COMP 3721
Introduction to Data Communications

12b - Week 12 - Part 2

COMP 3721数据通信导论

12b - 第12周 - 第2部分

Learning Outcomes

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

学习成果

- 在本讲座结束时，您将能够
  - 解释IPv6协议的工作原理及其优势。

Introduction

- **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.

简介

- **IPv6** 或 IPng（IP 下一代）
  - **128-位** 地址（16 字节）
  - 地址空间的大小?
    - 340,282,366,920,938,463,374,607,431,768,211,456 = 2^{128}
- **从 IPv4 迁移到 IPv6 的主要原因** 是 IPv4 中 **地址空间过小** 的 **地址空间** 在 IPv4 中。

IPv6 Address Space

- 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?

IPv6 地址空间

- 现在我们来做一些数学计算：
  - IPv6 地址长度比 IPv4 地址长度大多少？
  - IPv6 地址空间比 IPv4 地址空间大多少？
  - 假设全球人口达到 2^{34}（超过 160 亿），并且我们仅将 IPv6 地址的 1/64（约占 2%）分配给他们。
    - 每个人可以分配到多少个唯一的号码？

IPv6 Representation

- Two notations:
  - **Binary**
    - e.g., 111111101111011010 11 … 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 表示法

- 两种表示法：
  - **二进制**
    - 例如，111111101111011010 11 … 1111111100000000
    - 当地址存储在计算机中时使用。
  - **冒号十六进制**
    - 例如，FEF6:BA98:7654:3210:ADEF:BBFF:2922:FF00
    - **缩写**：
      - 一个节段的前导零可被省略，例如，000F → F 或 0074 → 74
      - 但请注意，例如，3210 不可进行缩写
      - 如果 **连续的节段** 全为零（零压缩），则可用 **双冒号** 代替（每个地址中仅允许使用一次），例如，FDEC:0:0:0:0:BBFF:0:FFFF → FDEC::BBFF:0:FFFF
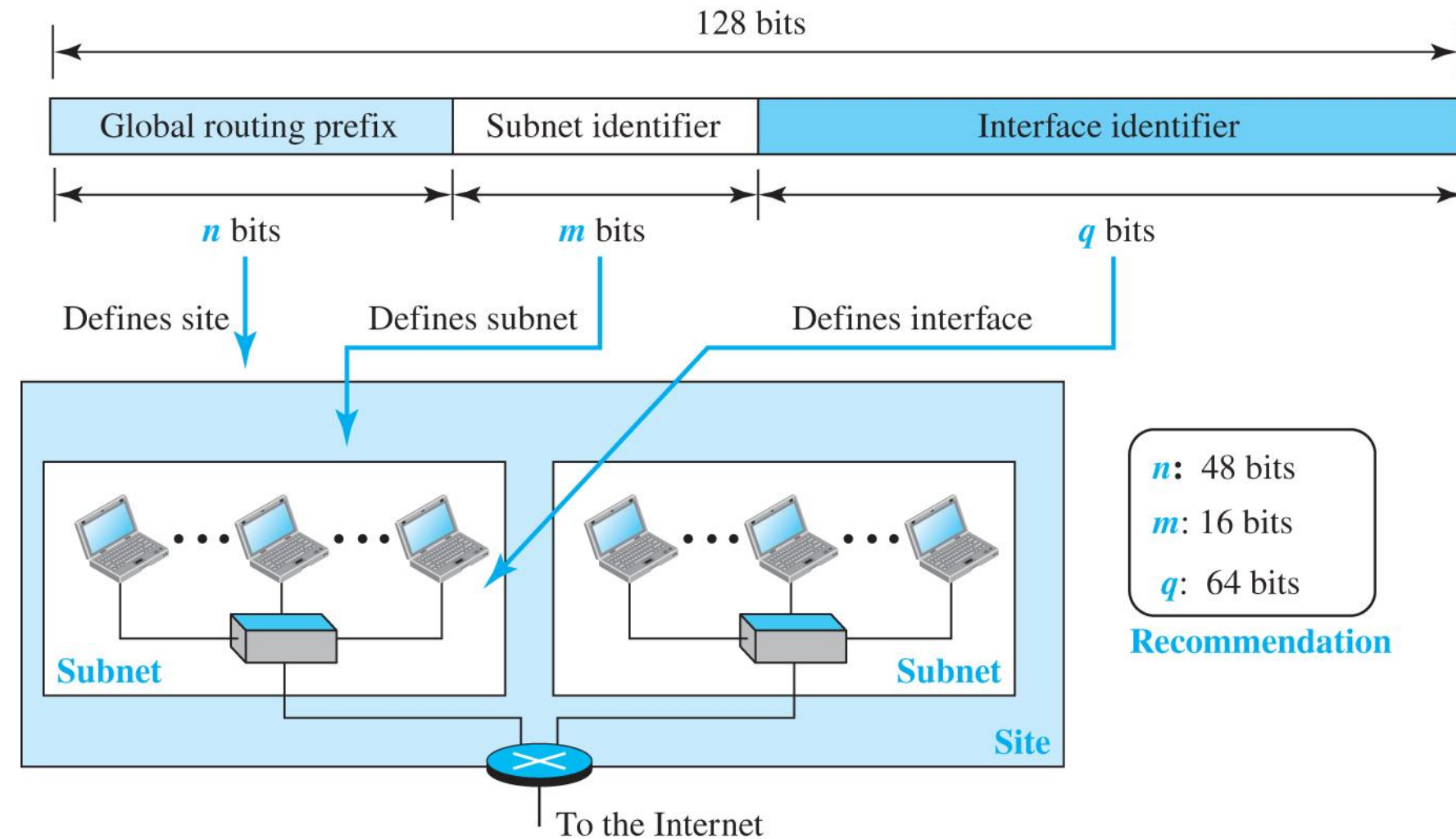
IPv6 Address Types

- 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.
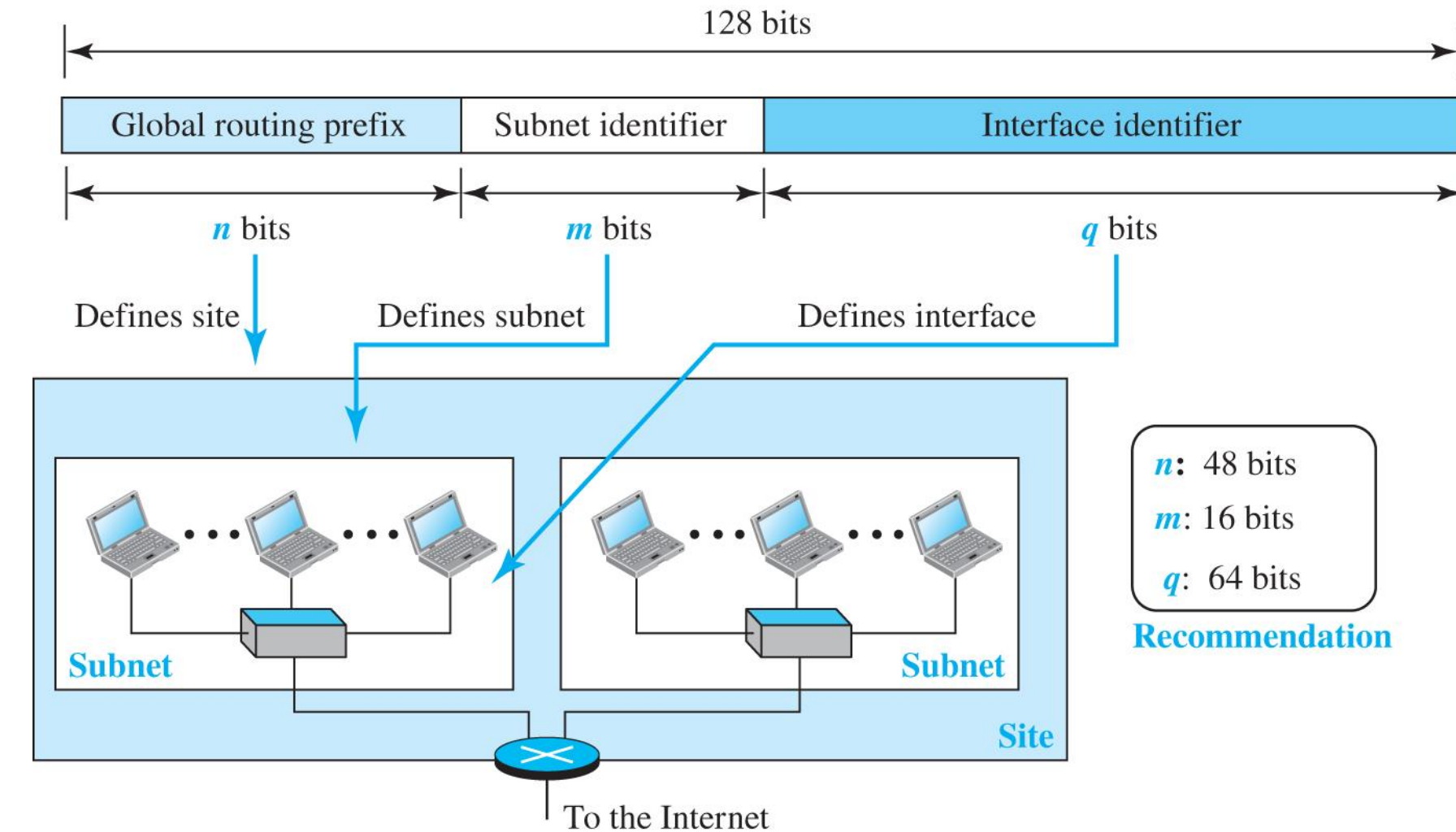
IPv6 地址类型

- 目的地址的三种地址类型：
  1. **单播地址**
     - 表示单个接口（主机或路由器）。
  2. **任播地址**
     - 表示一组共享单个地址的计算机。
     - 数据包被传送给该组中的 **唯一** 一个成员（最易到达的那个）。
  3. **多播地址**
     - 表示一组共享单个地址的计算机。
     - **每个成员** 都会收到一份数据包副本。
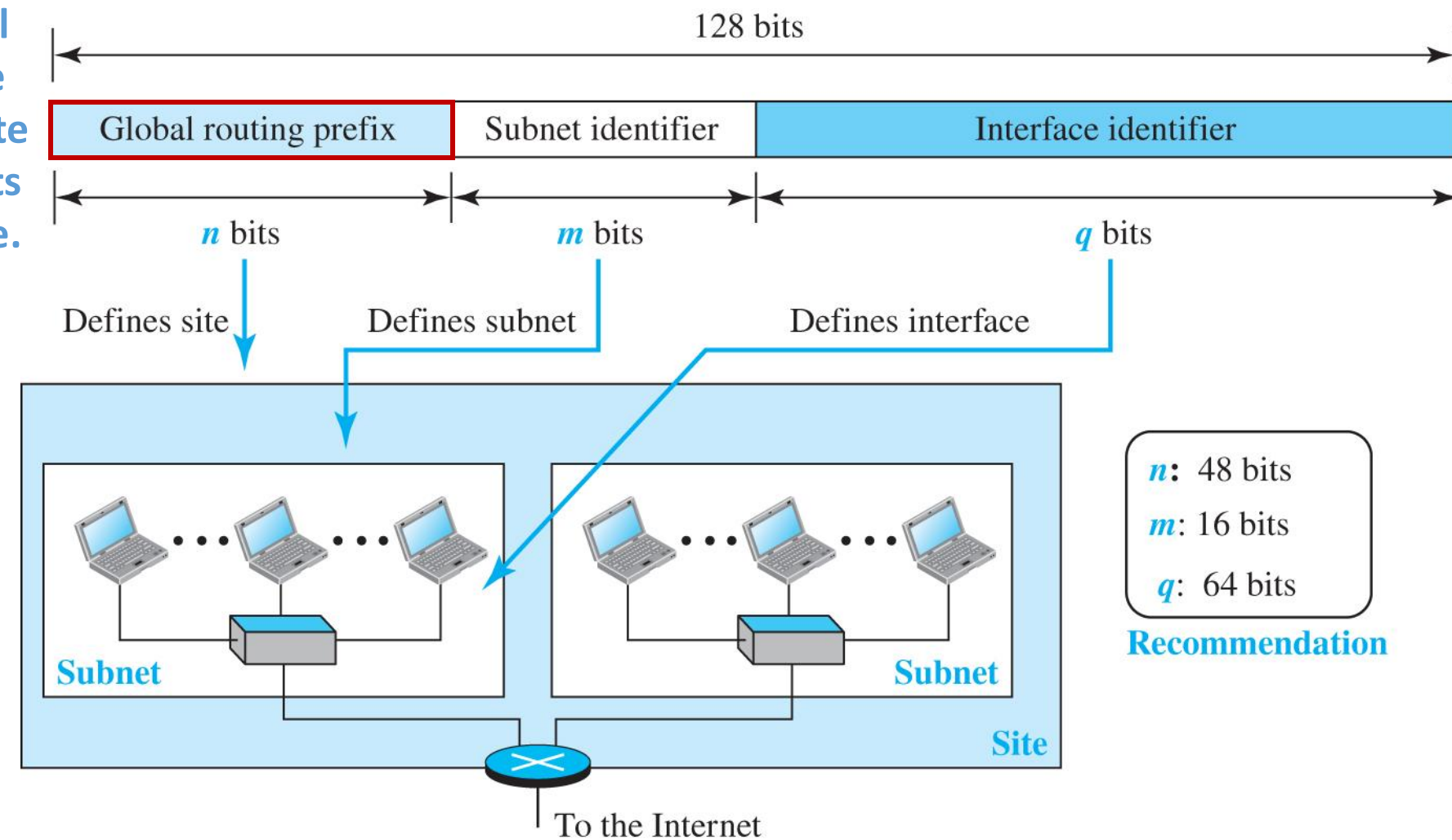   - 广播被视为多播的一种特殊情况。

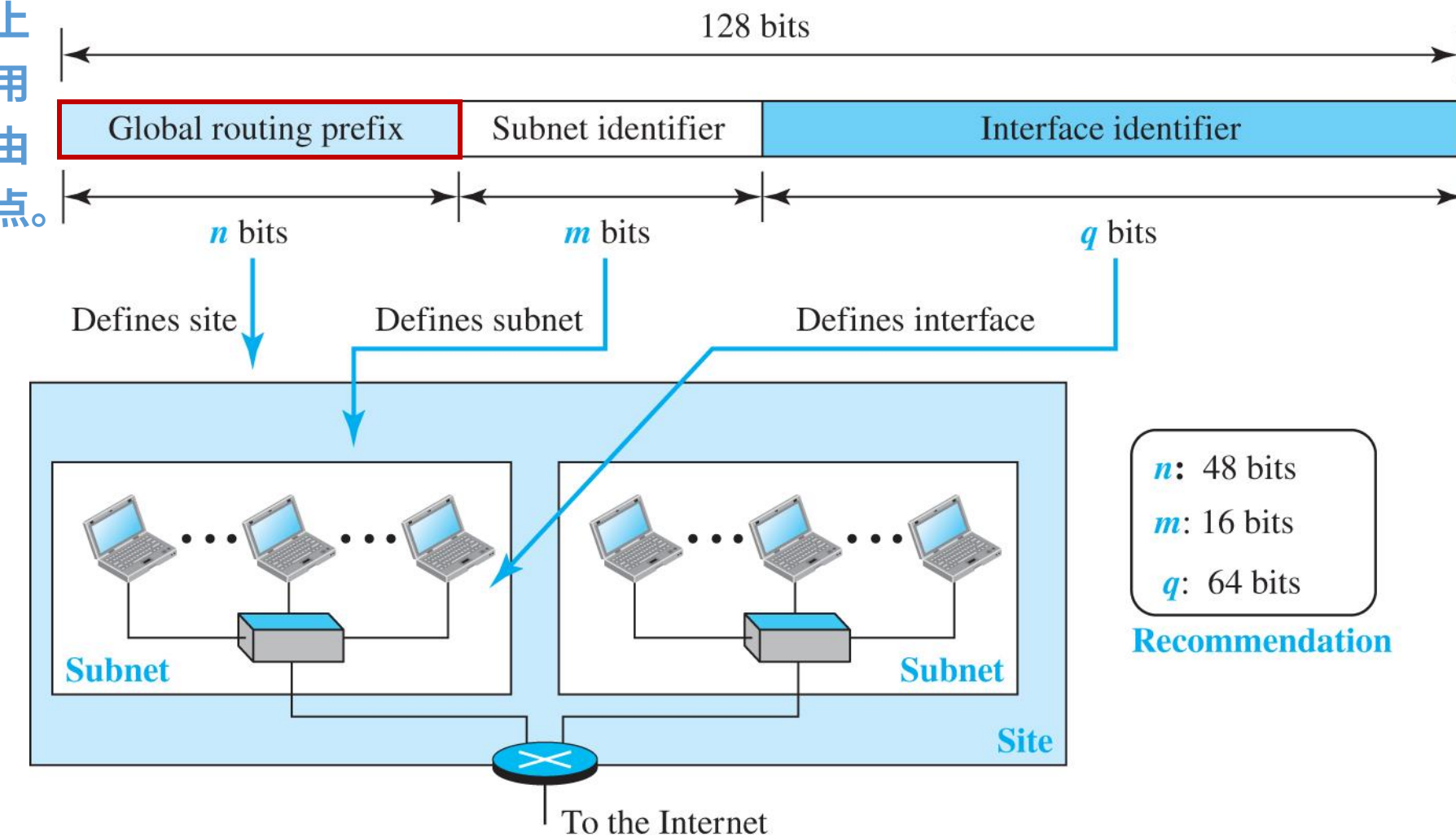# IPv6 Global Unicast Address

IPv6 全球单播地址

IPv6 Global Unicast Address

IPv6 全球单播地址

IPv6 Global Unicast Address

A subnet in an organization.

128 bits

| Global routing prefix | Subnet identifier | Interface identifier |

n bits — Defines site

m bits — Defines subnet

q bits — Defines interface

n: 48 bits
m: 16 bits
q: 64 bits
Recommendation

Subnet — Subnet — **Site**

To the Internet

IPv6 全球单播地址

组织中的一个子网。

128 bits

| Global routing prefix | Subnet identifier | Interface identifier |

n bits — Defines site

m bits — Defines subnet

q bits — Defines interface

n: 48 bits
m: 16 bits
q: 64 bits
Recommendation

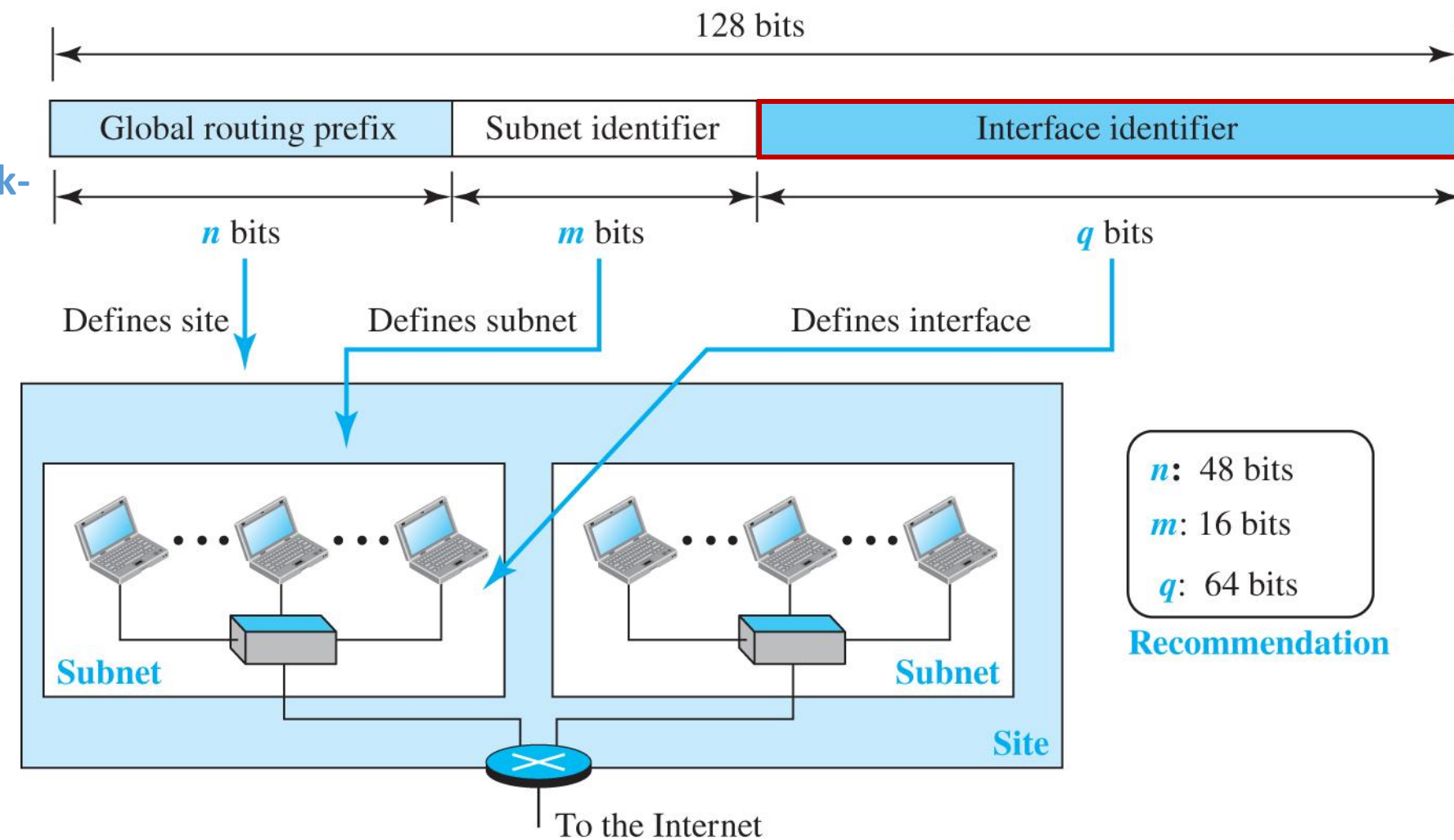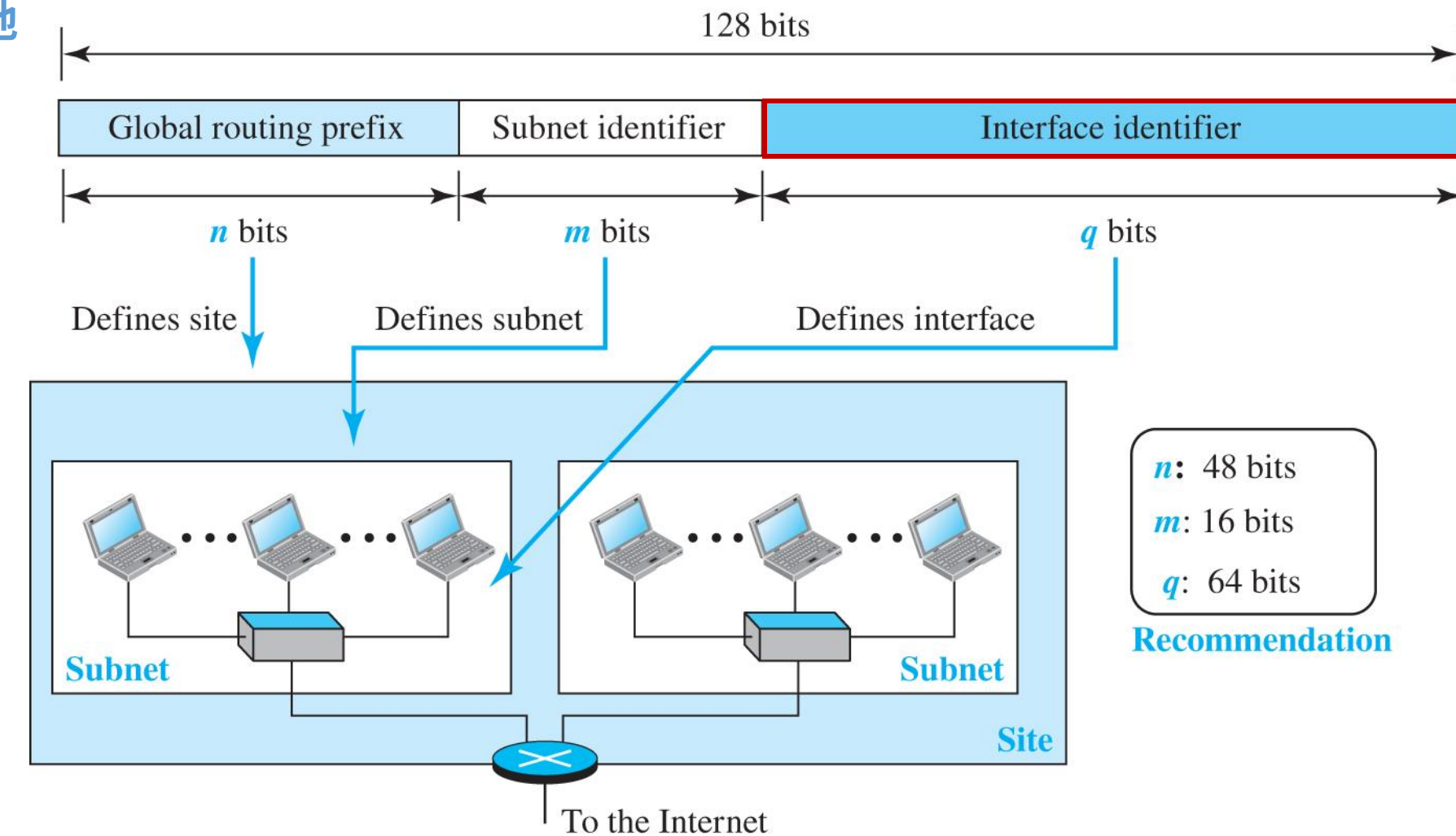Subnet — Subnet — **Site**

To the Internet

IPv6 Global Unicast Address

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

IPv6 全球单播地址

允许 IP 地址与链路层地址之间建立关联。
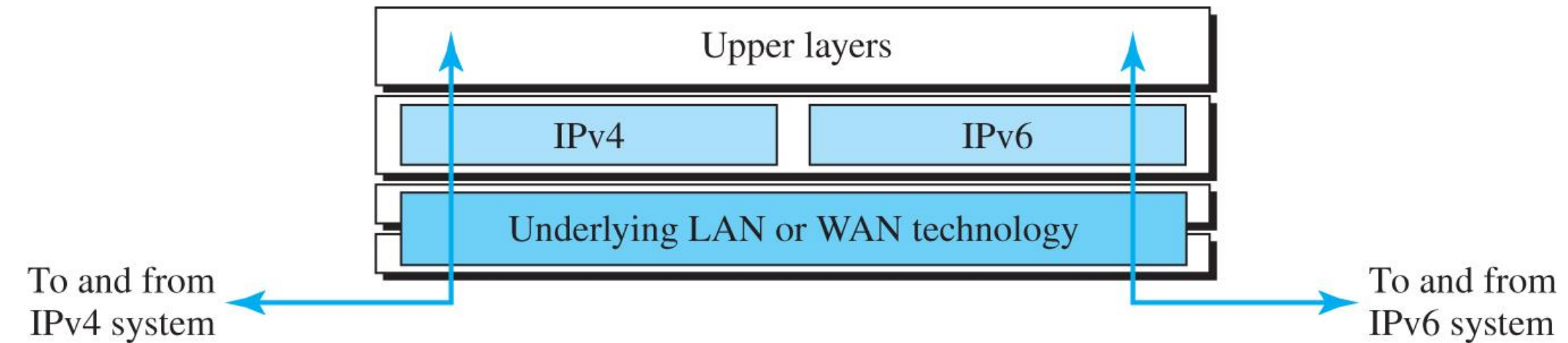
Transition to IPv6 – Strategies

- 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.

过渡到 IPv6 – 策略

- 由于互联网上的系统数量巨大，从 IPv4 过渡到 IPv6 无法突然发生。
- 三种过渡策略：
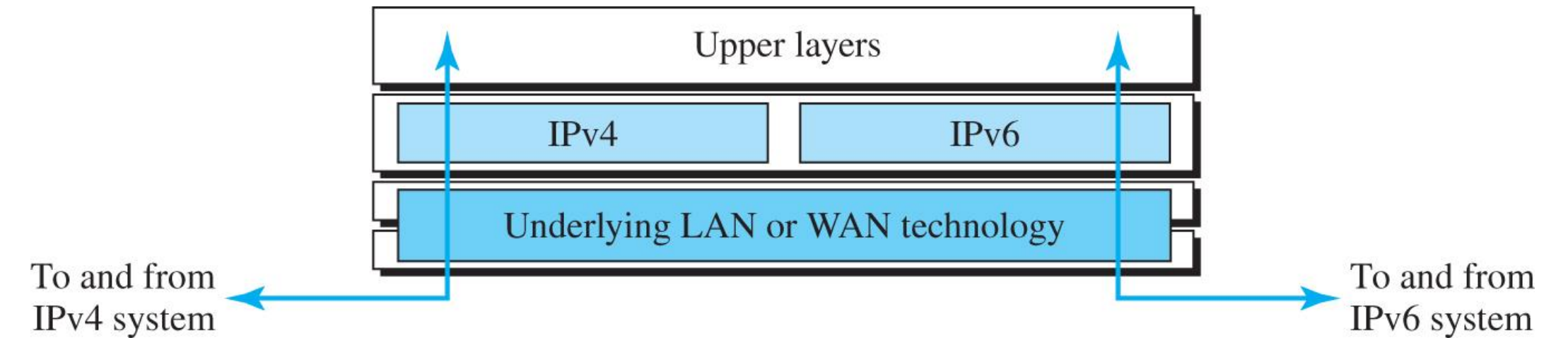 1. **双栈**
  2. **隧道技术**
  3. **报头转换**
- 在

  过渡期

Dual Stack

- A host must run IPv4 and IPv6 simultaneously until all the Internet uses IPv6.
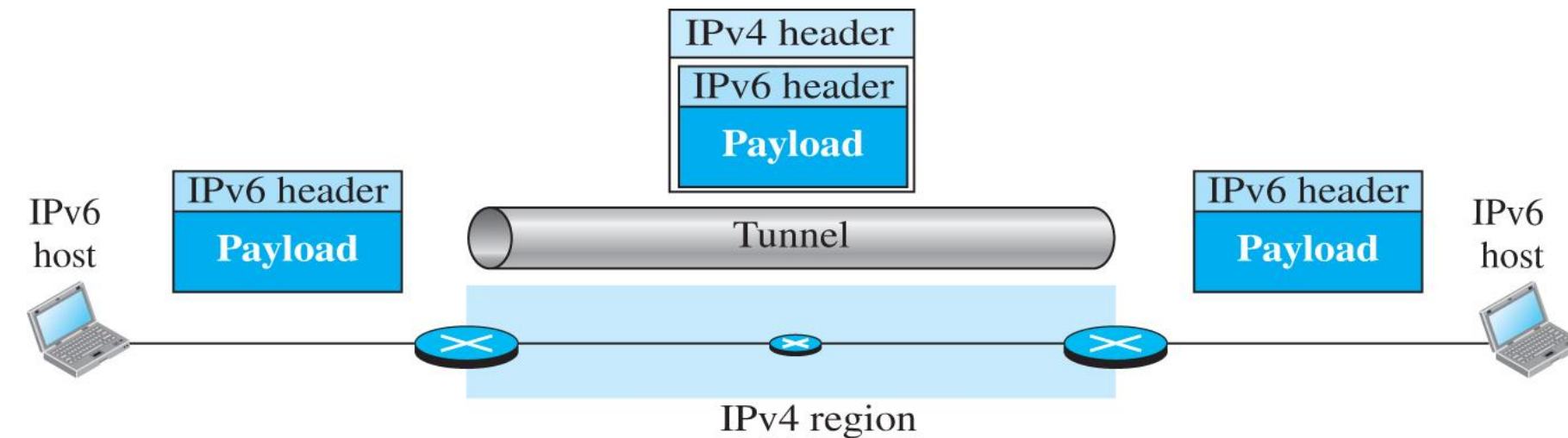 - How to indicate which version to use?

双栈

- 主机必须同时运行IPv4和IPv6，直到整个互联网使用IPv6为止。
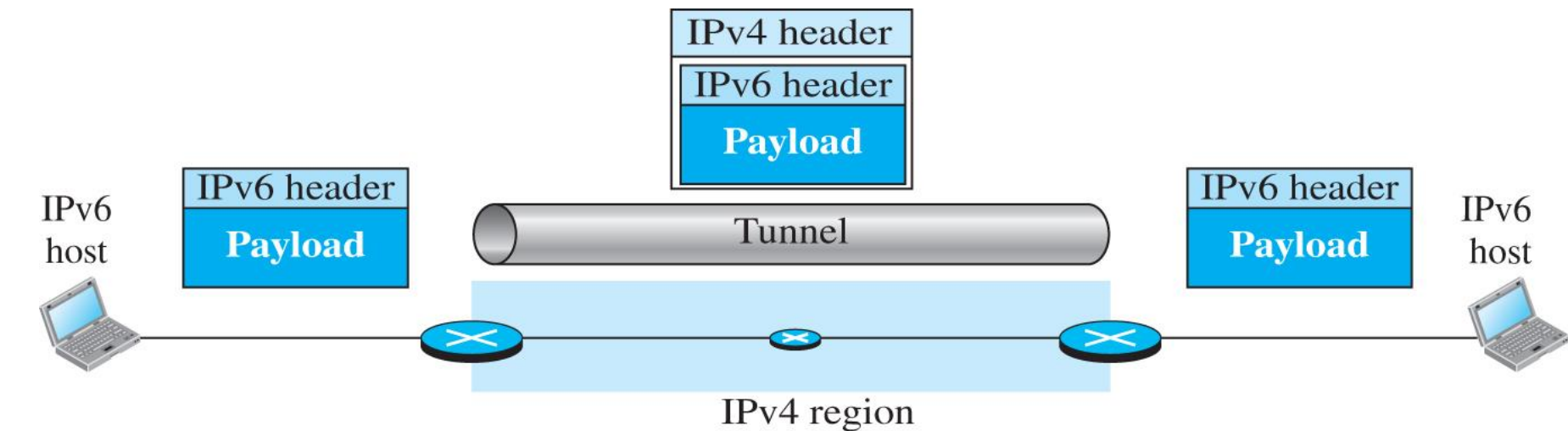 - 如何指明使用哪个版本?

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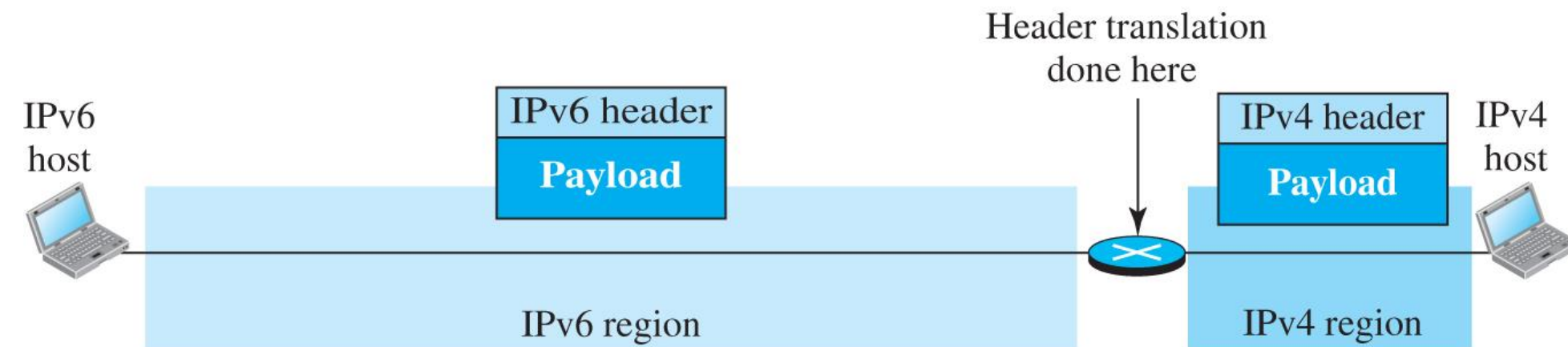- The value of protocol field in the header of IPv4 packet is set to 41.

隧道技术

- 当两台使用 IPv6 的计算机需要相互通信，且数据包必须经过一个使用 IPv4 的区域时，采用该技术。
- IPv6 数据包在进入该区域时被封装在 IPv4 数据包中，并在离开该区域时脱离封装。
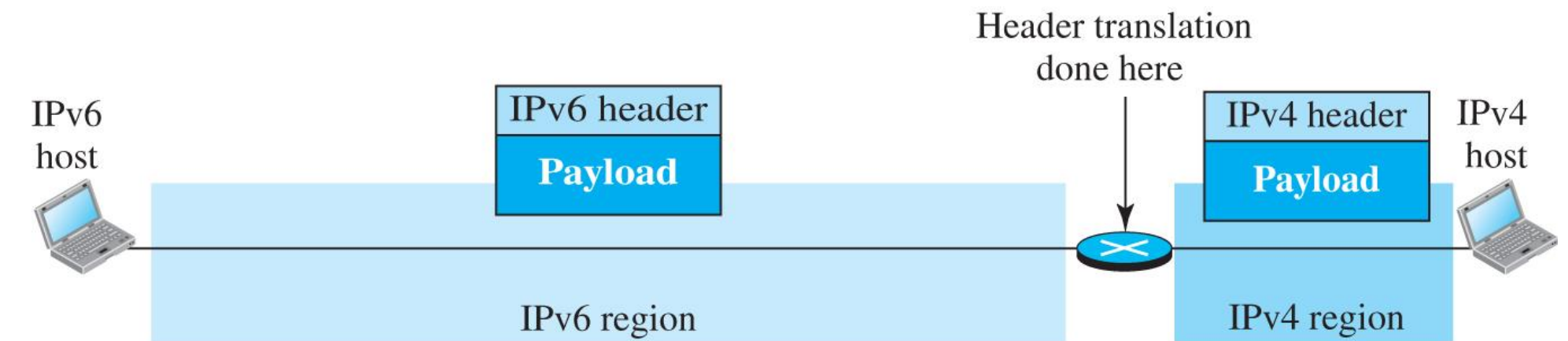- IPv4 数据包头部中的协议字段值设置为 41。

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.

报头转换

- 当大多数互联网已转向IPv6，但仍有一些系统使用IPv4时，这是必要的。
- 发送方希望使用IPv6，但接收方不支持IPv6。
- IPv6数据包的报头被转换为IPv4报头。

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**.

摘要

- **IPv6地址**作为解决**长期方案**的**IPv4地址耗尽问题**。

- 一个**IPv6全球单播地址**由三部分组成，分别表示**站点**、**子网**和一个**接口**。

- 三种向IPv6过渡的策略，包括**双栈**、**隧道技术**、以及**报头转换**。

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.

参考文献

[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)

阅读

- 教材第7章，7.4.2–7.4.4节
- 教材第7章，第7.8节（练习测试）