Chapter 17
Internetworking

Motivation: Universal Service

• The objective of chapter 12 was to design a large-scale wide area network technology
• However, we assumed a switch could copy the packet from one network to the other.
• This implies that all the links in a WAN must be of the same type (e.g., all point-to-point, all ethernet, all FDDI, ...).
• This may work for a WAN that connects a single large organization
• But, if we want to build a network that provides Universal Service, we must be able to handle heterogeneity.
Universal Service: (continued)

- Universal Service:

- Heterogeneity
Internetworking

- **Internetworking** is the concept of creating large-scale networks by connecting multiple networks of dissimilar (heterogeneous) technologies.

- **Terminology:**
  - An **internet** (little i):
  - An **internetwork**:
  - A **physical network**:

- Internetworking requires:
  1. **Hardware**: between physical networks to connect them
  2. **Software**: running on each attached computer to create the illusion of a single large network
So What’s New?

- Has the same scalability/routing/forwarding problems as homogeneous WANs
- New problem is heterogeneity.
- Must switch packets between heterogeneous networks
- Why is that hard?
**Routers**

- Internets use *routers* to connect heterogeneous physical networks together.
- Have also been called gateways, IMPs, PSNs, Fuzzballs, ...
- *Routers* differ from *switches* in the fact that the networks they connect need not be the same.
Figure 1: Switches vs. Routers
**Routers: (continued)**

- A router is a hardware component (to handle the physical/data link layer protocols) and hardware/software to handle the networking layer protocols.
- Routers must somehow transform an incoming packet into the appropriate outgoing packet.
- An internetwork is composed of arbitrarily many physical networks interconnected by routers.

![Multiple Physical Networks connected by Routers](image)

*Figure 2: Multiple Physical Networks connected by Routers*
**Routers: (continued)**

- Routers can have more than two interfaces

![Diagram of a router with multiple interfaces](image)

*Figure 3: Router with multiple interfaces*
Virtual Networks

- Internetworking software builds a single, seamless virtual network out of multiple physical networks
  - Universal addressing scheme
  - Universal service
- All details of physical networks hidden from users and application programs
Methods of Internetworking

- There are many ways to build internets
- Possible ways include the IPX protocol by Novel, the XNS protocol by Xerox, and the IP protocol by ARPA
- IP is by far the most widely used
- IP is vendor and platform independent
- Used in the Internet (big I)
IP Protocol Objectives

1. Connect physical networks of every possible type (even future network technologies not yet developed)

2. Scale to a WAN connecting many hosts
   - How many is “many”?

- To succeed, IP had to make minimal assumptions about the physical networks it connects
Physical Network Assumptions

- IP makes the following assumptions about the physical network technology

- What if the network does not provide this?
The IP Service Model

• Provides a Global Addressing Scheme

• Provides “best effort”, connectionless, variable-length, datagram delivery
The IP Service Model: (continued)

• Advantages of the Model

• Disadvantages of the Model