SECTION – B

TCP/IP

Part – II

Outline of the talk

- Fragmentation
  - Transparent Fragmentation
  - Non – transparent Fragmentation
- IP Addressing

Introduction

- **Most of the fields in the header of an IP datagram have been explained.**
- **We now discuss the fields used for fragmentation and reassembly of packets.**
  - **If the packet size exceeds a certain maximum value, it is split into two or more fragment packets.**
  - **The fragments are reassembled at some later stage.**

Fragmentation

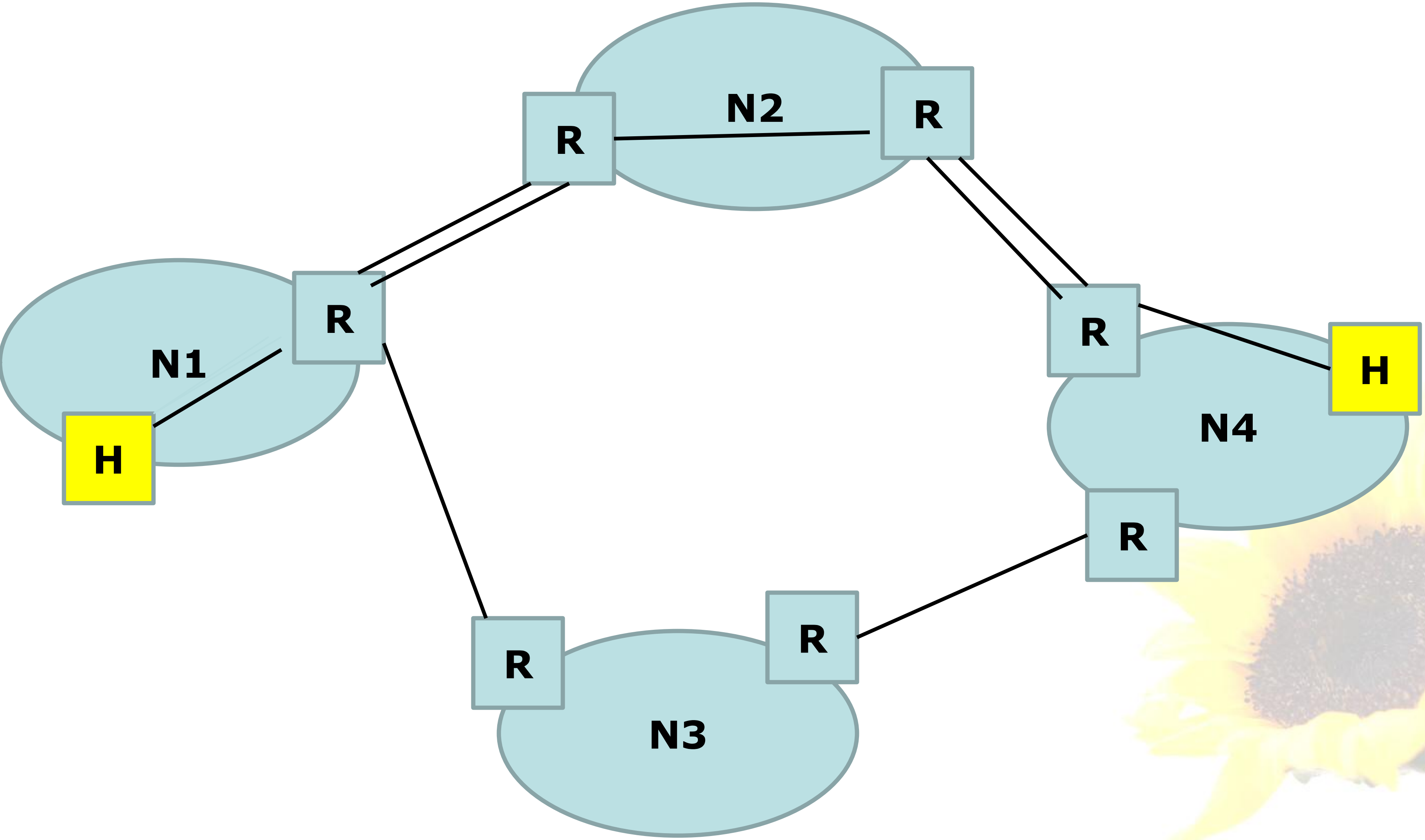
- Why needed?
  - The IP layer injects a packet into the data link layer, and hopes for the best.
    - Not responsible for the reliable transport of these packets.
  - Each layer imposes some maximum size of packets, due to various reasons.
    - Called Maximum Transfer Unit (MTU)
  - Suppose a large packet travels through a network whose MTU is too small.
    - Fragmentation is required.

Fragmentation (cont.)

- **What to do then?**
  - The different networks are connected among themselves through routers.
  - Allow the routers to break the packets into fragments, if necessary.
  - Each fragment is transmitted as a separate IP packet.
  - The fragments need to be reassembled back.

Fragmentation (cont.)

- When is reassembly of fragments carried out ?
  - Two alternatives:
    - Transparent fragmentation
    - Non-transparent fragmentation


N2
R
R
R
N1
H
R
H
N4
R
R
R
N3

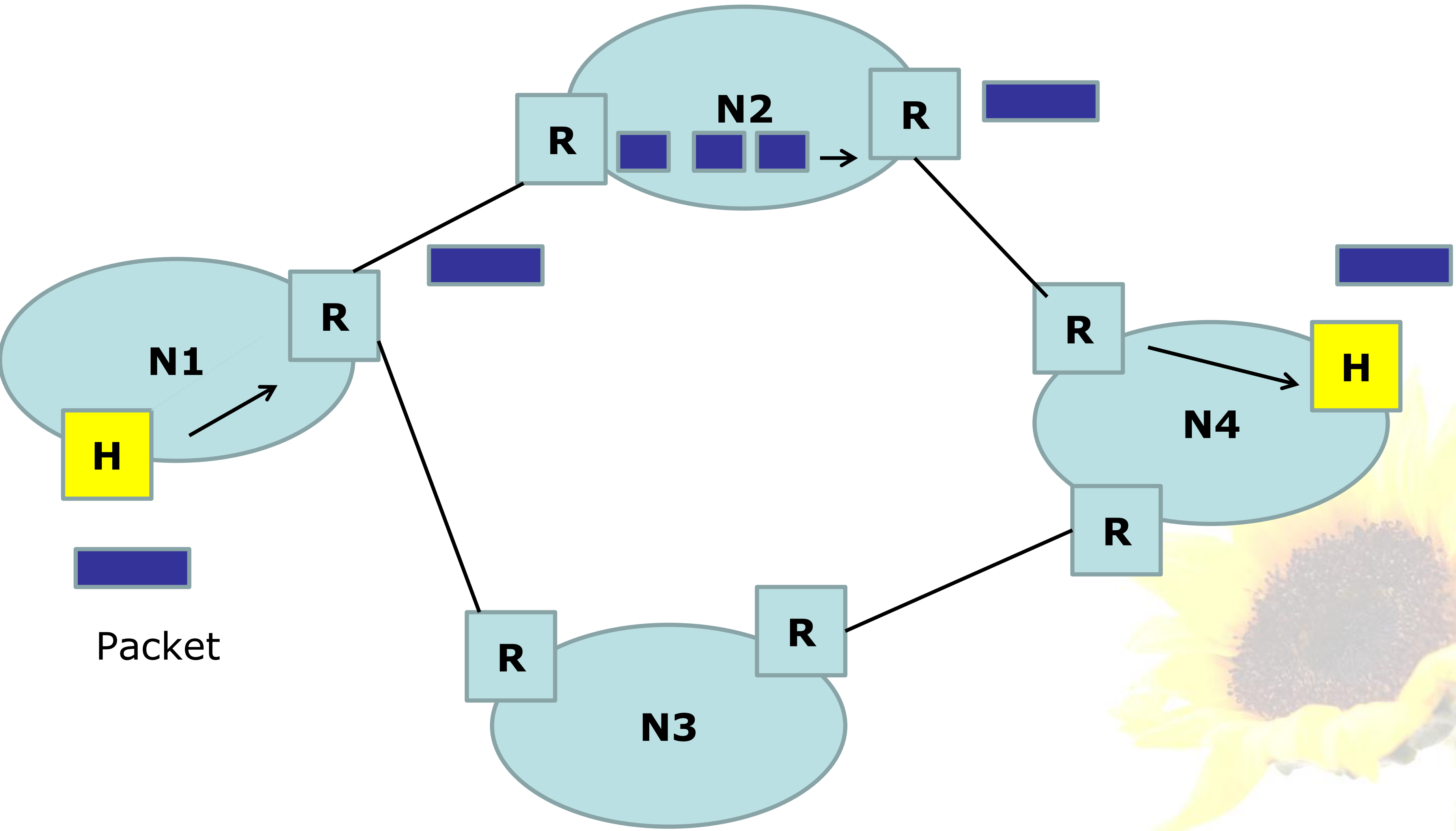
Transparent Fragmentation

- Fragmentation is made transparent to subsequent networks, through which the packet pass.
- Basic concept:
  - An oversized packet reaches a router.
  - Router breaks it up into fragments.
  - All fragments sent to the same exit router (say, R_E).
  - R_E reassembles the fragments before forwarding to the next network.

Transparent Fragmentation (cont.)

- Why called transparent?
  - Subsequent networks are not even aware that fragmentation had occurred.
- A packet may get fragmented several times on its way to the final destination.

Transparent Fragmentation (cont.)



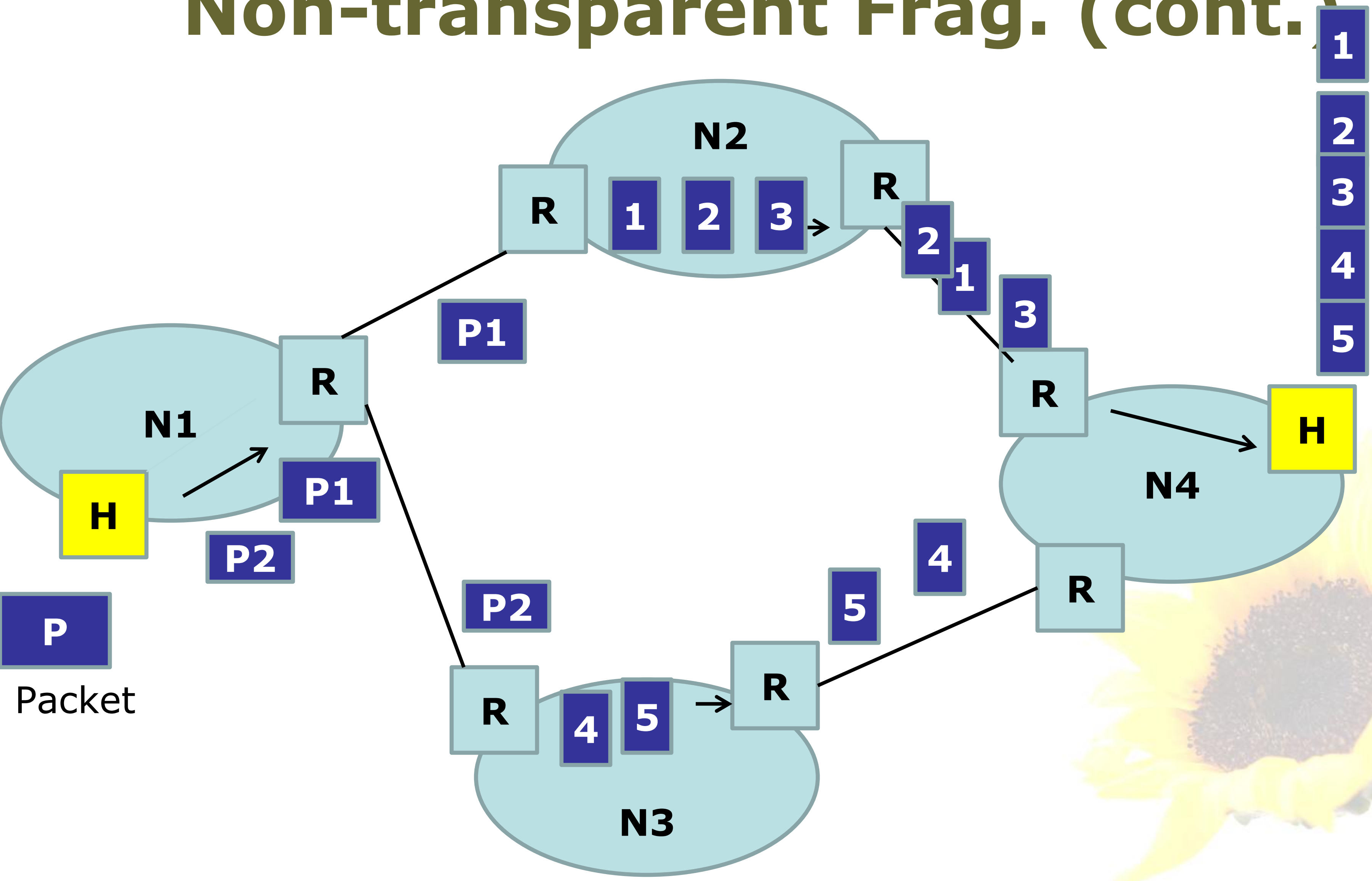
Transparent Fragmentation (cont.)

- Drawbacks:
  - All packets must be routed via the same exit router.
  - Exit router must know when all the pieces have been received.
    - Either a "**count**" field or "**end-of-packet**" field must be stored in each packet.
  - Lot of overhead
    - A large packet may be fragmented and reassembled repeatedly.

Non-transparent Fragmentation

- Fragmentation is not transparent to subsequent networks.
- Basic concept:
  - Packet fragments are not reassembled at any intermediate router.
  - Each fragment is treated as an independent packet by the routers.
  - The fragments are reassembled at the final destination host.

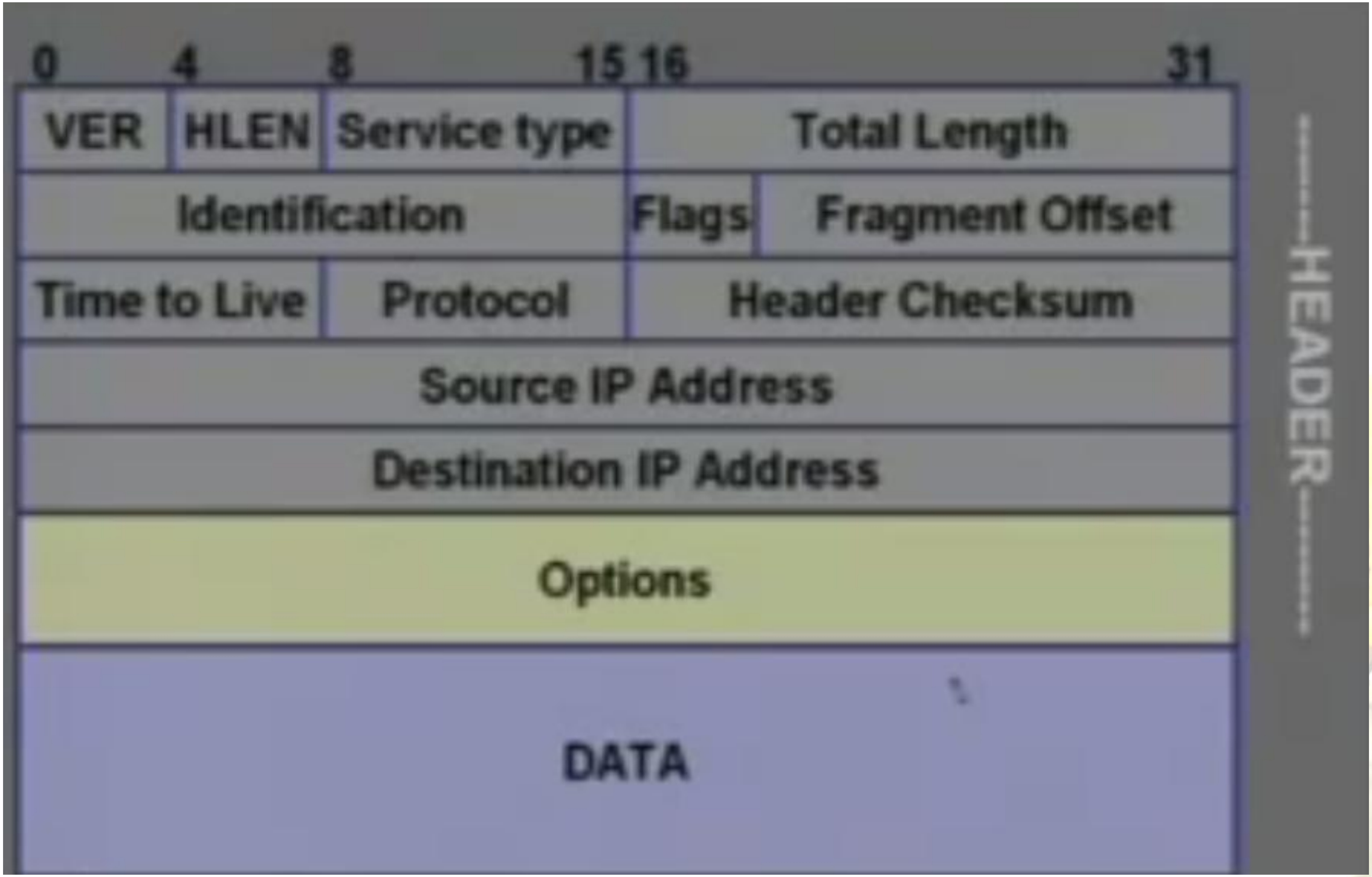
Non-transparent Frag. (cont.)



Non-transparent Frag. (cont.)

- Advantage:
  - Multiple exit routers may be used.
  - Higher throughput
- Drawback:
  - When a large packet is fragmented, overhead increases.
  - Each fragment must have a header (minimum 20 bytes).
- IP protocol uses non-transparent fragmentation.

IP Datagram


0
4
8
15 16
31
VER
HLEN
Service type
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source IP Address
Destination IP Address
Options
DATA
HEADER

What does IP do?

- To allow fragment reassembly at the final destination, IP uses the following fields in the header:
  - Identification (16 bits)
    - A datagram id set by the source.
  - Fragment offset(13 bits)
    - Indicates where in the original datagram this fragment belongs to.
    - Specified in multiple of 8 bytes.

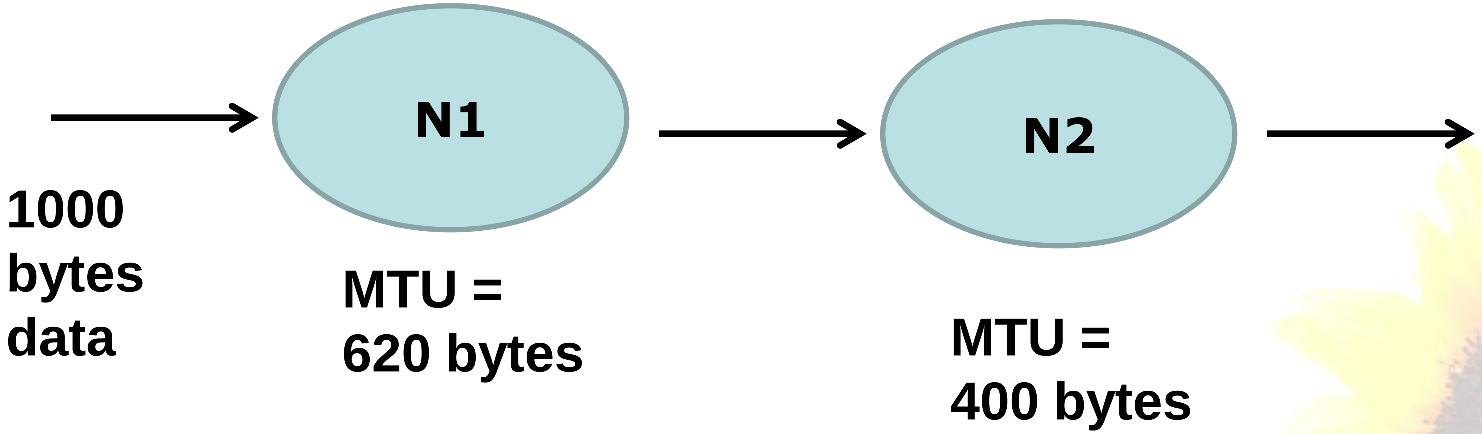
What does IP do?

- Flag (3 bits)
  - Two flags are defined:

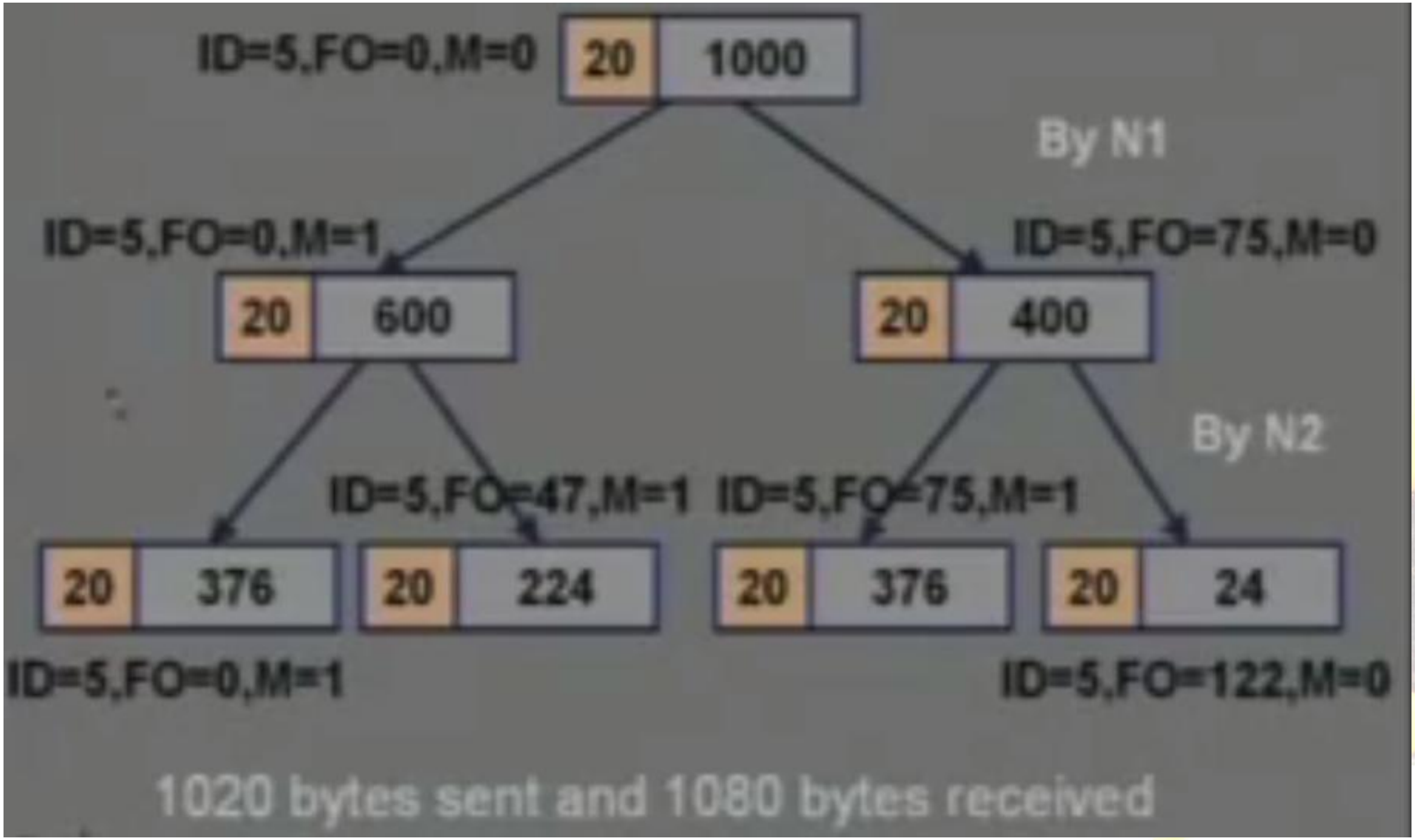
    D bit :: don’t fragment; prevents fragmentation from taking place.

    M bit :: more fragment; specifies if this fragment is the last one in the original packet or not.

Example ::IP Fragmentation



Example (contd.)



Basic IP Addressing

- Each host connected to the internet is identified by a unique IP address.
- An IP address is a 32-bit quantity
  - Expressed as a dotted decimal notation W.X.Y.Z, where dots are used to separate each of the four octets of the address.
  - Consists of two logical parts:
    - A network number
    - A host number
  - This partition defines the ***IP address classes.***

Dotted Decimal Notation

IP address: **01000010 10001000 00110000 01111110**

01000010 10001000 00110000 01111110

(66) (134) (48) (126)

Dotted Decimal Notation: **66.134.48.126**

Hierarchical Addressing

- A computer on the internet is addressed using a two-tuple:
  - The network number
    - Assigned and managed by central authority.
  - The host number
    - Assigned and managed by local network administrator.
- When routing a packet to the destination network, only the network number is looked at.

IP Address Classes

- There are five defined IP address classes.
  - **Class A** **UNICAST**
  - **Class B** **UNICAST**
  - **Class C** **UNICAST**
  - **Class D** **MULTICAST**
  - **Class E** **RESERVED**
- Identified by the first few bits in the IP address.
- There also exists some special-purpose IP addresses.

IP Address Classes (contd.)

- The class-based addressing is also known as the **classful model.**
  - Different network classes represent different network-to-host ratio.
  - Lend themselves to different network configurations.

Class A Address

0	Network	Host	Host	Host

- Network bits : 7
  - Number of networks = $2^7 - 1 = 127$
- Host bits : 24
  - Number of hosts = $2^{24} - 2 = 16,777,214$
- Address range:
  - 0.0.0.0 to 127.255.255.255

Class B

10	**Network**	**Network**	**Host**	**Host**

- Network bits : 14
  - Number of networks = $2^{14} - 1 = 16{,}383$
- Host bits : 16
  - Number of hosts = $2^{16} - 2 = 65{,}534$
- Address range:
  - 128.0.0.0 to 191.255.255.255

Class C

110	Network	Network	Network	Host

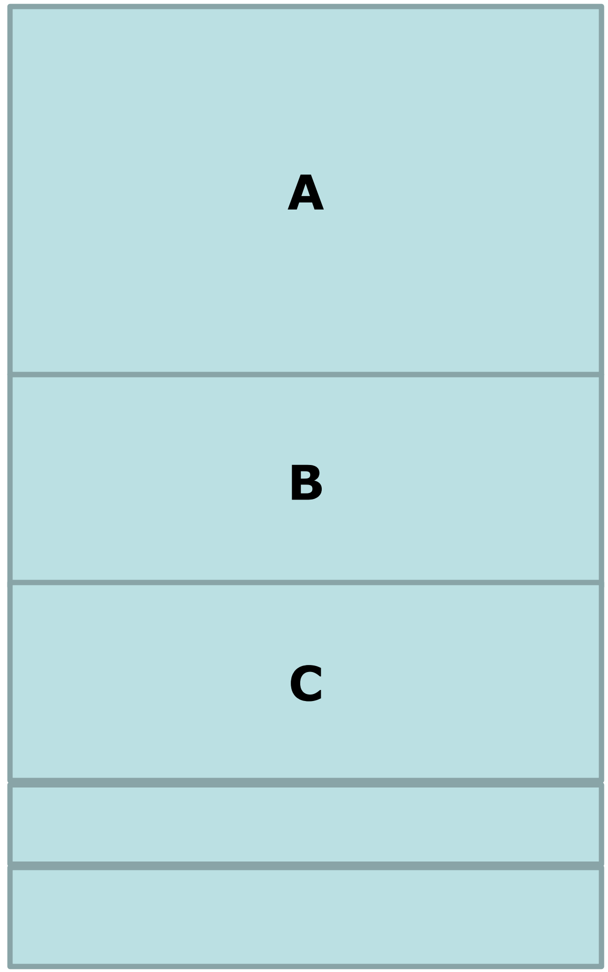
- Network Bits : 21
  - Number of networks = $2^{21} - 1$ = 2,097,151
- Host bits : 8
  - Number of hosts = $2^{8} - 2$ = 254
- Address range:
  - 192.0.0.0 to 223.255.255.255

Class D Address

1110	Multicast Address

- Address range:
  - 224.0.0.0 to 239.255.255.255

Address Distribution



2 billion

1 billion

500 million

Special purpose IP Addresses

- Reserved for private use
  - 10.x.x.x (Class A)
  - 172.16.x.x – 172.31.x.x (Class B)
  - 192.168.x.x (Class B)
- Loopback/local address
  - 127.0.0.0 – 127.255.255.255
- Default network
  - 0.0.0.0
- Limited broadcast
  - 255.255.255.255

Some Conventions

- Within a particular network (Class A, B or C), the first and last addresses serve special functions.
  - The first address represents the network number.
    - For example, 118.0.0
  - The last address represents the directed broadcast address of the network.
    - For example, 118.255.255.255