COMP 3721
Introduction to Data Communications

12b - Week 12 - Part 2

Learning Outcomes

- By the end of this lecture, you will be able to
  - Explain how the IPv6 protocol works and what are its benefits.

Introduction

Handwritten note: IPv4 → length? → 32 bits → Add space = 2^{32} = 4B.3

- **IPv6** or IPng (IP next generation)
  - **128-bit** address (16 bytes)
  - Size of the address space?
    - $340,282,366,920,938,463,374,607,431,768,211,456 = 2^{128}$
- **Main reason** for migration from IPv4 to IPv6 is the **small size** of the **address space** in IPv4.

IPv6 Address Space

$$\frac{128}{32} = 4 \qquad \frac{2^{128}}{2^{32}} = 2^{96}$$

- Now let's do some math:
  - How much larger IPv6 address length is comparing to IPv4 address length?
  - How much larger IPv6 address space is comparing to IPv4 address space?
  - Imagine the world population becomes 2^{34} (more than 16 billion), and we just assign 1/64 (almost 2%) of the IPv6 addresses to them.
    - How many unique numbers can be assigned to each person?

$$\frac{2^{128}}{2^6} = 2^{122} \longrightarrow \frac{2^{122}}{2^{34}} = 2^{88}$$

IPv6 Representation

- Two notations:
  - **Binary**
    - e.g., 11111110111101101011 … 1111111100000000
    - Used when the addresses are stored in a computer.
  - **Colon hexadecimal**
    - e.g., FEF6:BA98:7654:3210:ADEF:BBFF:2922:FF00
    - **Abbreviation**:
      - Leading zeros of a section are removed, e.g., 000F → F or 0074 → 74
      - But note that, e.g., 3210 cannot be abbreviated
      - If **consecutive sections** include only zeros (zero compression), replace them with a **double colon** (allowed only **once per address**), e.g., FDEC:0:0:0:0:BBFF:0:FFFF → FDEC::BBFF:0:FFFF

IPv6 Address Types

- Three address types for a destination address:
  1. **Unicast address**
     - Indicates a single interface (host or router).
  2. **Anycast address**
     - Indicates a group of computers that all share a single address.
     - The packet is delivered to **ONLY** one member of the group (the most reachable one).
  3. **Multicast address**
     - Indicates a group of computers that all share a single address.
     - **Each member** receives a copy of the packet.
     - Broadcasting is considered as a special case of multicasting.

IPv6 Global Unicast Address
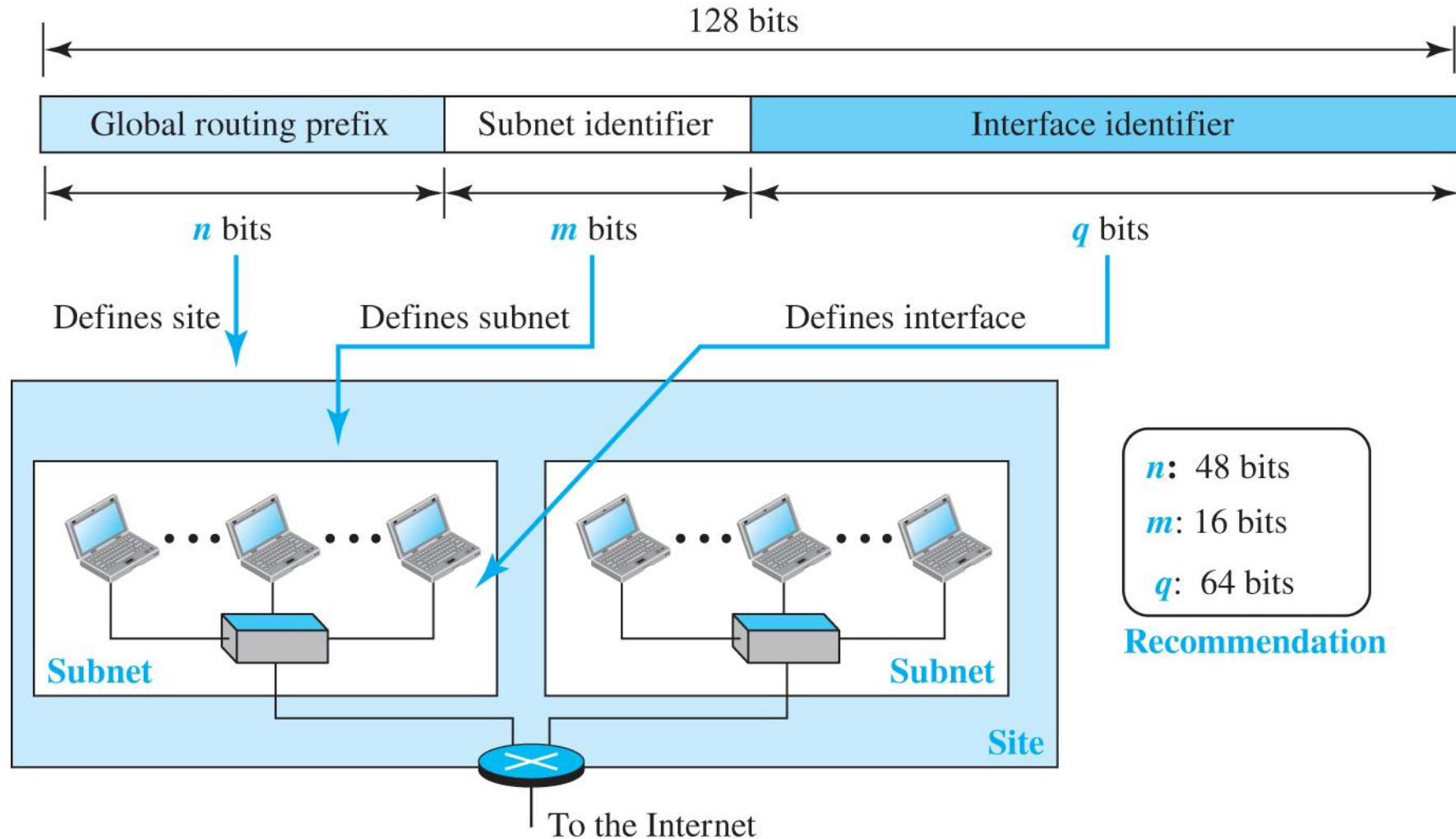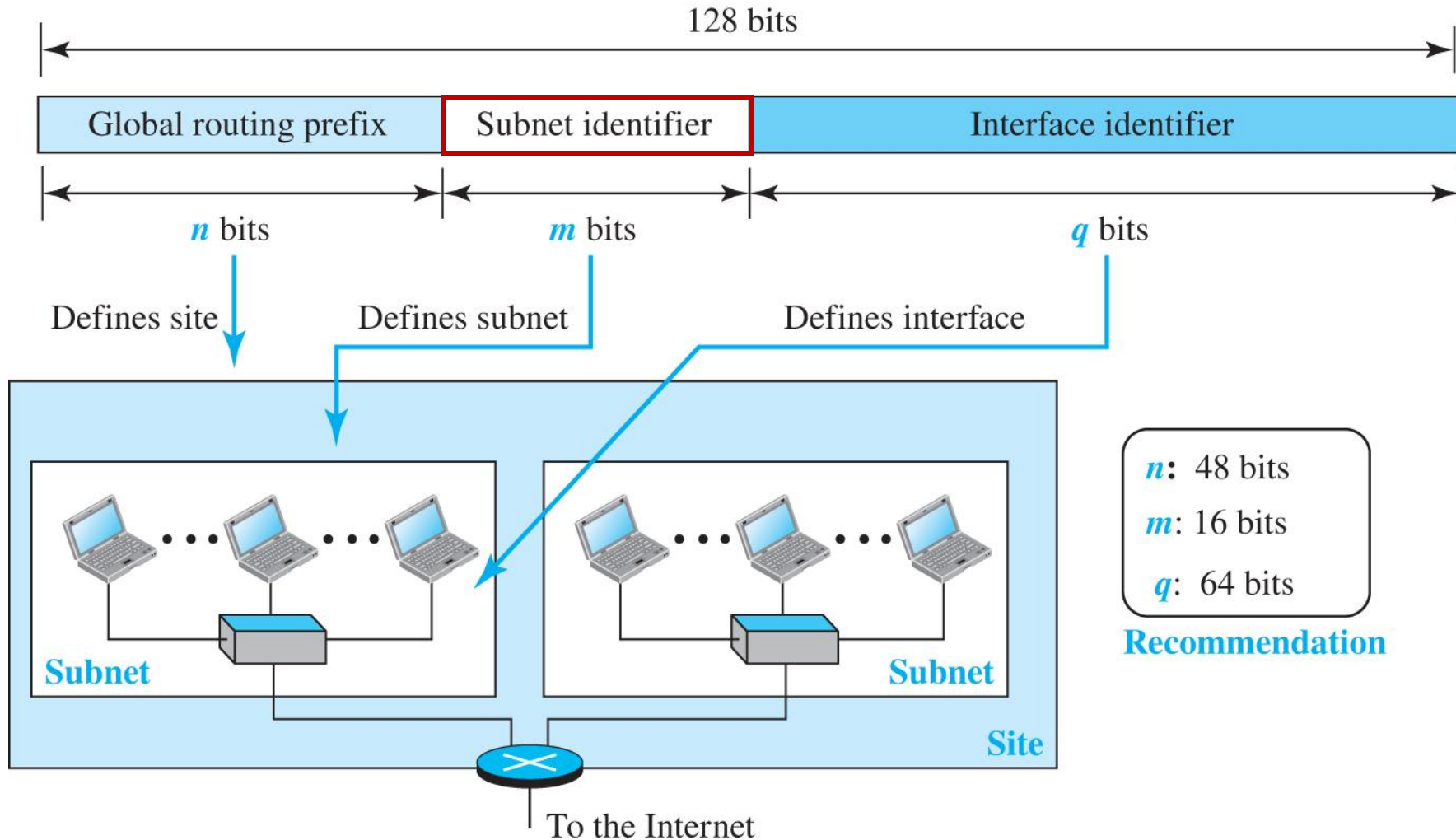
IPv6 Global Unicast Address

Used by global routers on the Internet to route the packet to its destination site.
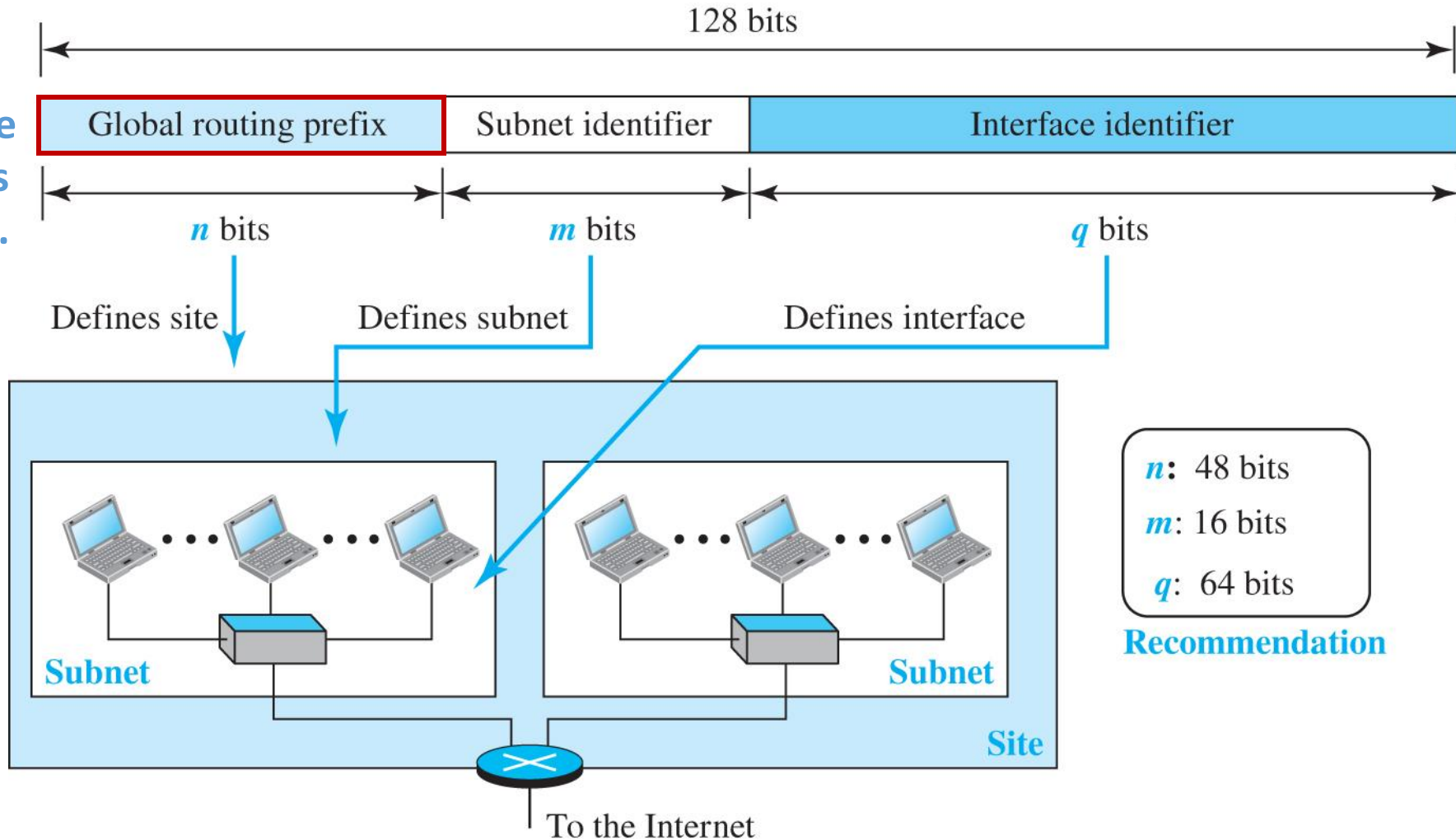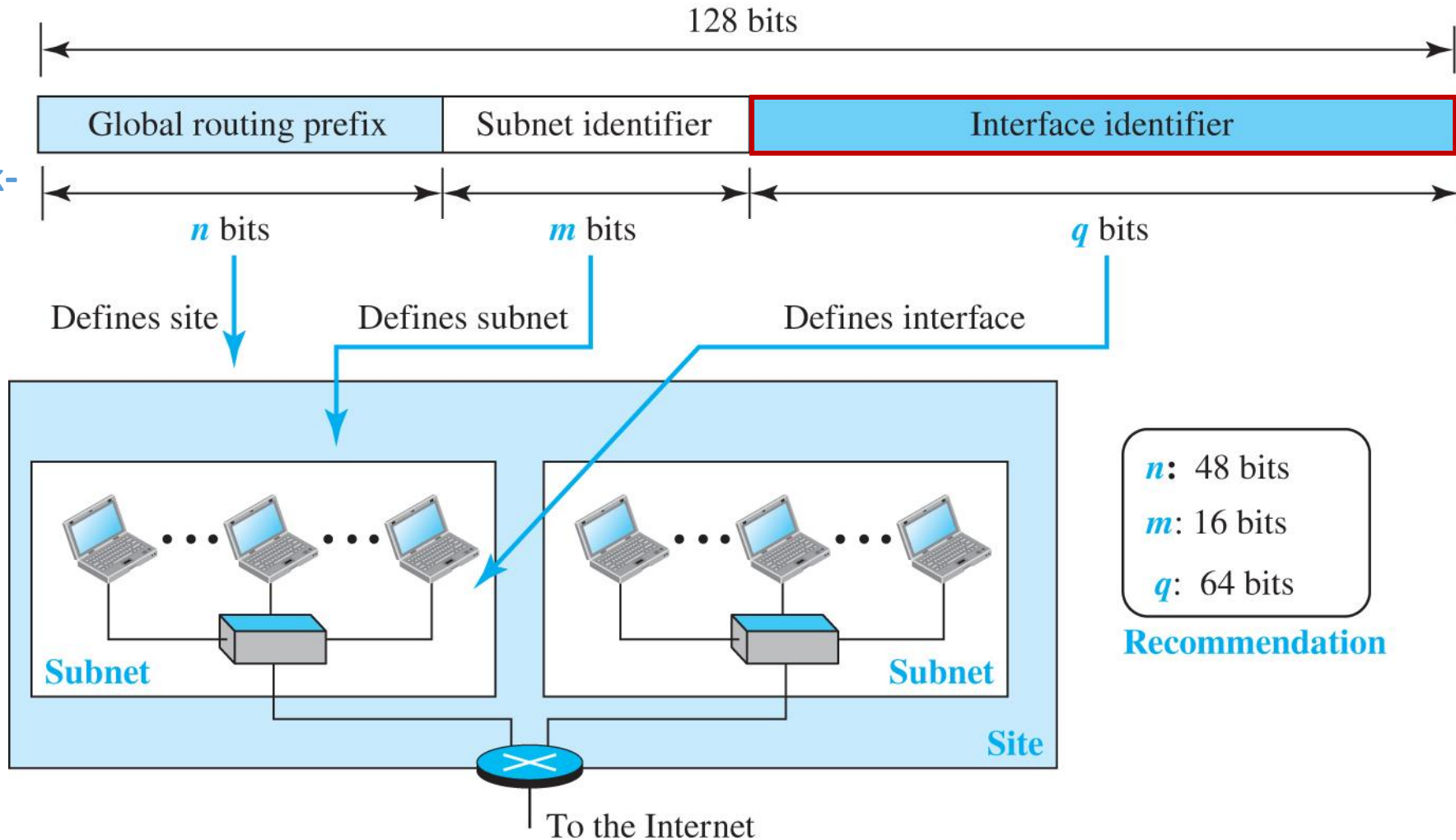
IPv6 Global Unicast Address

A subnet in an organization.

IPv6 Global Unicast Address

Allows a relationship between IP address and link-layer address.

Transition to IPv6 – Strategies

- Because of the huge number of systems on the Internet, the transition from IPv4 to IPv6 cannot happen suddenly.

- Three strategies for transition:
  1. **Dual stack**
  2. **Tunneling**
  3. **Header translation**

- One or all of these three strategies can be implemented during the transition period.
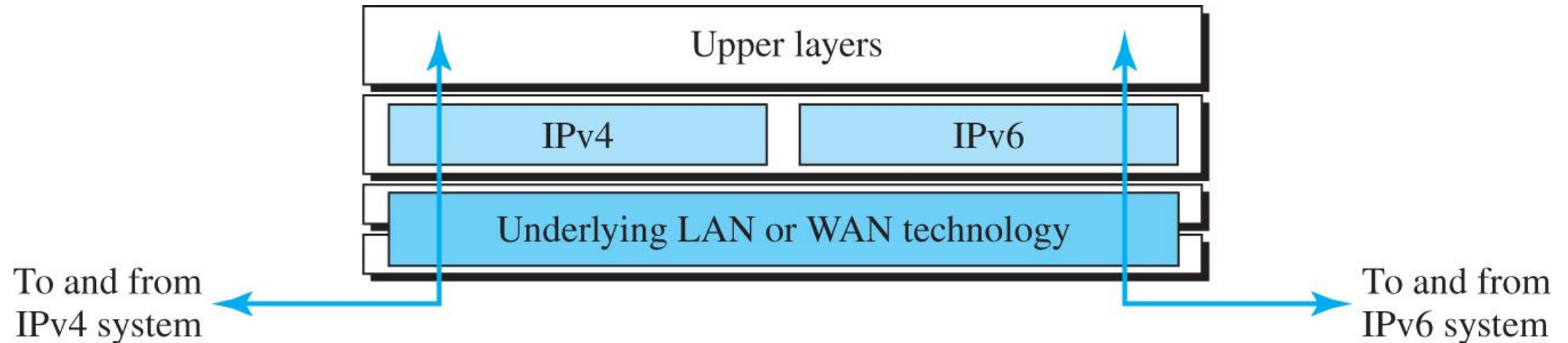
Dual Stack

[handwritten: ARP: IP ⟶ MAC]

[handwritten: DNS: URL ⟶ IP]

- A host must run IPv4 and IPv6 simultaneously until all the Internet uses IPv6.
 - How to indicate which version to use? *[handwritten: DNS Response]*

Tunneling

- Used when two computers using IPv6 want to communicate with each other, and the packet must pass through a region that uses IPv4.

- The IPv6 packet is encapsulated in an IPv4 packet when it enters the region, and it leaves its capsule when it exits the region.

- The value of protocol field in the header of IPv4 packet is set to 41.
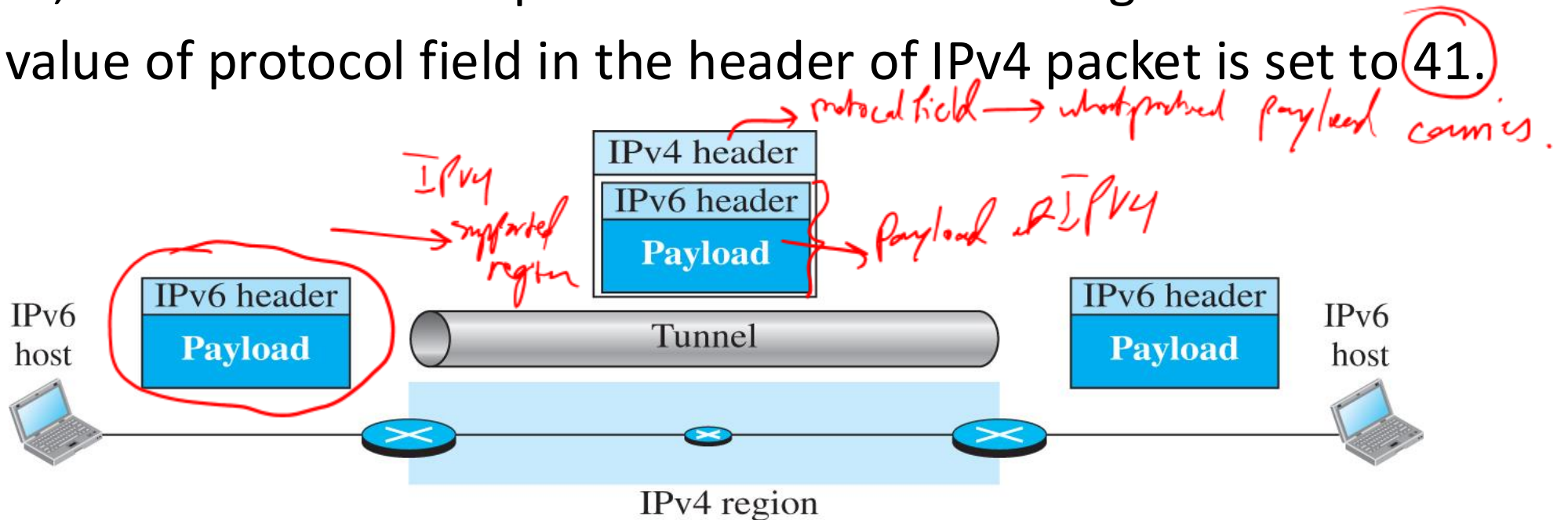
Header Translation

- Necessary when the majority of the Internet has moved to IPv6, but some systems still use IPv4.

- The sender wants to use IPv6, but the receiver does not understand IPv6.

- The header of the IPv6 packet is converted to an IPv4 header.
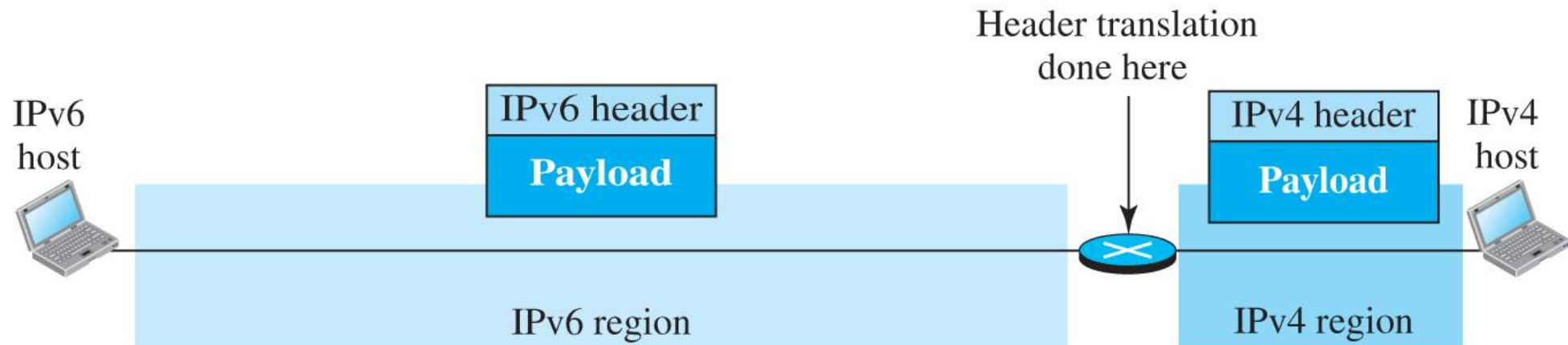
Summary

- **IPv6 addresses** as a **long-term solution** for **IPv4 address depletion** problem.

- An **IPv6 global unicast address** has three parts to indicate a **site**, **subnet** and an **interface**.

- Three strategies to transition to IPv6, including **dual stack**, **tunneling**, and **header translation**.

References

[1] Behrouz A.Forouzan, Data Communications & Networking with TCP/IP Protocol Suite, 6th Ed, 2022, McGraw-Hill companies.

[2] J.F. Kurose, K.W. Ross, Computer Networking: A Top-Down Approach, 7th Ed, 2017, Pearson Education, Inc.

Reading

- Chapter 7 of the textbook, sections 7.4.2–7.4.4
- Chapter 7 of the textbook, section 7.8 (Practice Test)