Network Layer

COMP90007 Internet Technologies

Lecturer: Ling Luo

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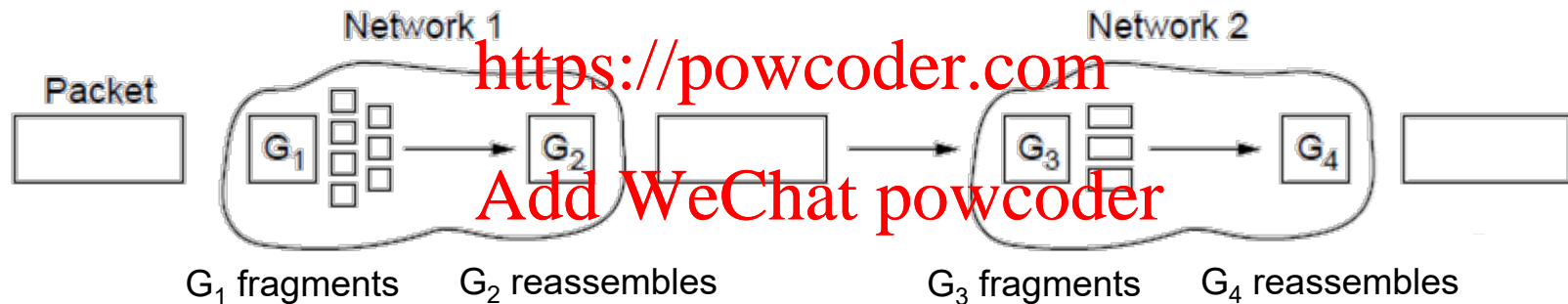# Fragmentation

- All networks have a maximum size for packets (Maximum Transmission Unit, MTU)
  - Hardware and operating system
  - Protocols and standards compliance
  - Efficiency of transmission
- Solution: fragmentation
  - divides packets into fragments when large packets need to be routed through a network whose maximum packet size is too small.

Types of Fragmentation (1)

- **Solution: Fragmentation and Reassembly**.

- **Transparent:** packets fragmented & reassembled in each network. Route constrained, more work.

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Network 1   Network 2

Packet G_1 G_2 G_3 G_4

G_1 fragments G_2 reassembles G_3 fragments G_4 reassembles
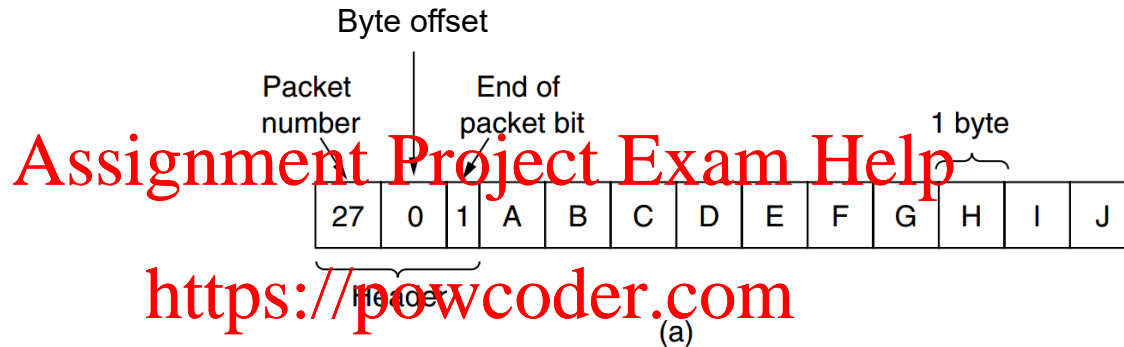
Types of Fragmentation (2)

- **Solution: Fragmentation and Reassembly**.
- **Non-transparent:** fragments are reassembled at destination. Router has less work. IP works this way. Each packet requires packet number, byte offset, end of packet flag
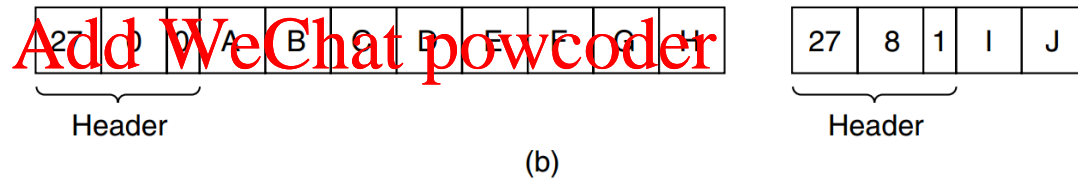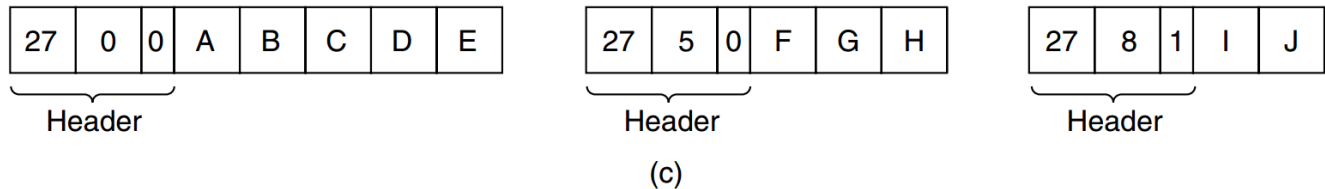

Packet

G_1 fragments

reassemble at destination
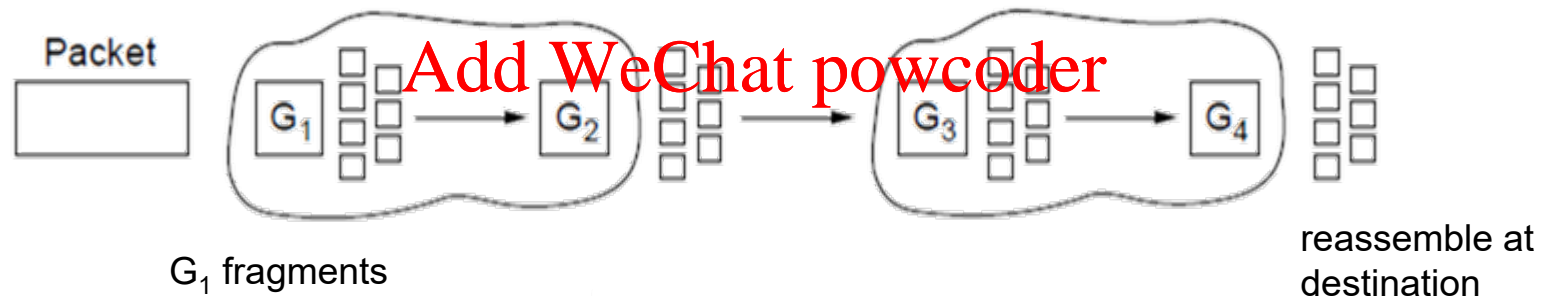
IP-Style Fragmentation

Original packet:
(10 data bytes)

Fragmented:
(to 8 data bytes)

Re-fragmented:
(to 5 bytes)

Byte offset

Packet number

End of packet bit

1 byte

| 27 | 0 | 1 | A | B | C | D | E | F | G | H | I | J |

Header

(a)

| 27 | 0 | 1 | A | B | C | D | E | F | G | H |

Header

| 27 | 8 | 1 | I | J |

Header

(b)

| 27 | 0 | 0 | A | B | C | D | E |

Header

| 27 | 5 | 0 | F | G | H |

Header

| 27 | 8 | 1 | I | J |

Header
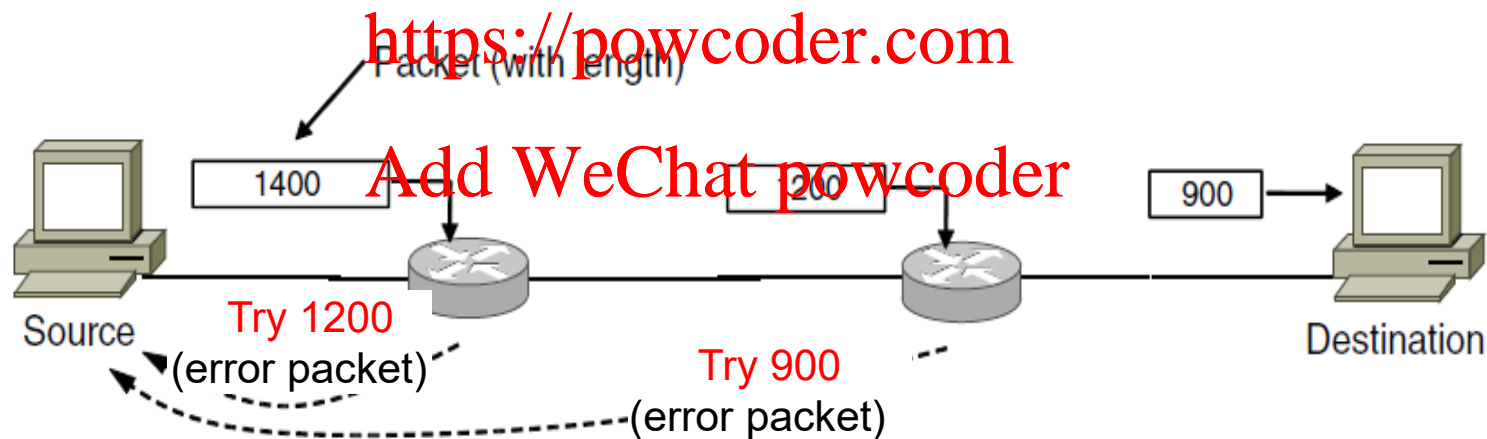
(c)

Path MTU Discovery

- Alternative to Fragmentation
- Advantage: the source knows what length packet to send
- If the routes and path MTU change, new error packets will be triggered and the source will adapt to the new path

Packet (with length)

1400

1200

900

Source

Try 1200
(error packet)

Try 900
(error packet)

Destination

Outline

- Network layer in the Internet
- Types of services
- Internetworking
  - Tunneling
  - Fragmentation
  - Path MTU discovery
- Internet Protocol
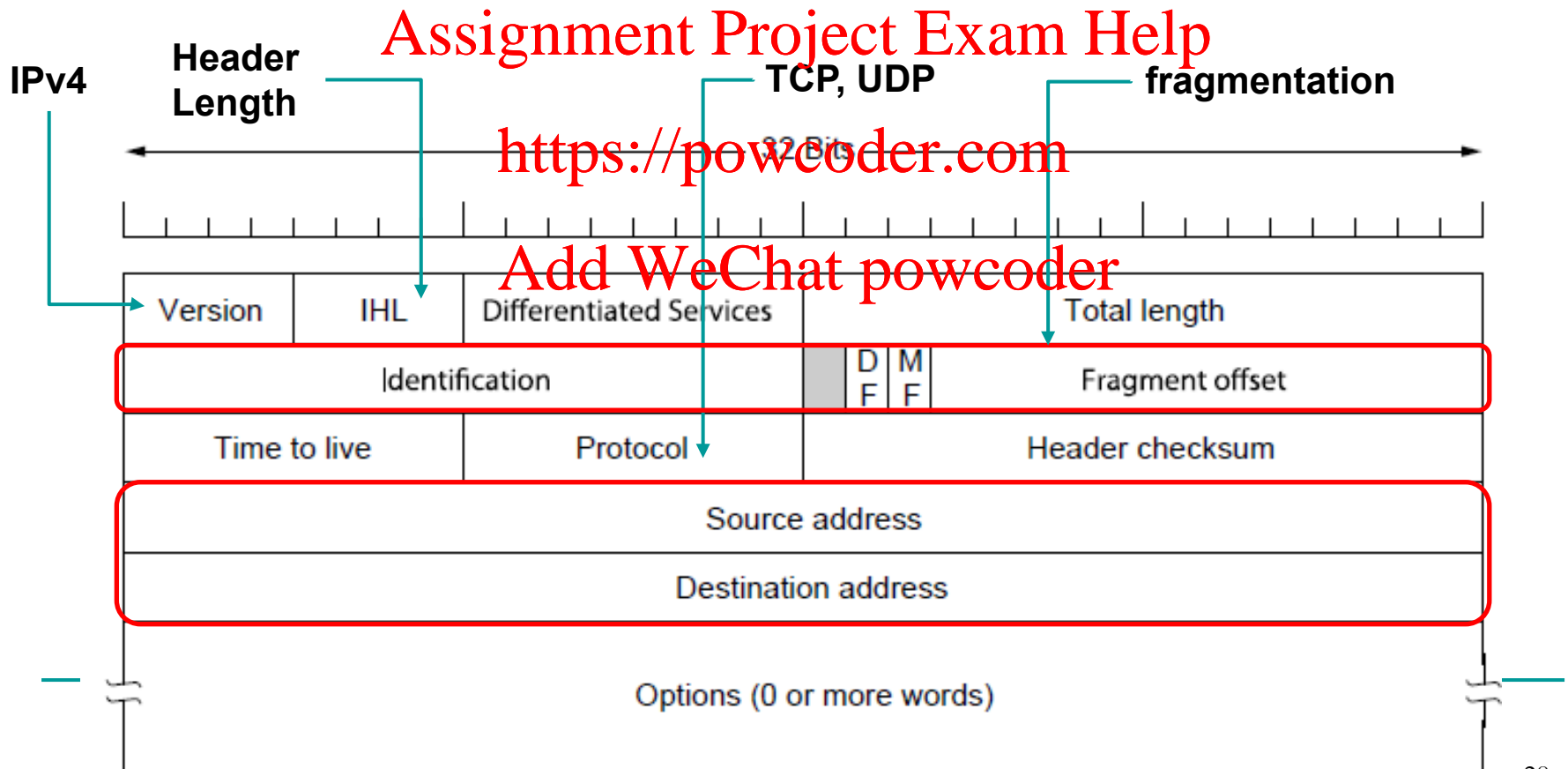 - Addressing
  - Subnetting
- Routing algorithms

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IPv4 Datagram Structure (1)

- **IPv4 (Internet Protocol) datagram** consists of a header and payload
- **IPv4 header** has fields for the key parts of the protocol
- **Header format**: 20-byte fixed part + variable-length optional part

IPv4 Datagram Structure (2)

- **IHL**: Internet Header Length, in 32-bit units, min is 5 and max is 15

- **Differentiated services**: different classes of service

- **Total Length**: header and payload, max length 65535 bytes

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- **Identification**:
  - Allows host to determine which datagram the new fragment belongs to.
  - All fragments of same datagram have same ID

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- **DF**: Don't Fragment Add WeChat powcoder
  - is used as part of the process to discover the path MTU

- **MF**: More Fragment, is this the last one?

- **Fragment offset**: where in the datagram the current fragment belongs

IPv4 Datagram Structure (3)

- **TTL**: Time to live, limits packet lifetimes in hops or seconds

- **Protocol**: TCP, UDP

- **Header Checksum**: verifies the header only

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- **Source Address**: IP address of the sender

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- **Destination Address**: IP address of the receiver

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- **Options**: e.g. security, strict vs. loose source routing, record route, timestamp

IP Addresses (1)

- IP address (IPv4) is 32-bit long, written in dotted decimal notation

128.18.3.11

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2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	1	0	0	1	0

range: 0-255

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- Addresses are **hierarchical** and can be allocated in **blocks**

  e.g. 256 addresses in the block 128.18.3.0 – 128.18.3.255

- Overall, IP allocation is managed by Internet Corporation for Assigned Names and Numbers (ICANN)

IP Addresses (2)

- network portion + host portion
- **Prefix:** determined by the network portion, all hosts on a single network has the same network portion.
  prefix is written as: lowest address/bit-length

  128.18.3.0/24 18.2.0.0/16

- **Subnet mask**: all 1s in the network portion
- **Extract** prefix: ANDed the IP address with the subnet mask
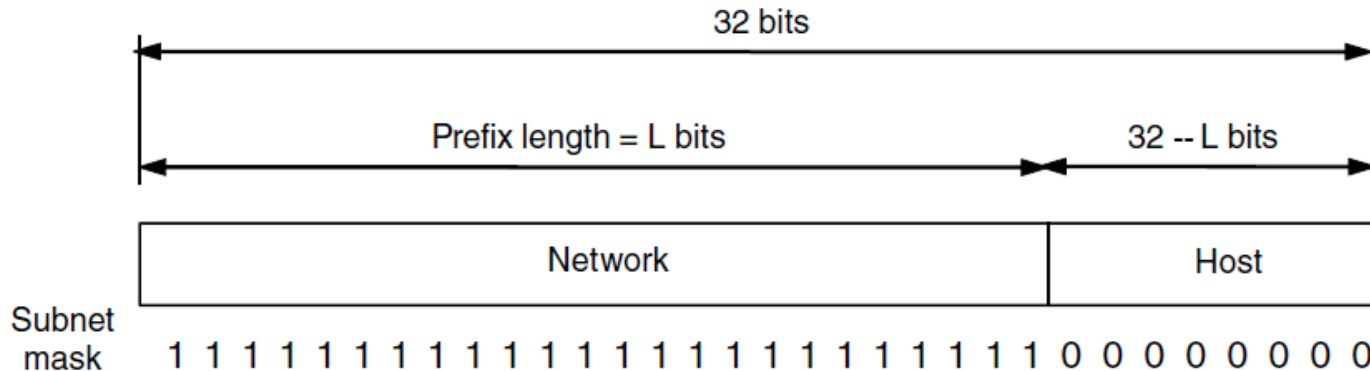
IP Addressing and Routing Tables

- Routing tables are typically built on a triplet:
    - Prefix Address
    - Subnet Mask
    - Outgoing Line (physical or virtual)
- Example: a row of a routing table.

Prefix	Subnet Mask	Interface
128.18.3.0/24	255.255.255.0	Eth 0