

# The TCP/IP Data Communications Protocol

Brian S. Mitchell

Drexel University

# Agenda

- ◆ Historical Perspective on TCP/IP
- ◆ Data Communications Primer
- ◆ IP Network Model and Devices
- ◆ IP Addressing
- ◆ TCP Stream Transport Services
- ◆ Internet Naming Hierarchy
- ◆ Domain Name Server (DNS)
- ◆ Subnetting
- ◆ Dynamic Host Configuration with DHCP

# Historical Perspective on TCP/IP

- ◆ TCP/IP was developed in the mid 1970's by the Department of Defense to interconnect their private networks
- ◆ Universities and research facilities quickly adopted TCP/IP so that researchers and professors could collaborate
  - ◆ TCP/IP proved to be a viable protocol for connecting sparse networks
- ◆ Commercial adoption of TCP/IP began in the late 1980's to early 1990's when corporations started to connect their private networks (WAN)
  - ◆ Based on the proven strength of TCP/IP to interconnect remote private networks

# Data Communications Primer



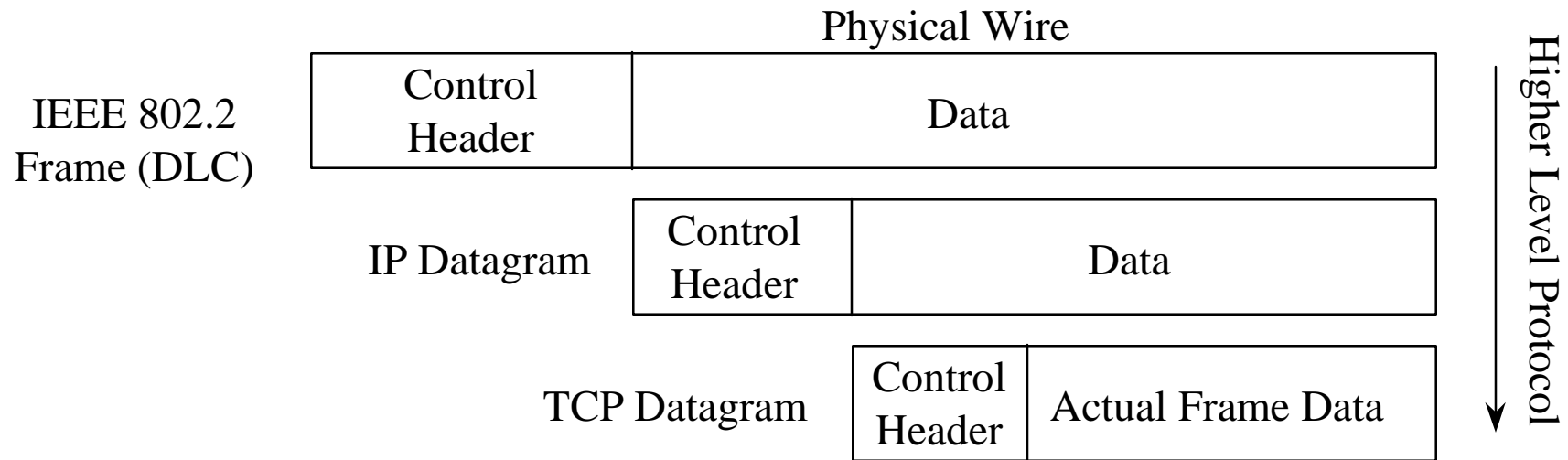
## ◆ Connection Oriented Architectures

- ◆ Works like phone system (setup, data transfer, termination)
- ◆ ATM

## ◆ Connectionless Architectures

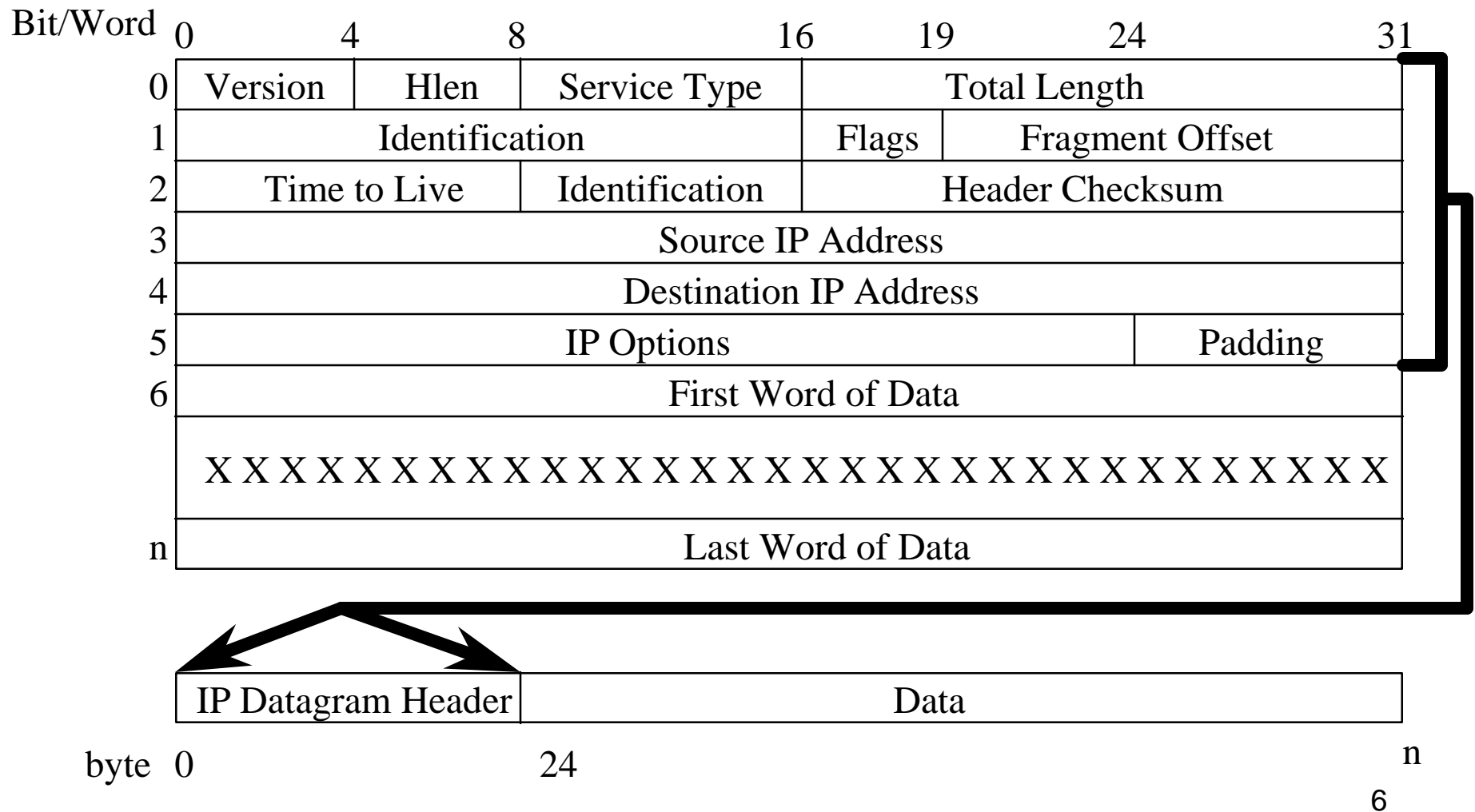
- ◆ Conversation broken up into a sequence of frames
- ◆ Each packet contains control information and data
  - ◆ Control block (header)
    - ◆ Source and destination addresses
    - ◆ CRC checksum
    - ◆ Data Length
  - ◆ Data block contains the actual frames data
    - ◆ Can be variable or fixed length

# Data Communication Primer (con't)

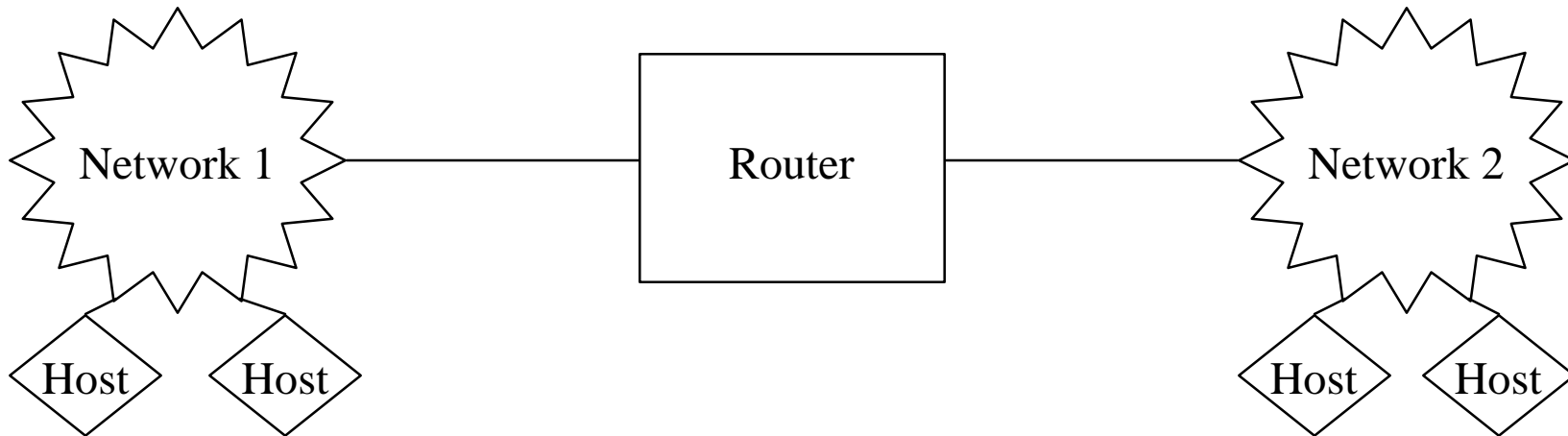


- ◆ Frames can be layered
  - ◆ Maximum flexibility
  - ◆ Plug and play of encapsulated protocols
- ◆ Layered Architecture enables multiple protocols to flow over the same wire
  - ◆ SNA, NetBIOS, SPX/IPX, TCP/IP, UDP/IP

# IP Datagram Format



# IP Network Model

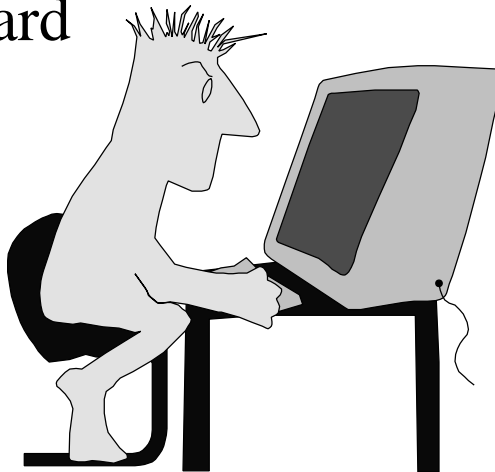


IP Networks contain

- ◆ Networks (a collection of hosts)
- ◆ Hosts (actual user stations and servers)
- ◆ Routers (used to move frames between networks)
  - ◆ Routers copy (route) packets based on destination network, **NOT** destination host

# IP Addressing

- ◆ IP Address is a 32 bit binary value
- ◆ **IP Addresses encode both a network identifier and a host on the network**
  - ◆ Routers extract the network ID from the IP address in order to make routing decisions
  - ◆ IP specification defines five addressing classes (A, B, C, D, E)
- ◆ IP is an open standard



# IP Address Classes

		0	1	2	3	4	5	6	7	8		15	16		23	24		31				
Class	A	0 [Network ID ]							[Host ID ]													
	B	1 0 [Network ID			]											[Host ID ]						
	C	1 1 0 [Network ID					]											[ Host ID ]				
	D	1 1 1 0 [Multicast Address							]													
	E	1 1 1 1 0 [Reserved							]													

		Network #Bits/Number	Hosts #Bits/Number
Class	A	7 -256	24 - 16,777,216
	B	14 - 16,384	16 - 65,536
	C	21 -2,097,152	7 - 256
	D	N/A	N/A
	E	N/A	N/A

# IP Dotted Decimal Notation

W. X. Y. Z  
octet 0    octet 1    octet 2    octet 3

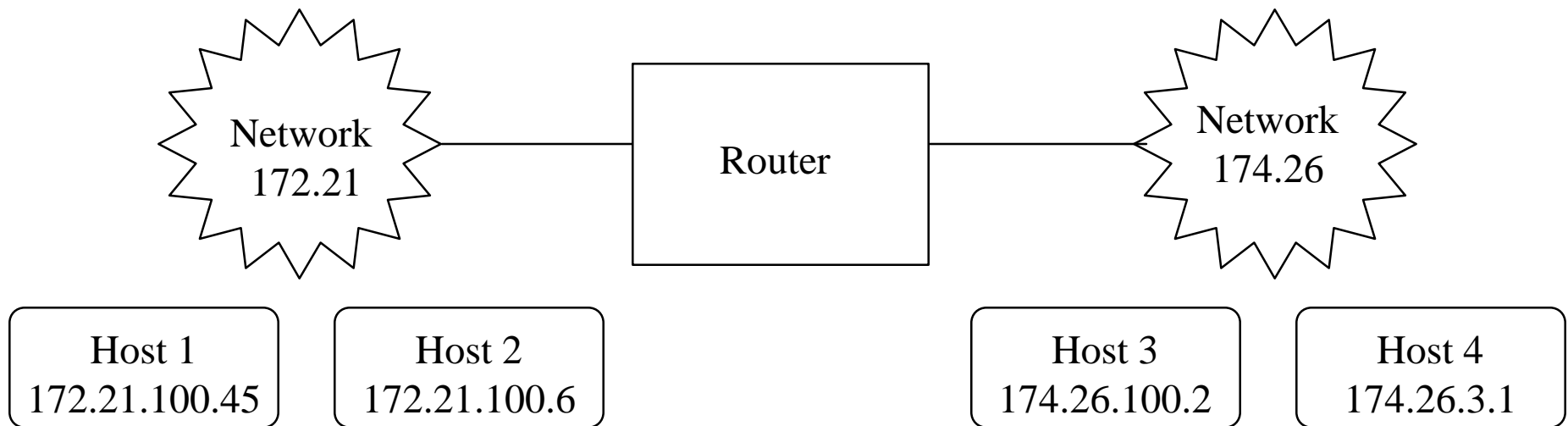
- ◆ Representation of an IP address in a form that humans can deal with
- ◆ Each octet consists of a decimal value ranging from 0 to 255
- ◆ All four octet's are used to represent the actual 32 bit IP address

# IP Dotted Decimal Notation

172.21.100.45

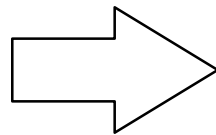
- ◆ The 32 bit network address can be represented in the following formats:
  - ◆ Binary: 10101100 0001010 01100100 00101101
  - ◆ Hex: AC 15 64 28
  - ◆ Decimal: 2887083048
  - ◆ Dotted Decimal: 172.21.100.45

# IP Addressing Example 1



*Send message from 172.21.100.45 to 172.21.100.6*

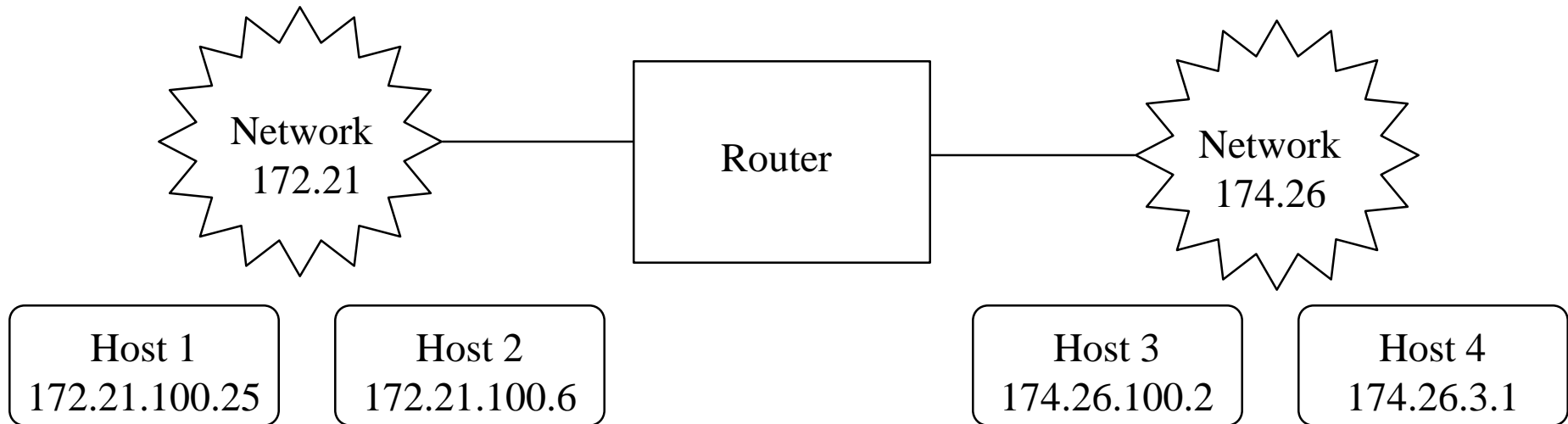
Sender  
172.21.100.45  
10101100.21.100.45  
10[101100.21].[100.45]  
Class B [44.21].[100.45]  
Net ID = 44.21  
Host ID = 100.45



Receiver  
172.21.100.6  
10101100.21.100.6  
10[101100.21].[100.6]  
Class B [44.21].[100.6]  
Net ID = 44.21  
Host ID = 100.6

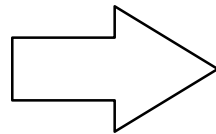
Conclusion  
**Router does not copy  
packet from network  
172.21 to network 174.26**

# IP Addressing Example 2



*Send message from 172.21.100.6 to 174.26.3.1*

Sender  
172.21.100.6  
10101100.21.100.6  
10[101100.21].[100.6]  
Class B [44.21].[100.6]  
Net ID = 44.21  
Host ID = 100.6



Receiver  
174.26.3.1  
10101110.26.3.1  
10[101110.26].[3.1]  
Class B [46.26].[3.1]  
Net ID = 46.26  
Host ID = 3.1

Conclusion  
**Router recognizes that it  
need to copy packet from  
network 172.21 to  
network 174.26**

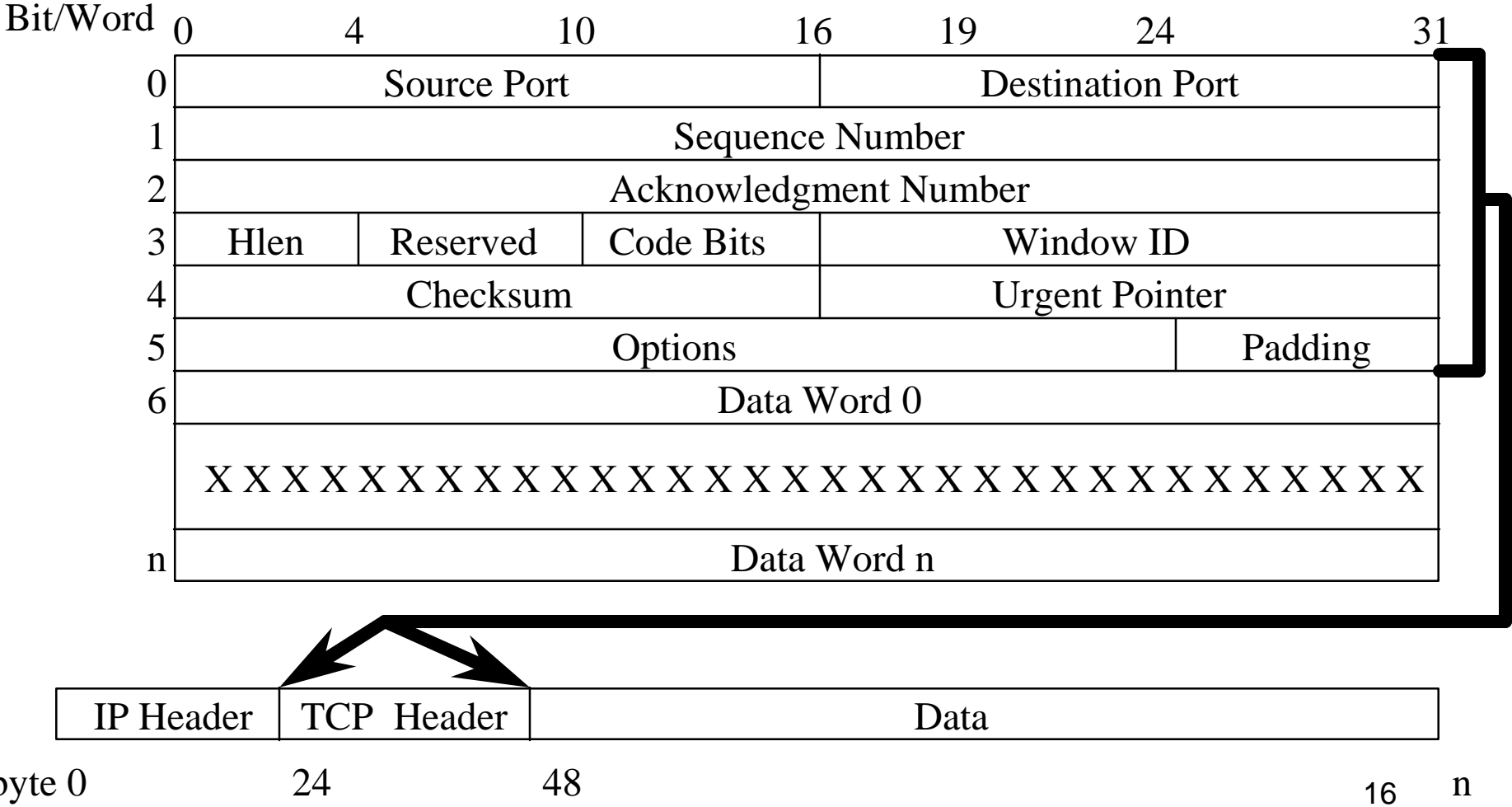
# IP is not Enough

- ◆ IP is a datagram delivery protocol
  - ◆ Delivery of packet from source to destination not guaranteed
    - ◆ Congestion will result in lost packets
  - ◆ Packets might arrive out of order
- ◆ Because IP is not reliable another protocol must be layered on top of it
- ◆ TCP was designed to sit on top of IP to make it a reliable stream delivery protocol
- ◆ TCP datagram is encapsulated inside the data area of the IP datagram

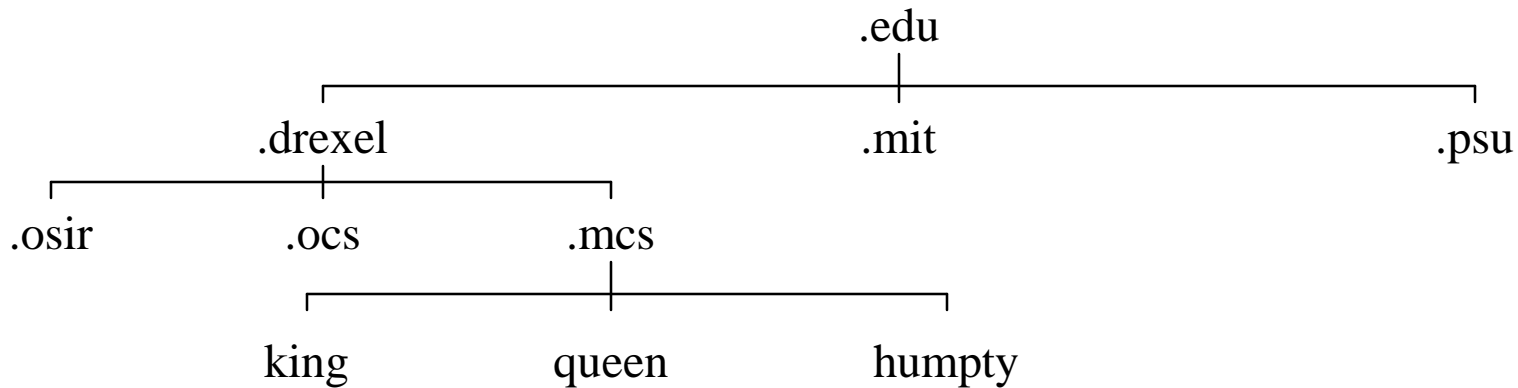
# TCP - The Reliable Stream Transport Service

- ◆ TCP makes IP reliable
  - ◆ Guaranteed delivery of messages (not packets)
    - ◆ Lost packets are retransmitted
    - ◆ “Old” packets are killed
  - ◆ Packets are always delivered in order
  - ◆ Reliability ensured by using acknowledgments on all messages
    - ◆ Slows down overall throughput
- ◆ TCP is not a complete protocol
  - ◆ Needs IP to identify the sending and receiving workstations
- ◆ TCP works with messages as its basic transport unit
  - ◆ IP transport unit is a frame
  - ◆ Higher level view of networking data

# TCP Datagram Format

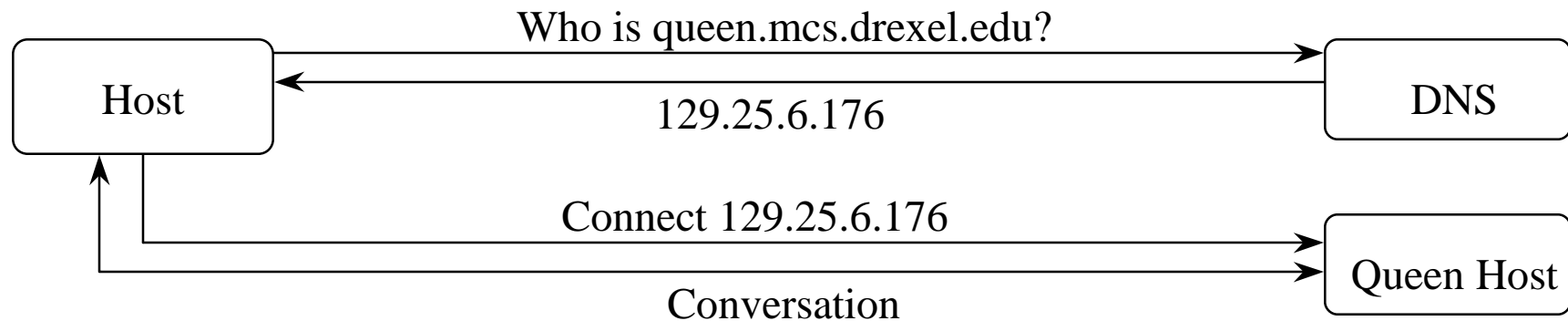


# The Internet Naming Hierarchy



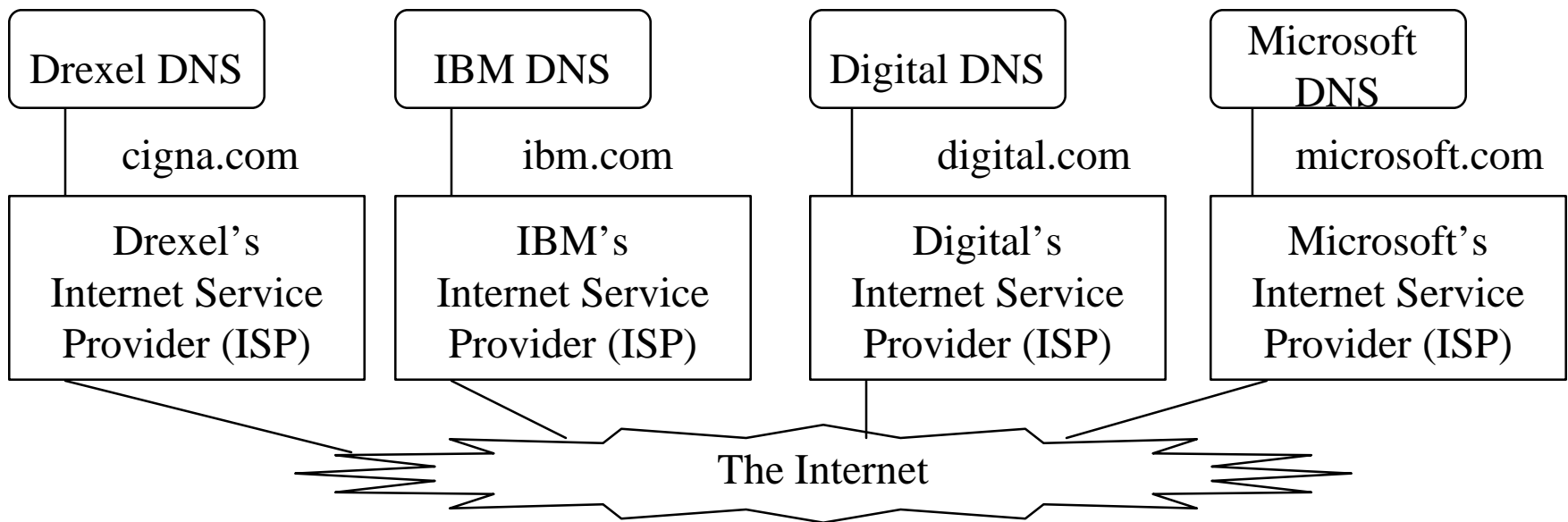
- ◆ Using a hierarchy makes remembering names easier
- ◆ The “queen” server is known as 129.25.6.176 or aliased by queen.mcs.drexel.edu

# Domain Name Server (DNS)



- ◆ The domain name server maps “english-like” hierarchical names to IP addresses
- ◆ Names must be registered with the DNS by placing an entry in the DNS database

# Overall DNS Architecture



- ◆ A DNS is responsible for resolving all names that fall below its hierarchical assigned key
  - ◆ king.mcs.drexel.edu is resolved by Drexel's DNS
  - ◆ home.digital.com is resolved by Digital's DNS
  - ◆ www.microsoft.com is resolved by Microsoft's DNS

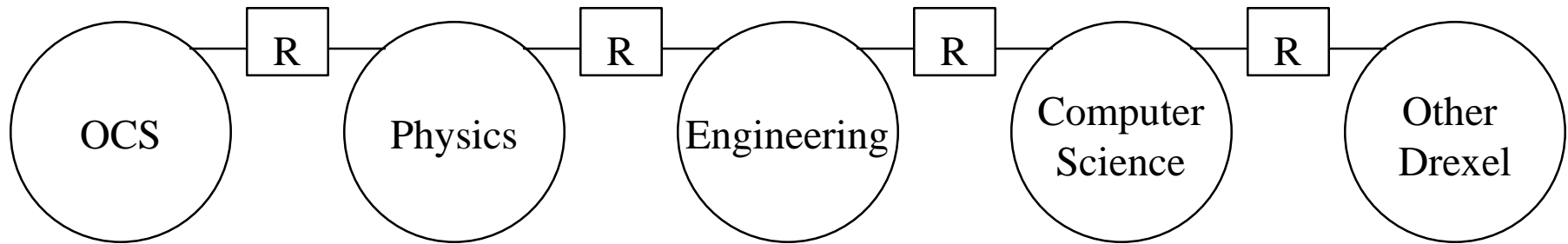
# Checking Connectivity and DNS Name Resolution

- ◆ The ping utility
  - ◆ Command line: “ping host-name”
    - ◆ Host-name can be an IP address or a registered name resolved by the DNS
  - ◆ Examples
    - ◆ ping 129.25.6.176
    - ◆ ping humpty.mcs.drexel.edu
    - ◆ ping mit.edu

# Internet Addressing Dilemma

- ◆ Everybody connecting to the recognized internet must use an assigned IP address in order to prevent conflicts
- ◆ drexel.edu is assigned two class B address
  - ◆ [129.25].x.y (New Internet2 Network)
  - ◆ [144.118].x.y
- ◆ Drexel must stick to the 129.25 and 144.118 prefixes
  - ◆ Allowed to assign remainder of addresses without restriction
- ◆ Limits the assignable addresses to 65536 hosts for each class B IP address

# Internet Addressing Dilemma (con't)



- ◆ As was stated earlier, the real power of IP is its encapsulation of the network and the host ID fields in the IP address
- ◆ Problems arise with the internet because the network ID is assigned
  - ◆ How are the Drexel routers going to make decisions if the network ID's are fixed?
- ◆ The answer lies in “subnetting”
- ◆ Because all registered Internet TCP/IP addresses are on one logical network, we need subnets to create logical networks within the TCP/IP Internet

# Subnetting

IP Address: 172.21.100.45

Subnet Mask: 255.255.255.0

- ◆ Subnetting enables the user to define the network ID and the host ID inside the original host ID field of the IP address
- ◆ This “second” network ID field is referred to as the subnetwork ID
- ◆ With this architecture, the “real” network ID field is not used to make routing decisions; instead the routers use the subnetwork ID

# Analysis of the Subnetwork Mask

- ◆ IP Address
  - ◆ 172.21.100.45 = 10101100 00010101 01100100 00101101
- ◆ Subnetwork Mask
  - ◆ 255.255.255.0 = 11111111 11111111 11111111 00000000
- ◆ The first two bits in 172.21.100.45 are “10” which defines the IP address as a class B address
- ◆ The subnetwork ID can be derived by bitwise anding the remainder of the IP address (100.45) with the corresponding bits in the subnetwork mask

$$\begin{array}{r} 100.45 = 01100100 \bigg| 001001101 \\ 255.0 = \underline{11111111} \bigg| \underline{000000000} \end{array}$$

Subnetwork ID      Adjusted Host ID

# Subnetwork Mask Example

- ◆ Determine the network ID, subnetwork ID, and host ID given
  - ◆ IP Address
    - ◆ 172.21.37.45 = 10101100 00010101 00100101 00101101
  - ◆ Subnetwork Mask
    - ◆ 255.255.240.0 = 11111111 11111111 11110000 00000000
- ◆ This is a class B address- “10” are the first two bits in 172.21.37.45
  - ◆ 172.21 is the network ID
- ◆ Bitwise compare remainder of address

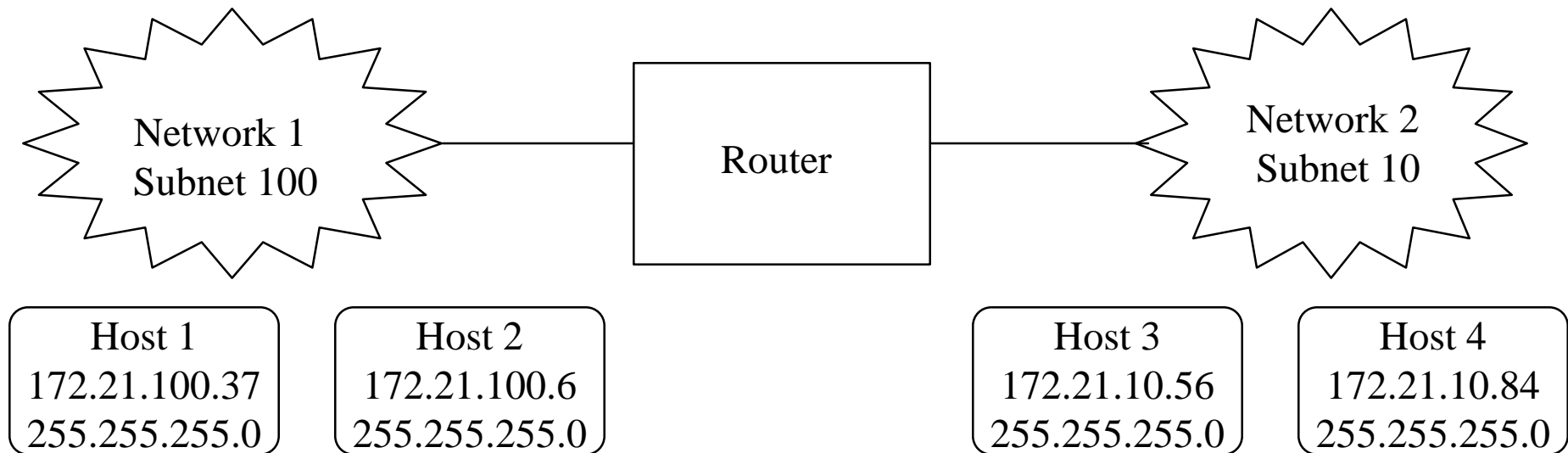
0010	0101 00101101
1111	0000 00000000

Subnetwork ID	Host ID
------------------	------------

Subnetwork ID = 0010 = 2; Host ID = 010100101101 = 52D = 1325    25

# Routing with Subnetworks

## Example



- ◆ Send a message from 172.21.100.37 to 172.21.10.56 using the appropriate subnet masks
  - ◆ Both are class B addresses, so the router cannot make a decision based on the network ID (172.21)
  - ◆ Using the subnetwork ID, the router determines that host1 is on the Network1 subnet and host3 is on the Network2 subnetwork
  - ◆ Router copies packets from Network1 to Network2 network based on the subnetwork ID

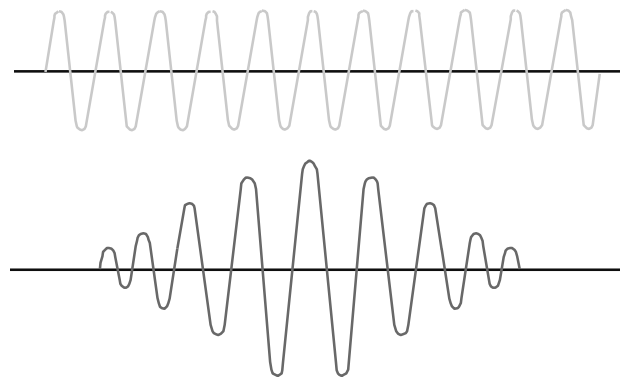
# Requirements for Setting Up IP on a Workstation

- ◆ IP Address
- ◆ Subnetwork Mask
- ◆ Gateway (router) IP address
- ◆ Domain name server (DNS) IP address

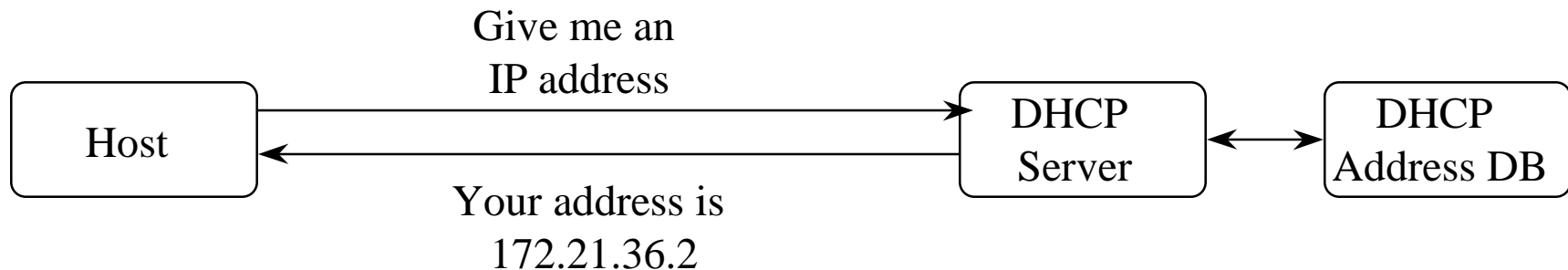


# Managing IP Address Assignments

- ◆ Complex management task on a large network
- ◆ Physically moving a machine might result in a change in its network and/or subnetwork ID
  - ◆ IP addresses must change or router will not be able to locate the machine
- ◆ Management of IP address assignments is simplified if address are dynamically assigned when the machine first connects to the network



# Dynamic Host Configuration Protocol (DHCP)



- ◆ DHCP server is used to dynamically assign an IP address to a host when the host first connects to the network
  - ◆ Host broadcasts a special message
  - ◆ DHCP server intercepts the broadcast and replies to the sender with an authentic IP address, and a lease on the address
  - ◆ Host uses the supplied address for the duration of its lease
- ◆ With DHCP, a host will attempt to renew its lease on its currently held address once the lease expires
- ◆ Can not count on a host having the same address forever with DHCP

# DHCP (con't)

- ◆ LAN clients can use DHCP supplied addresses because they are users of LAN services
- ◆ LAN-based servers will use static IP addresses because their locations must be known by all LAN clients

