in the public internet** (i.e., packets bearing private ip addresses are not forwarded by routers in the Internet). We need to through a public gateway and use its IP address.

- For networks connected to the public internet, the service provider makes the class of IP address to be assigned to an organization's network; where as in a private internet, the local administrator selects the class.

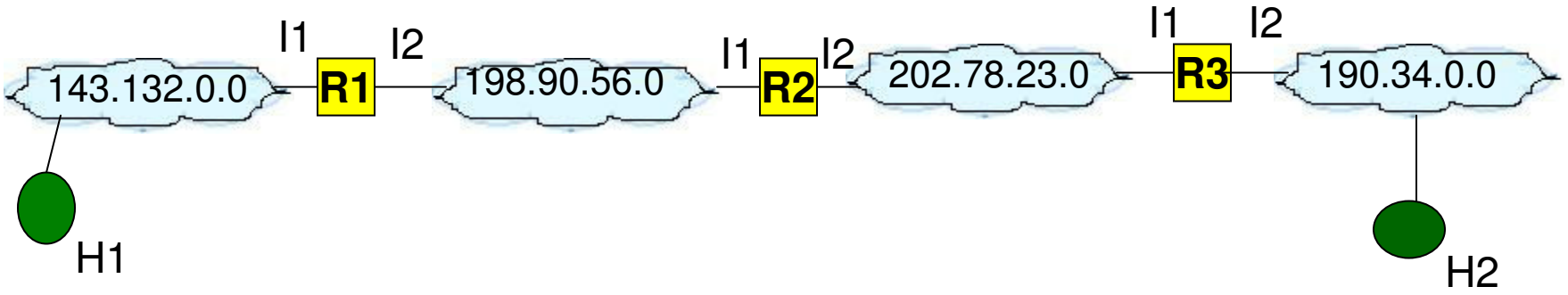
Sample Question: IP Addresses

- Identify whether the following is a network address, broadcast IP address, unicast IP address, multicast IP address or a private IP address:
  - a) 143.132.10.1
  - b) 229.0.1.2
  - c) 16.1.255.255
  - d) 10.1.1.1
  - e) 172.18.12.34
  - f) 202.14.12.255
  - g) 156.25.32.0
  - h) 202.45.69.0
  - i) 156.23.0.0

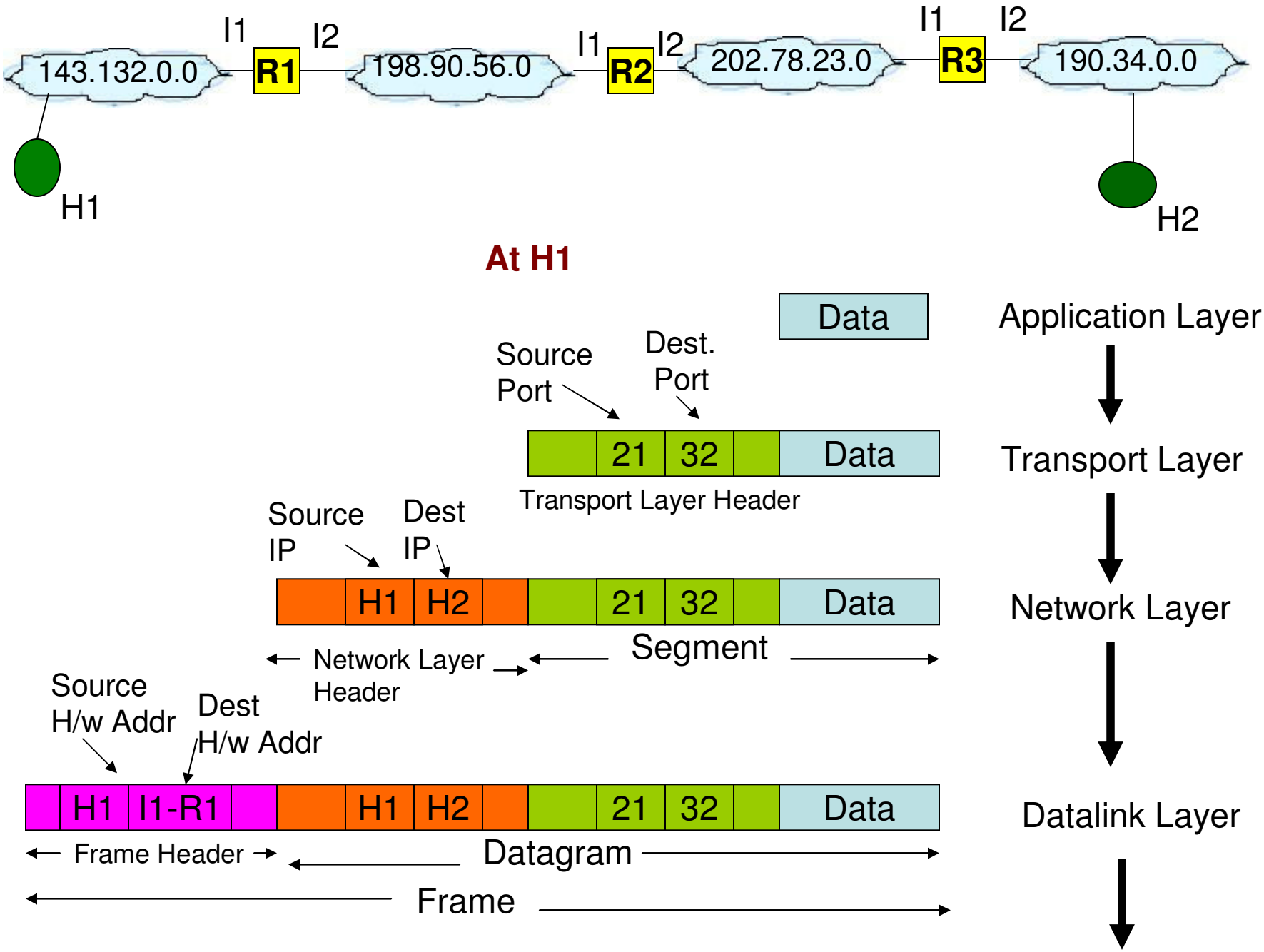
Sample Question: IP Addresses

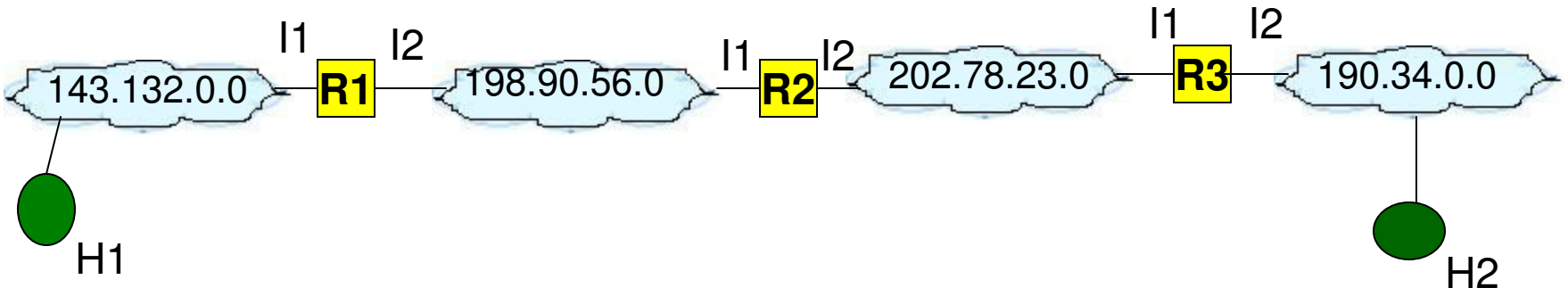
- Identify whether the following is a network address, broadcast IP address, unicast IP address, multicast IP address or a private IP address:
  - a) 143.132.10.1 – unicast IP address for a class B network
  - b) 229.0.1.2 – multicast IP address
  - c) 16.1.255.255 – unicast IP address for a class A network
  - d) 10.1.1.1 – private IP address
  - e) 172.18.12.34 – private IP address
  - f) 202.14.12.255 – broadcast IP address for a class C network
  - g) 156.25.32.0 – unicast IP address for a class B network
  - h) 202.45.69.0 – network address for a class C network
  - i) 156.23.0.0 – network address for a class B network

Example for End-to-End Packet Transmission across the Internet

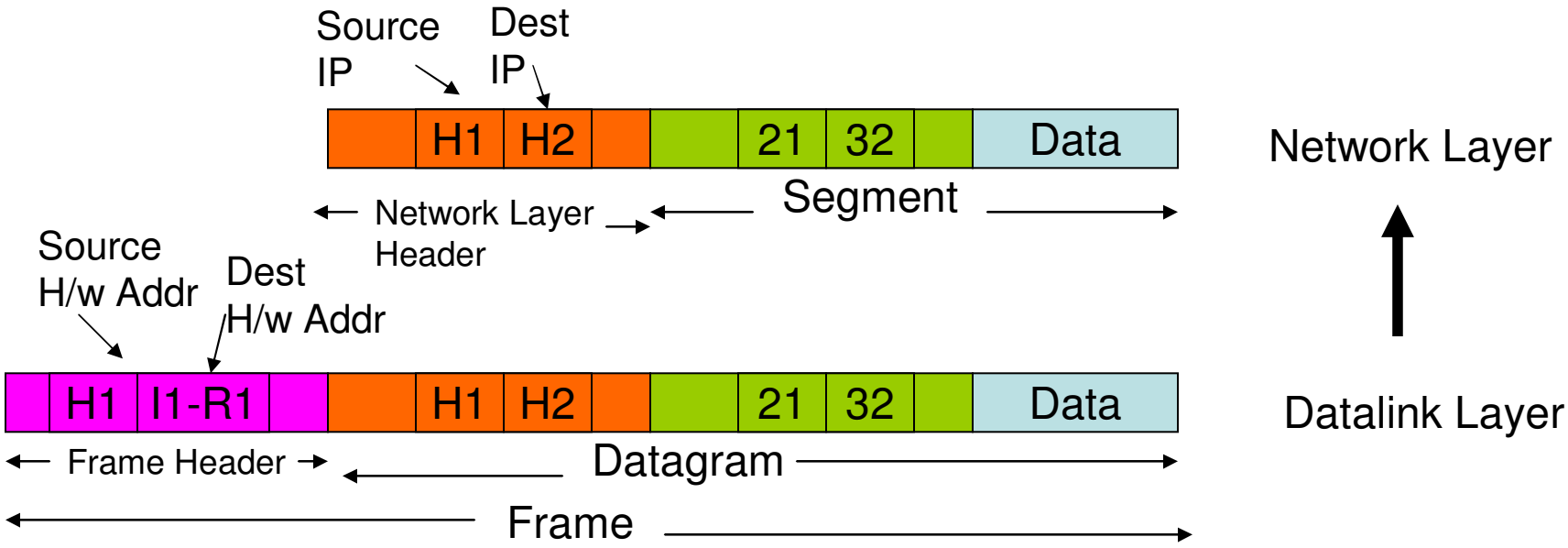


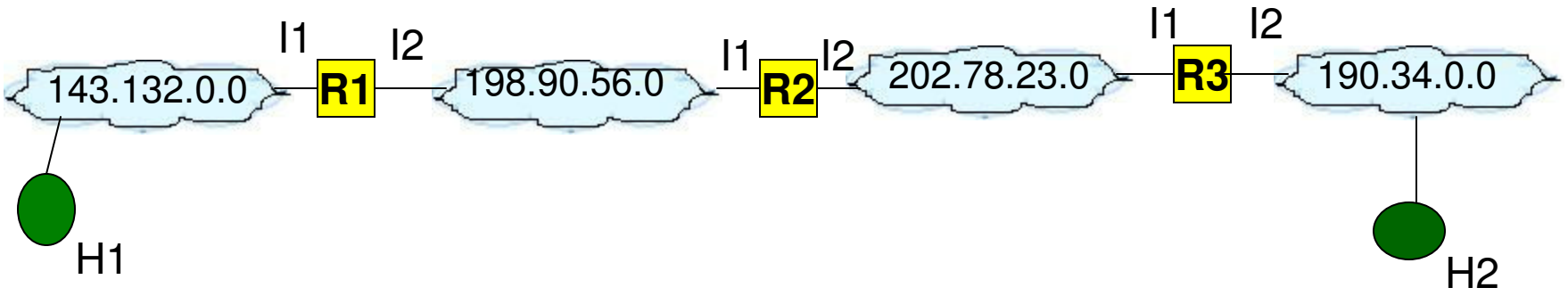
Host/ Router	IP address	Hardware address
H1	143.132.0.1	34:12:45:AB:CD:EF
Interface 1 of R1	143.132.90.2	38:45:A9:E2:B5:C3
Interface 2 of R1	198.90.56.1	4C:9A:3B:54:DF:12
Interface 1 of R2	198.90.56.2	24:3B:1C:4A:52:CD
Interface 2 of R2	202.78.23.1	9C:12:AB:89:CF:33
Interface 1 of R3	202.78.23.2	BC:32:11:A2:45:23
Interface 2 of R3	190.34.0.1	28:12:AB:45:69:12
H2	190.34.0.2	30:90:CD:EF:AB:43


I1
I2
I1
I2
I1
I2
143.132.0.0
R1
198.90.56.0
R2
202.78.23.0
R3
190.34.0.0
H1
H2
At H1
Data
Application Layer
Source Port
Dest. Port
21
32
Data
Transport Layer
Transport Layer Header
Source IP
Dest IP
H1
H2
21
32
Data
Network Layer
Segment
Network Layer Header
Source H/w Addr
Dest H/w Addr
H1
I1-R1
H1
H2
21
32
Data
Datalink Layer
Frame Header
Datagram
Frame

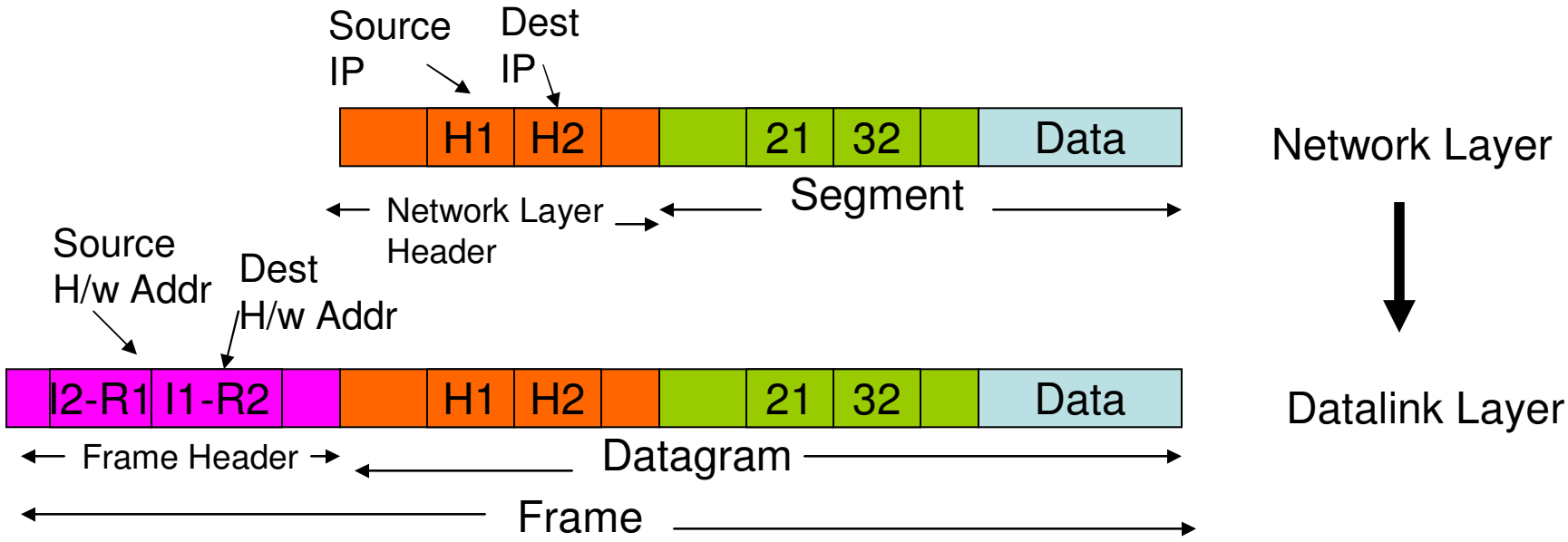


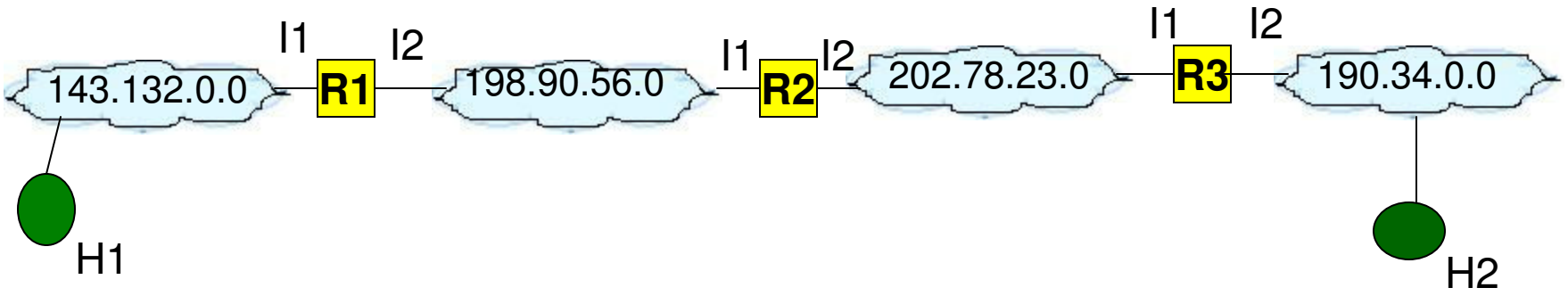
At Interface 1 of R1



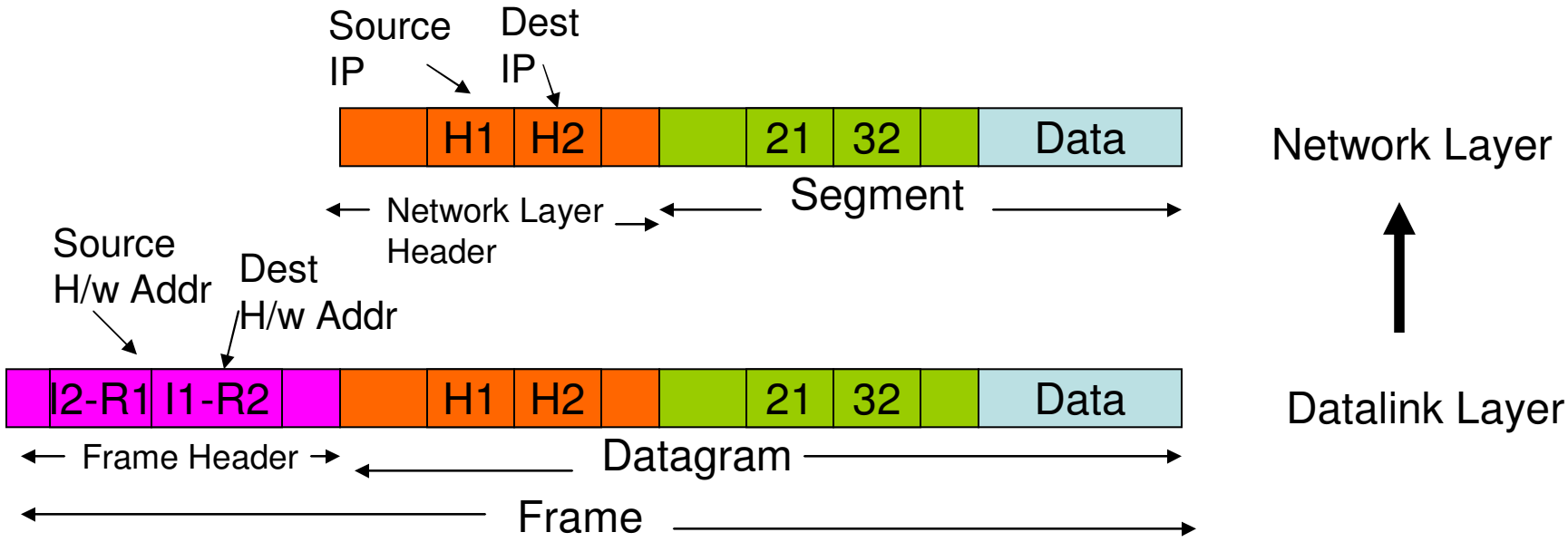


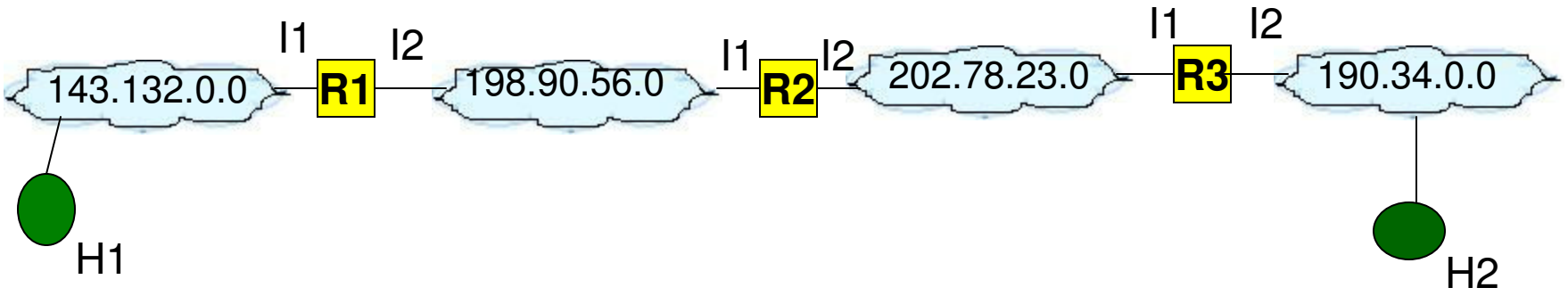
At Interface 2 of R1



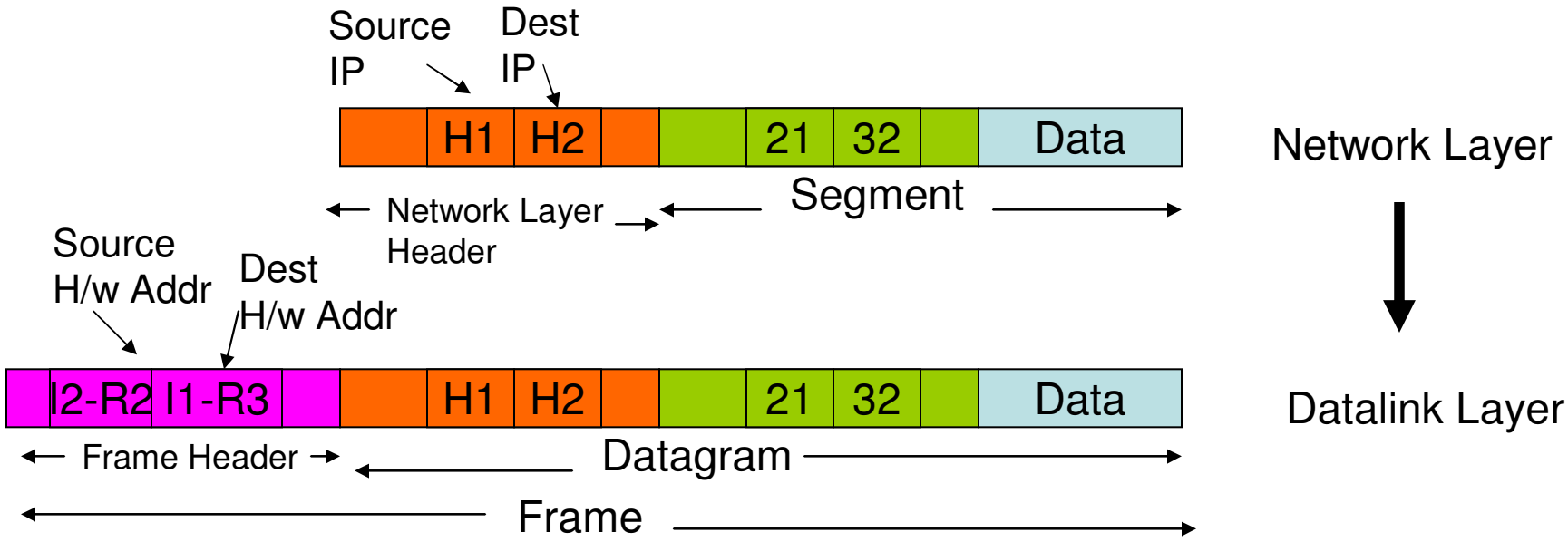


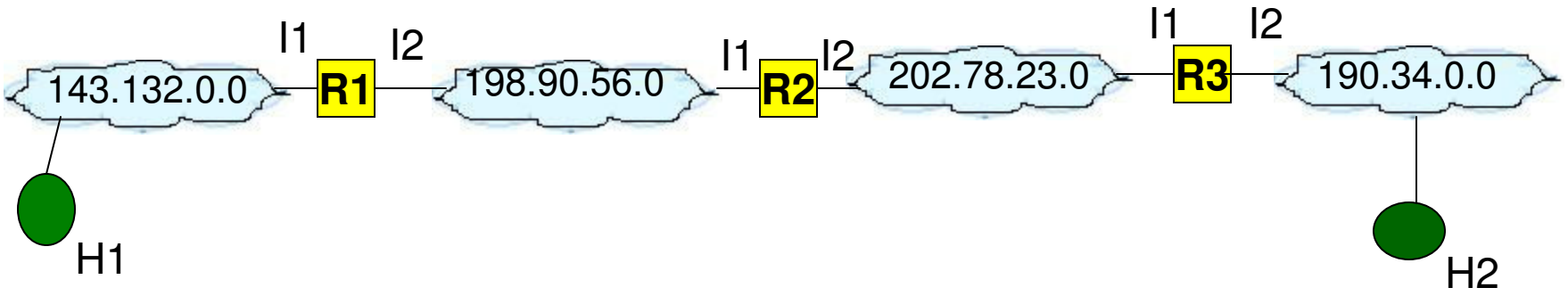
At Interface 1 of R2



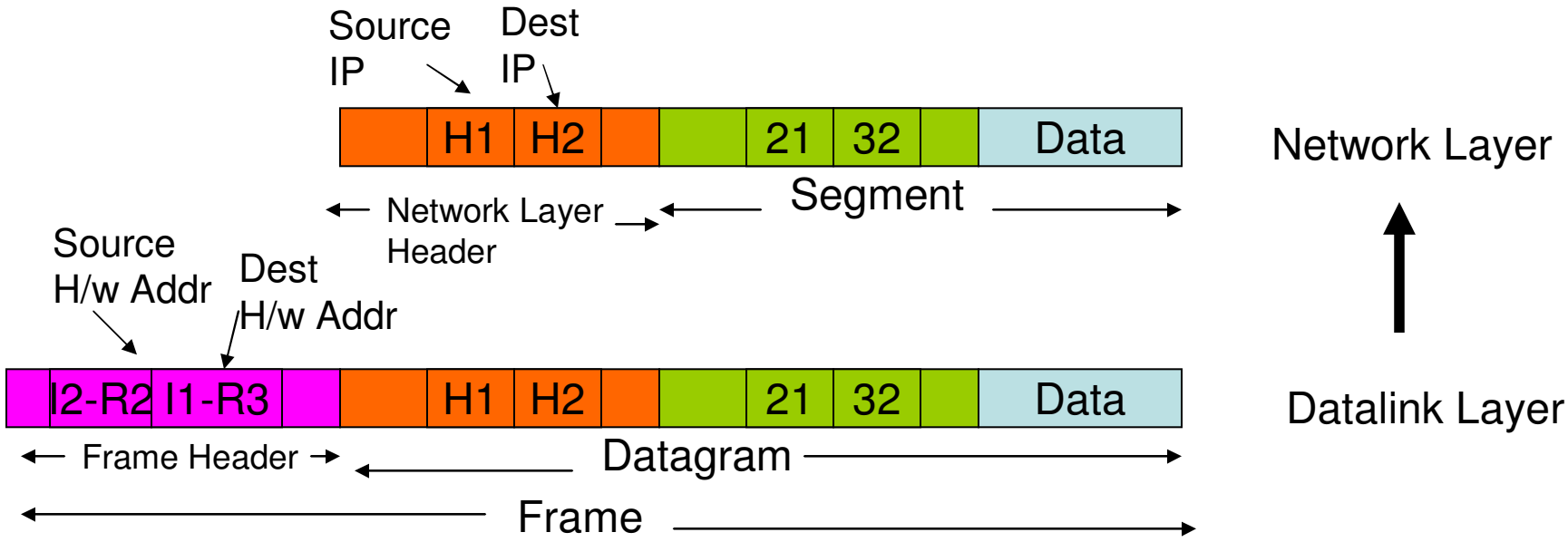


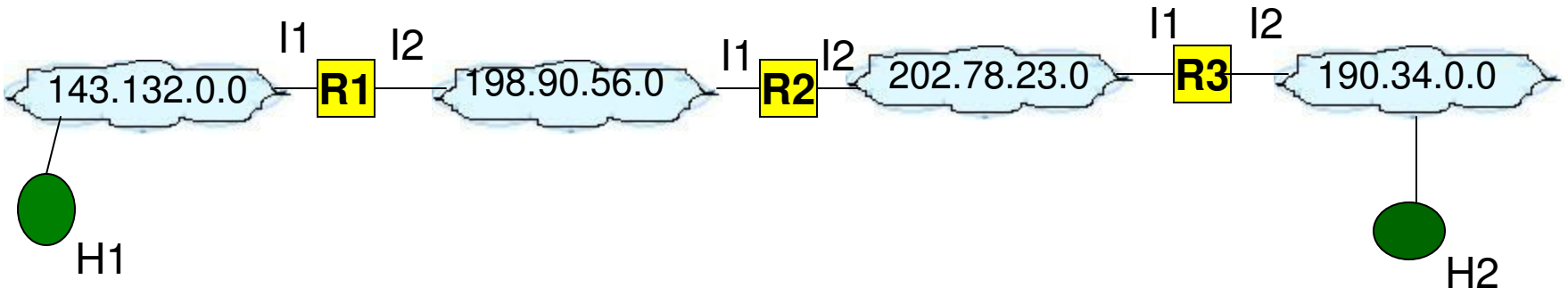
At Interface 2 of R2



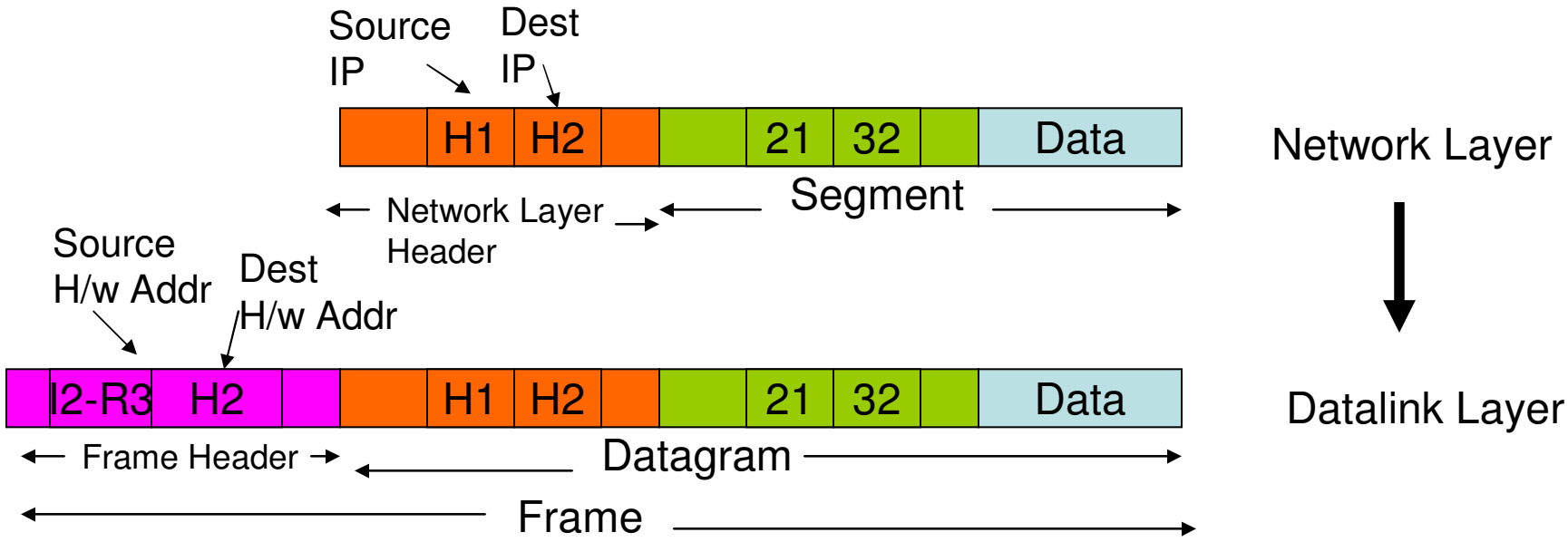


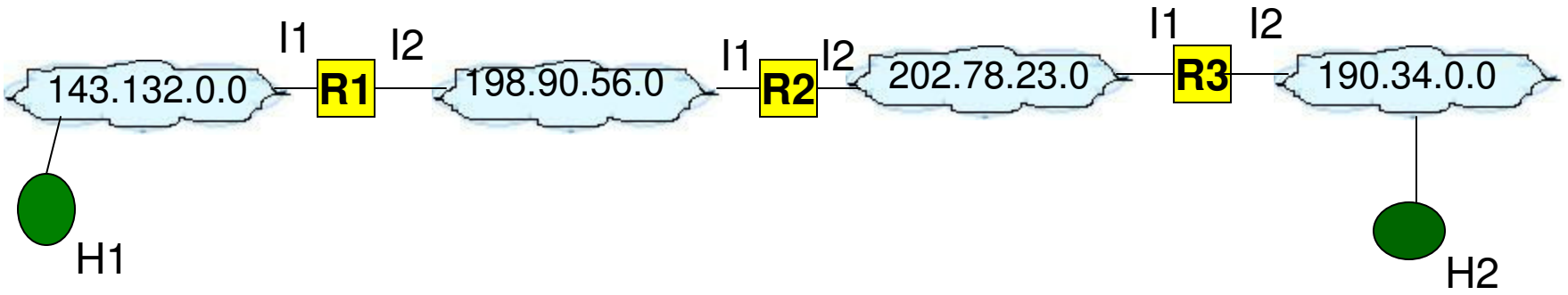
At Interface 1 of R3



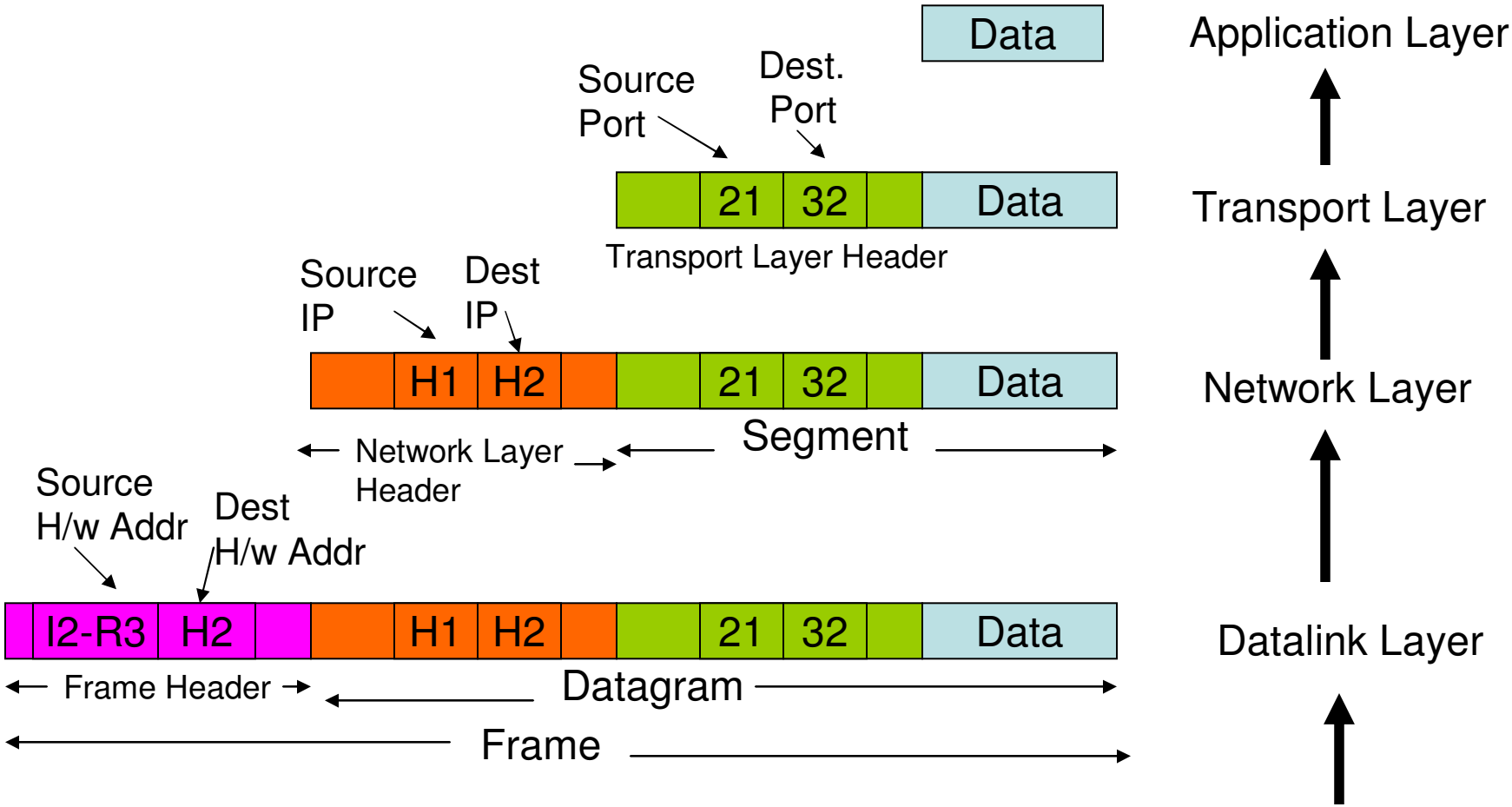


At Interface 2 of R3



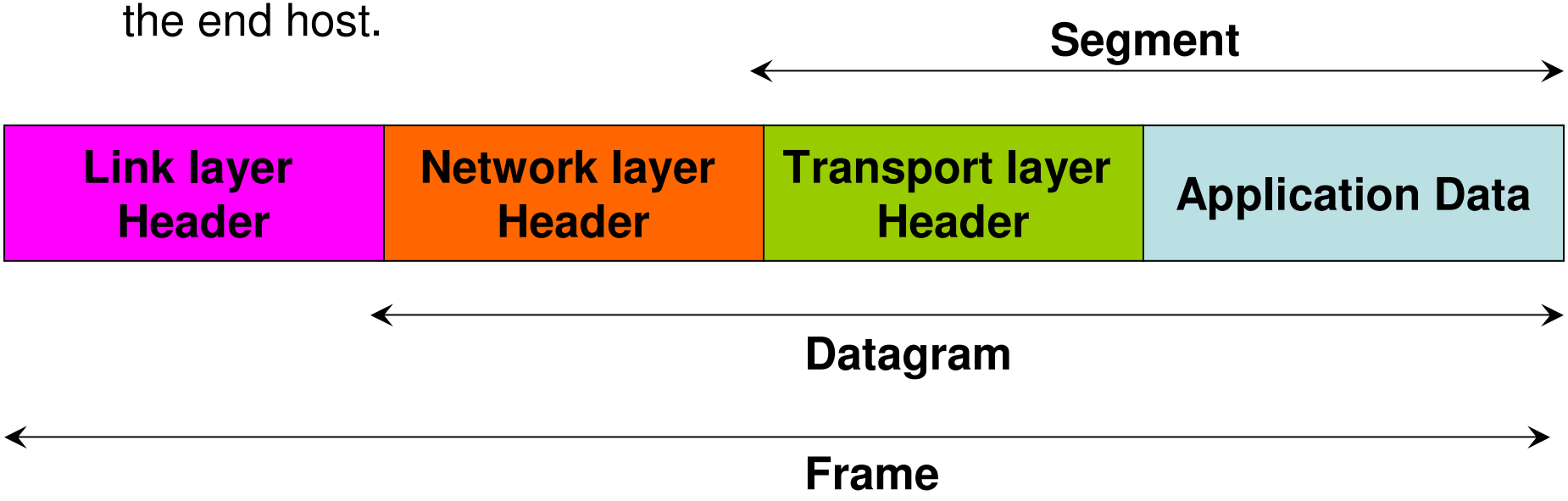

I1
I2
I1
I2
I1
I2
143.132.0.0
R1
198.90.56.0
R2
202.78.23.0
R3
190.34.0.0
H1
H2

At H2

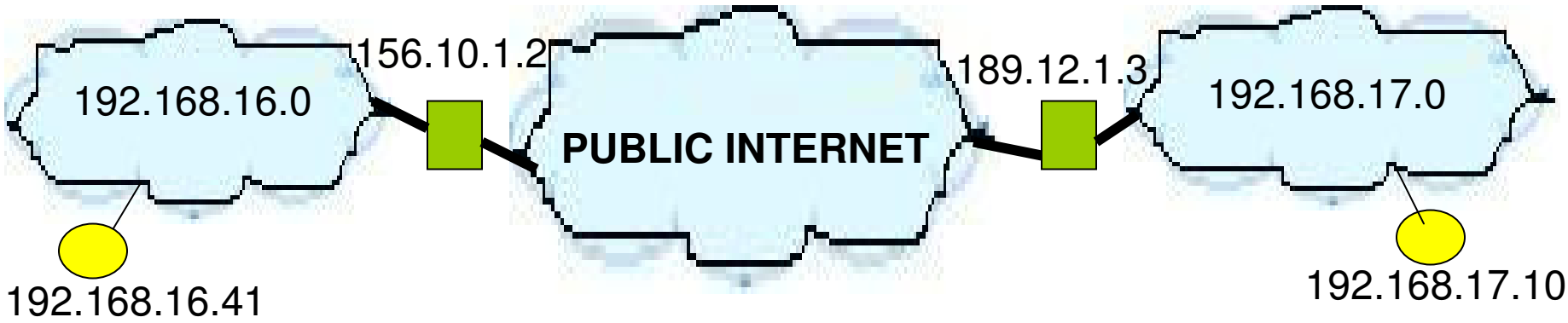

Data
Application Layer
Source Port
Dest. Port
21
32
Data
Transport Layer Header
Transport Layer
Source IP
Dest IP
H1
H2
21
32
Data
Network Layer
Segment
Network Layer Header
Source H/w Addr
Dest H/w Addr
I2-R3
H2
H1
H2
21
32
Data
Datalink Layer
Frame Header
Datagram
Frame

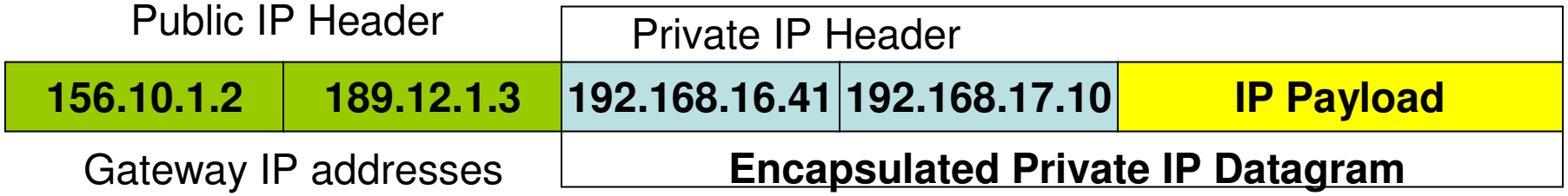
Segment, Datagram and Frame

- Segment – Transport layer (TCP or UDP) header + Application Data
- Datagram – Network layer (IP) header + Segment
- Frame – Link layer (frame) header + Datagram
- The physical layer, network interface and Internet layers are called the host-to-host layers as the headers corresponding to these layers are exposed at each intermediate; whereas, the transport and application layers are called as the end-to-end layers as the header and application data corresponding to these layers are seen only at the end host.



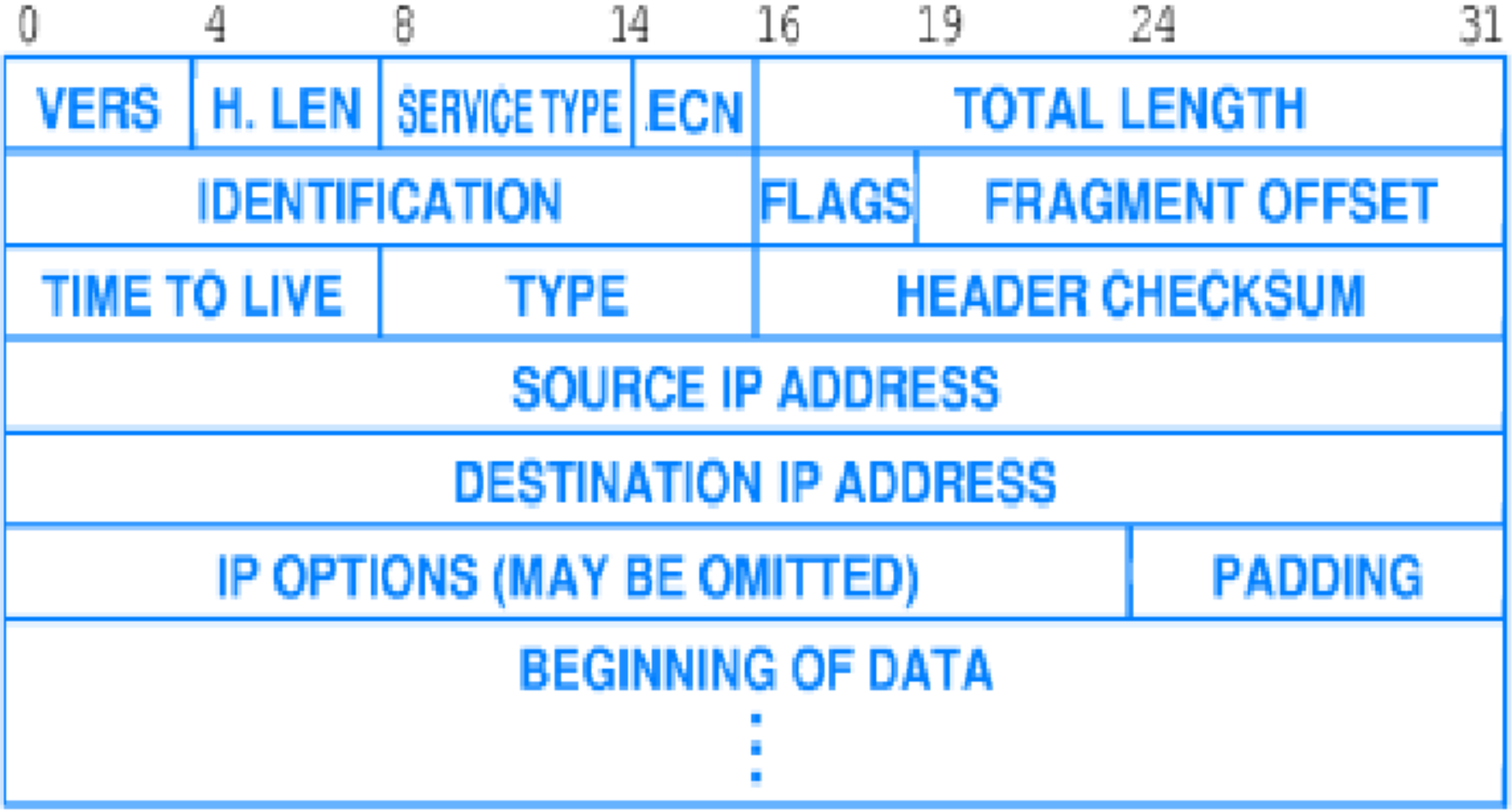
Communication between Two Private IP Addresses



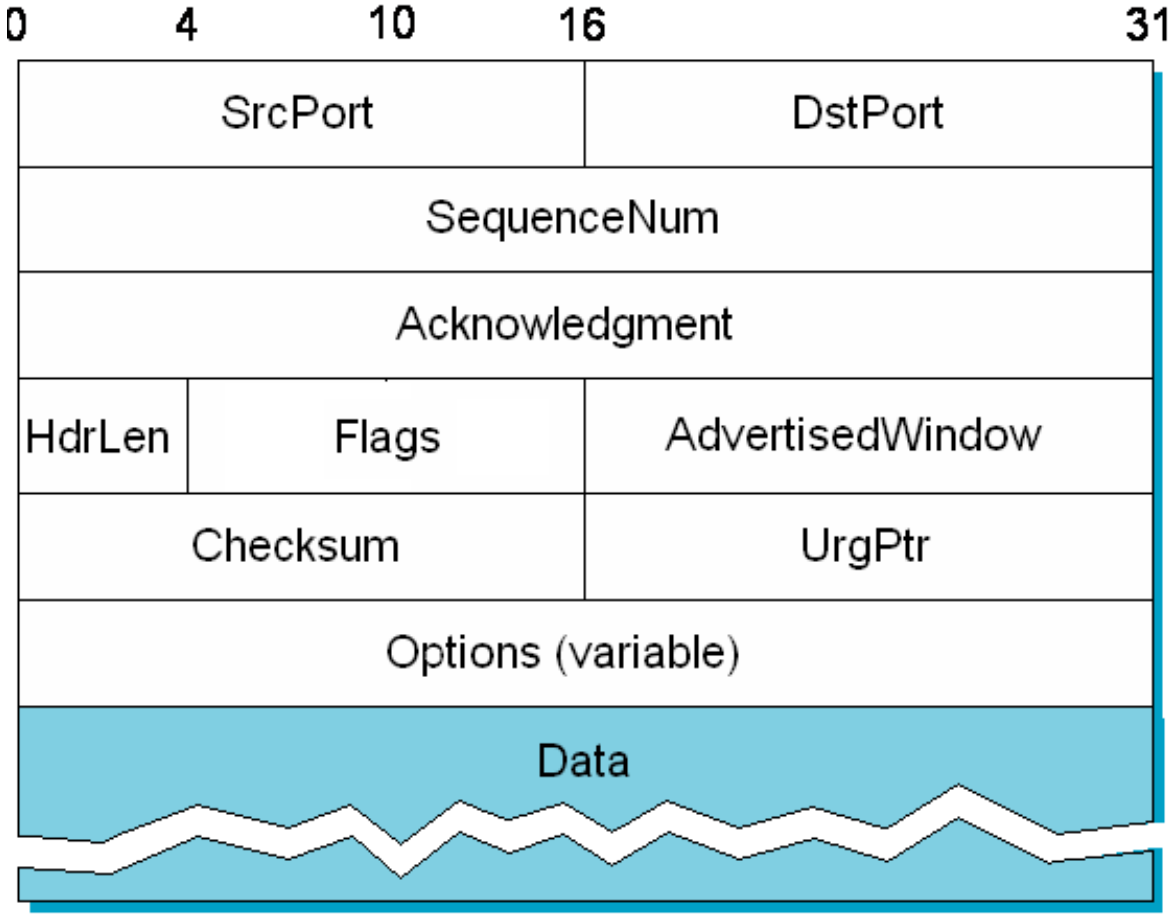


IP-in-IP Encapsulation

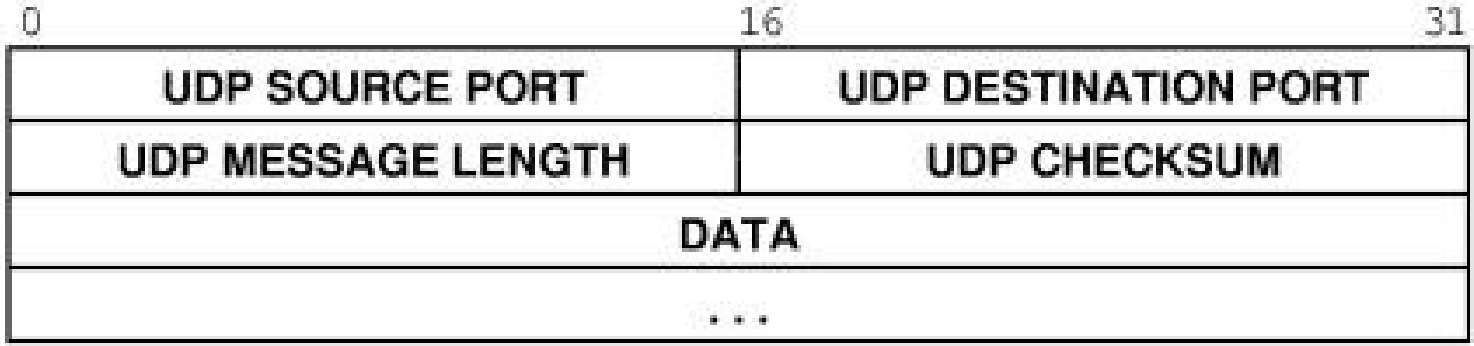
IP Header Format (v4)



TCP Header Format

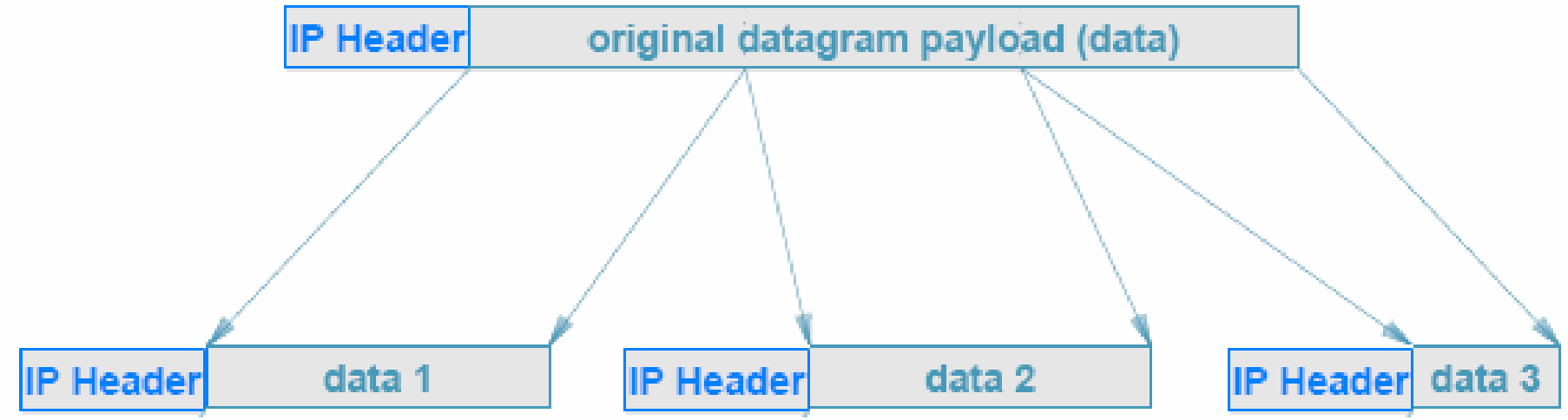


UDP Header Format

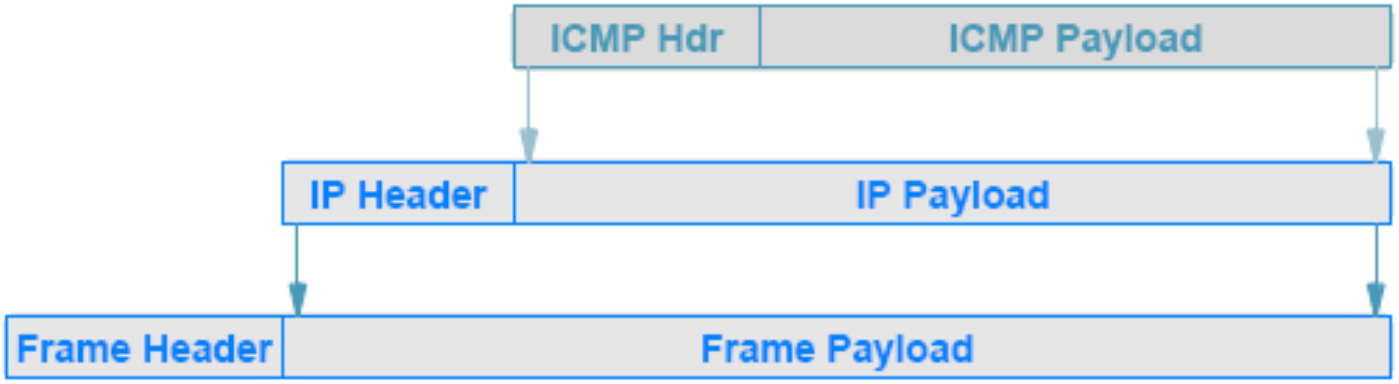


IP Datagram Fragmentation

- MTU – Maximum size of the datagram
- Each network can have a different MTU
- If the datagram size is larger than the MTU of the network, the datagram has to be fragmented.
  - The IP header is attached to each fragment
  - The TCP/UDP header is not fragmented. It typically goes with the first fragment.



ICMP Encapsulation



Number	Type	Purpose
0	Echo Reply	Used by the ping program
3	Dest. Unreachable	Datagram could not be delivered
5	Redirect	Host must change a route
8	Echo	Used by the ping program
11	Time Exceeded	TTL expired or fragments timed out
12	Parameter Problem	IP header is incorrect
30	Traceroute	Used by the traceroute program