Network Layer

COMP90007 Internet Technologies

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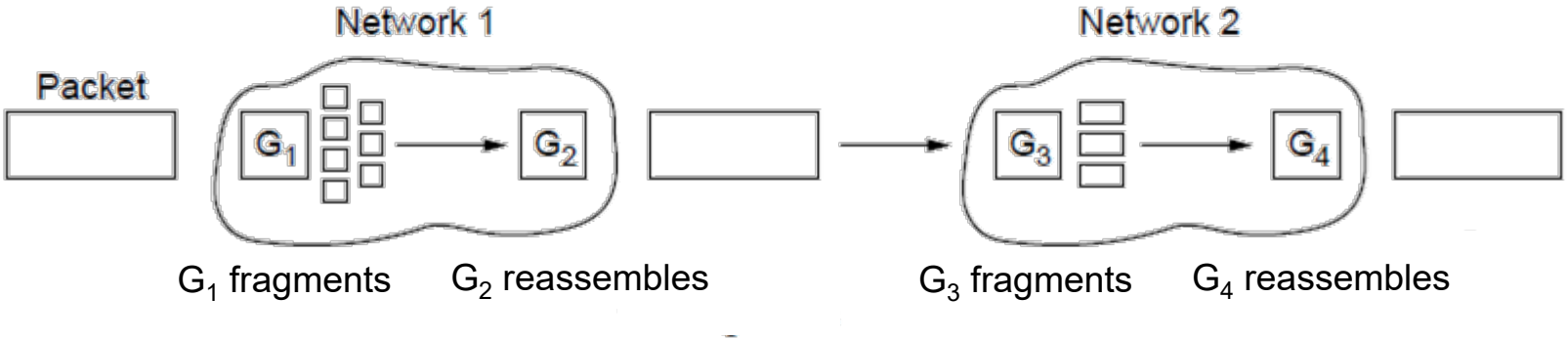
Fragmentation

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

Types of Fragmentation (1)

- **Solution: Fragmentation and Reassembly.**

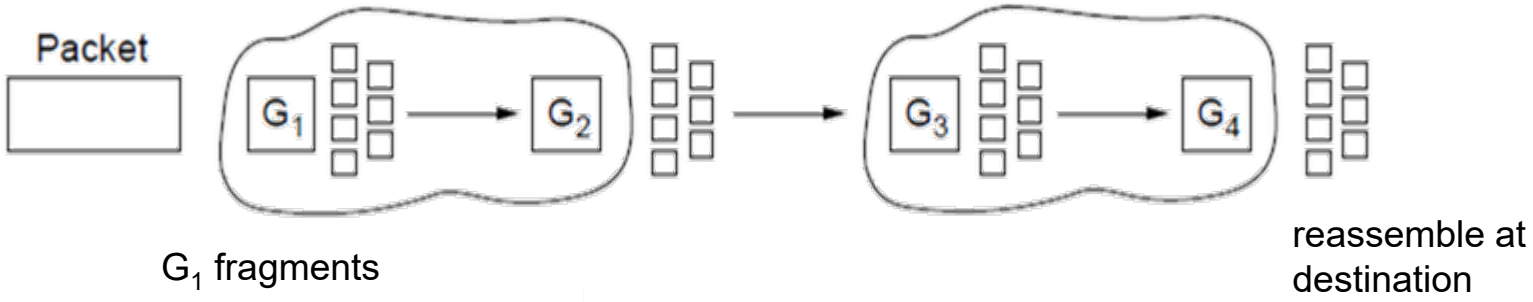
  Transparent: packets fragmented & reassembled in each network. Route constrained, more work.



Types of Fragmentation (2)

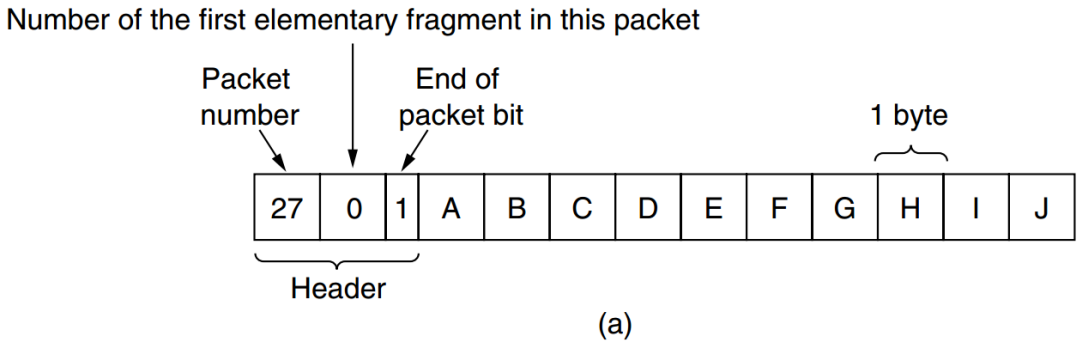
- **Solution: Fragmentation and Reassembly.**

  Non-transparent: fragments are reassembled at destination. Router has less work, but each packet requires packet number, byte offset, end of packet flag. IP works this way.

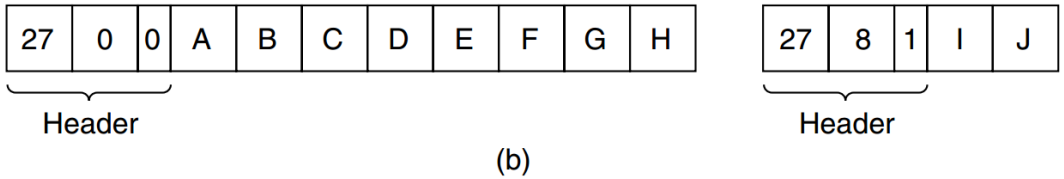


IP-Style Fragmentation

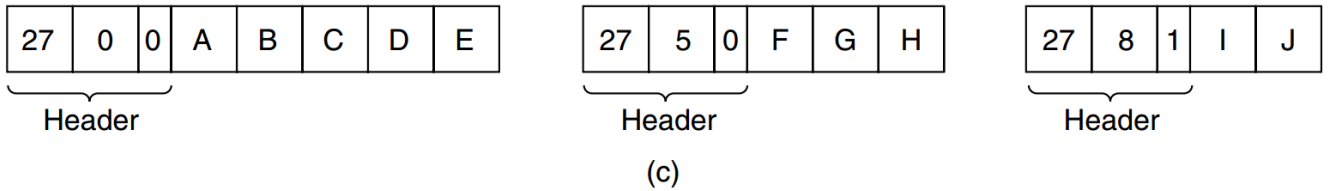
Original packet:
(10 data bytes)



Fragmented:
(to 8 data bytes)

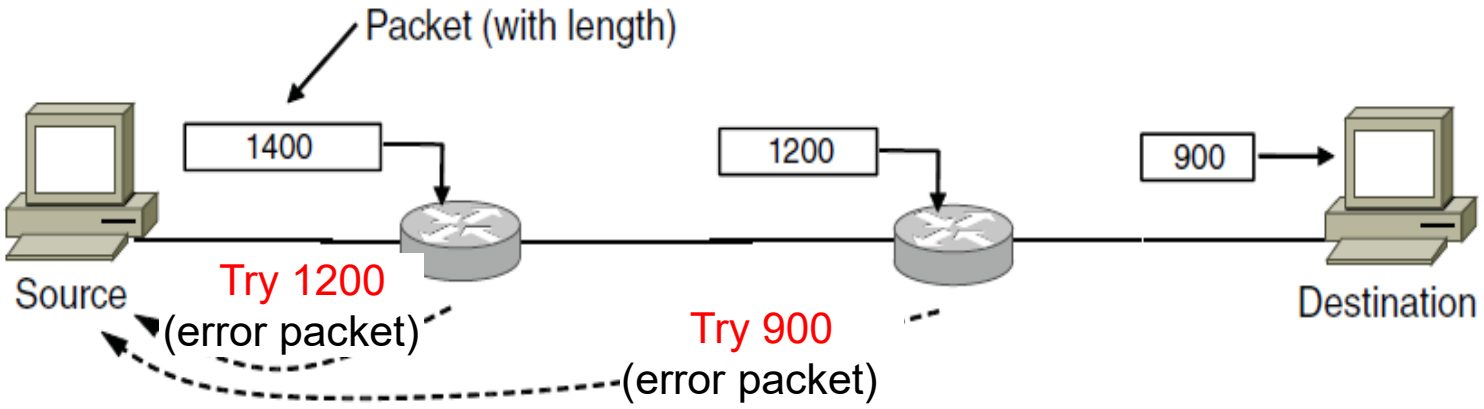


Re-fragmented:
(to 5 bytes)



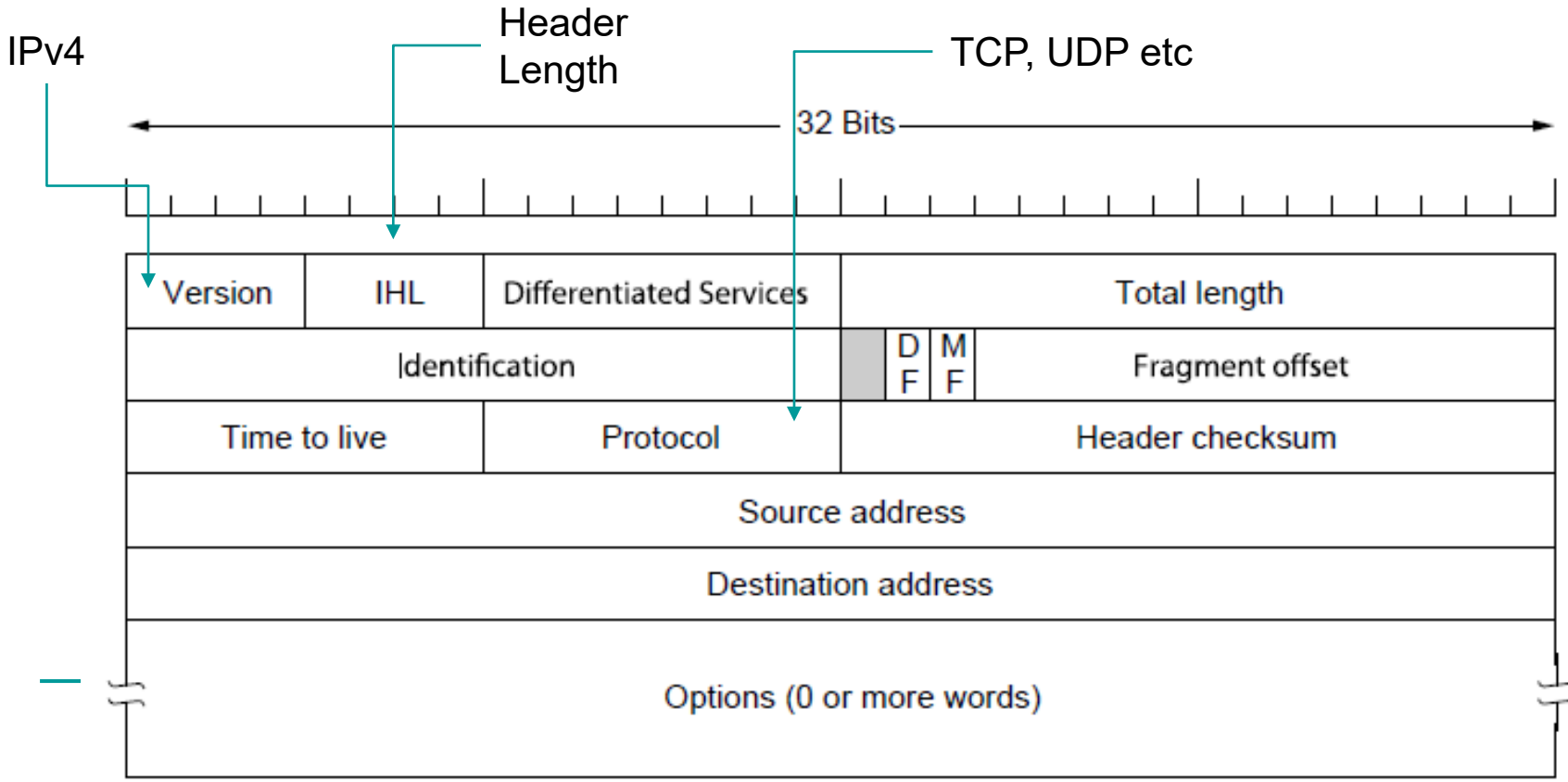
Path MTU Discovery

- 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



IPv4 Datagram Structure (1)

- **IPv4** (Internet Protocol) **datagram** consists of a header and payload
- **IPv4 header** is carried on all packets and 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

- Identification:
  - Allows host to determine which datagram the new fragment belongs to.
  - All fragments of same datagram have same ID
- DF: Don't Fragment
  - Now it is used as part of the process to discover the path MTU, which is the largest packet that can travel along a path without being fragmented
- MF: More Fragment, is this the last one?
- Fragment offset: where in the datagram the current fragment belongs

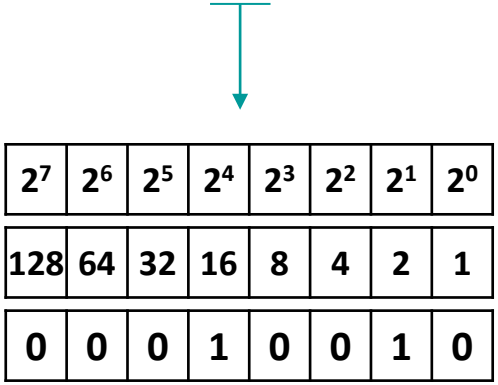
IPv4 Datagram Structure (3)

- TTL: Time to live, limits packet lifetimes in hops or seconds
- Protocol: TCP, UDP ...
- Header Checksum: verifies the header only
- Source Address: IP address of the sender
- Destination Address: IP address of the receiver
- 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



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

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

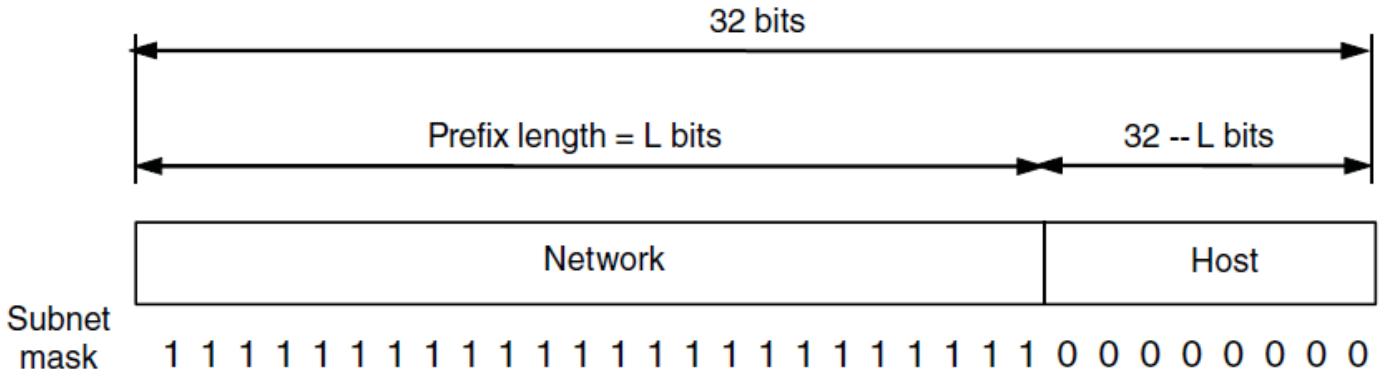
  e.g. 256 addresses in the block 128.18.3.0 – 128.18.3.255
- Overall, IP allocation is managed by Internet Corporation for Assigned Names and Numbers (ICANN)

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



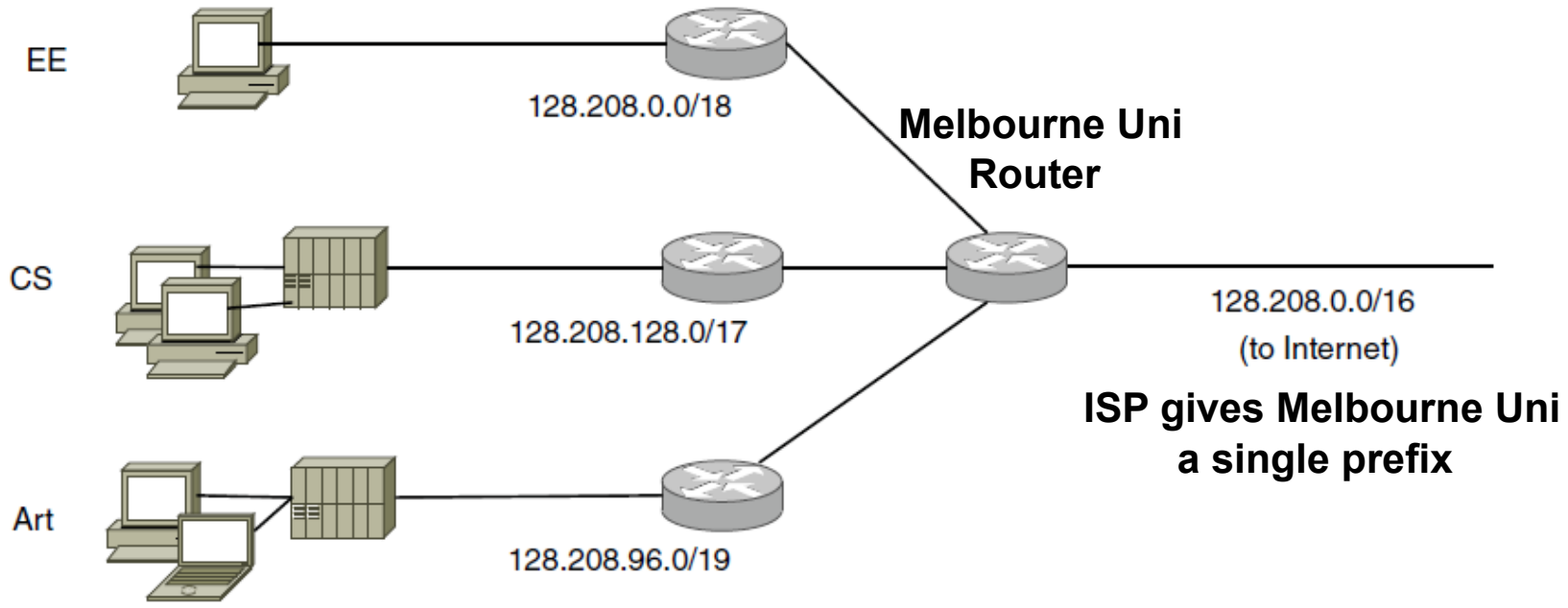
IP Addressing and Routing Tables

- 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

Subnets (1)

- Subnetting allows networks to be split into several parts for internal uses whilst acting like a single network for external use
- Looks like a single prefix outside the network



Network is divided into subnets internally

Subnets (2)

128.208.0.0/16 → number of addresses 2^{16}