

## **PART VII**

# **INTERNET PROTOCOL: FORWARDING IP DATAGRAMS**

# Datagram Transmission

- Host delivers datagrams to directly connected machines
- Host sends datagrams that cannot be delivered directly to router
- Routers forward datagrams to other routers
- Final router delivers datagram directly

# Question

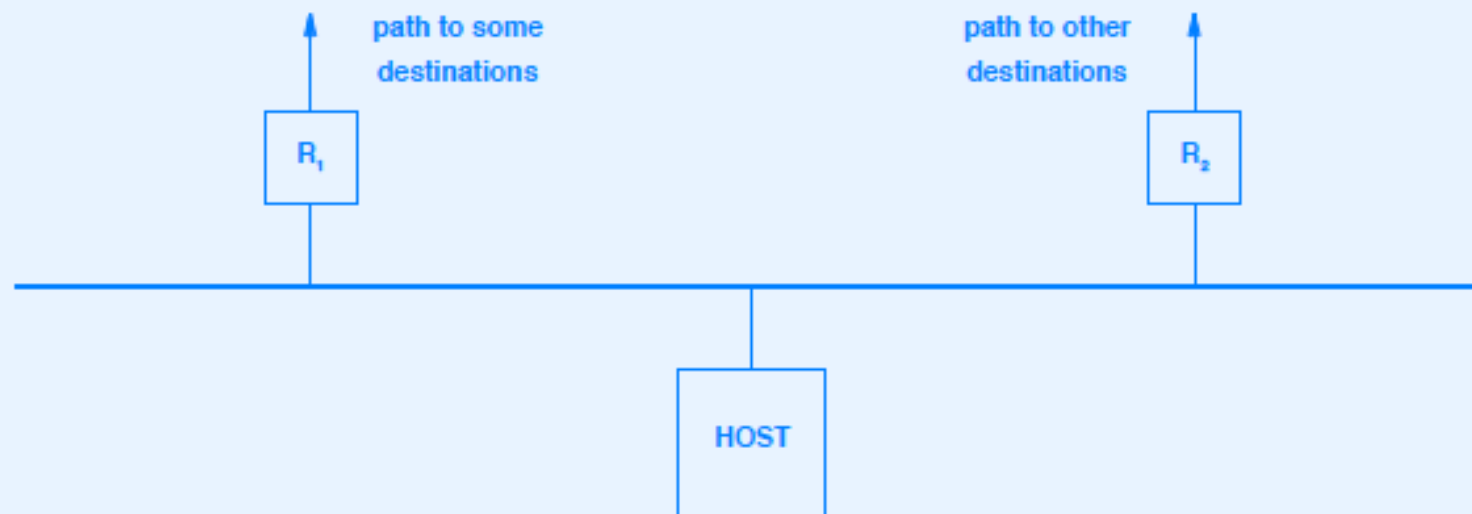
Does a host need to make forwarding choices?

## Question

Does a host need to make forwarding choices?

Answer: YES!

# Example Host That Must Choose How To Forward Datagrams



- Note: host is singly homed!

## Two Broad Cases

- Direct delivery
  - Ultimate destination can be reached over one network
  - The “last hop” along a path
  - Also occurs when two communicating hosts both attach to the same physical network
- Indirect delivery
  - Requires intermediary (router)

## Important Design Decision

*Transmission of an IP datagram between two machines on a single physical network does not involve routers. The sender encapsulates the datagram in a physical frame, binds the destination IP address to a physical hardware address, and sends the resulting frame directly to the destination.*

## **Testing Whether A Destination Lies On The Same Physical Network As The Sender**

*Because the Internet addresses of all machines on a single network include a common network prefix and extracting that prefix requires only a few machine instructions, testing whether a machine can be reached directly is extremely efficient.*



# Datagram Forwarding

- General paradigm
  - Source host sends to first router
  - Each router passes datagram to next router
  - Last router along path delivers datagram to destination host
- Only works if routers cooperate

## General Concept

*Routers in a TCP/IP Internet form a cooperative, interconnected structure. Datagrams pass from router to router until they reach a router that can deliver the datagram directly.*

# Efficient Forwarding

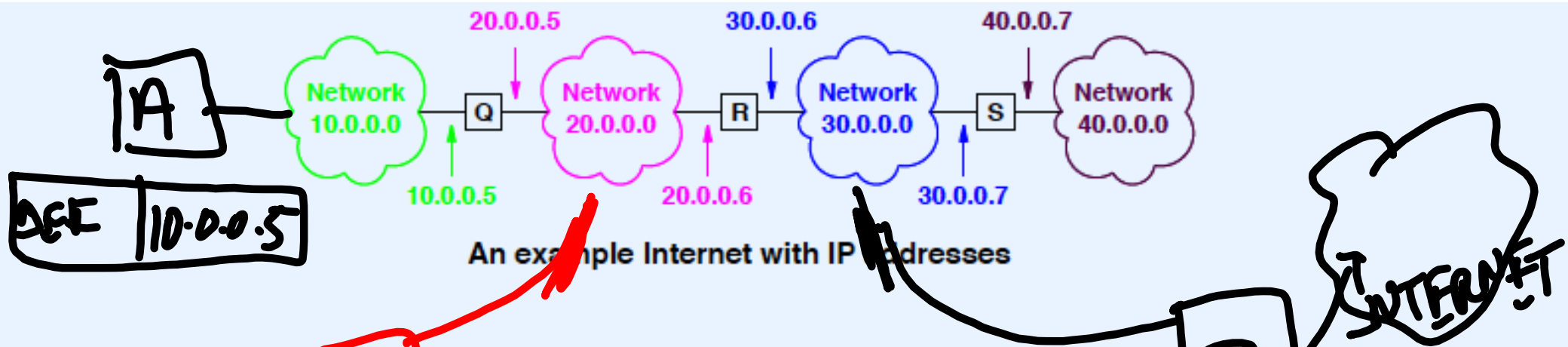
- Decisions based on table lookup
- Routing tables keep only network portion of addresses (size proportional to number of networks, not number of hosts)
- Extremely efficient
  - Lookup
  - Route update

## Important Idea

- Table used to decide how to send datagram known as *routing table* (also called a *forwarding table*)
- Routing table only stores address of next router along the path
- Scheme is known as *next-hop forwarding* or *next-hop routing*

# Terminology

- Originally
  - *Routing* used to refer to passing datagram from router to router
- More recently
  - Purists decided to use *forwarding* to refer to the process of looking up a route and sending a datagram
- But...
  - Table is usually called a *routing table*



Q

10.0.0.0	DIRECT
20.0.0.0	DIRECT
30.0.0.0	20.0.0.6
40.0.0.0	20.0.0.6
DEF	20.0.0.6
<del>20.0.0.1</del>	<del>20.0.0.6</del>

R

TO REACH NETWORK	ROUTE TO THIS ADDRESS
20.0.0.0	DELIVER DIRECT
30.0.0.0	DELIVER DIRECT
10.0.0.0	20.0.0.5
40.0.0.0	30.0.0.7

The routing table for router R

DEFAULT	30.0.0.1
20.0.0.1	DIRECT

S

10.0.0.0	30.0.0.6
20.0.0.0	30.0.0.6
30.0.0.0	DIRECT
40.0.0.0	DIRECT
DEFAULT	30.0.0.1
<del>20.0.0.1</del>	<del>30.0.0.6</del>

## Special Cases

- Default route
- Host-specific route

## Default Route

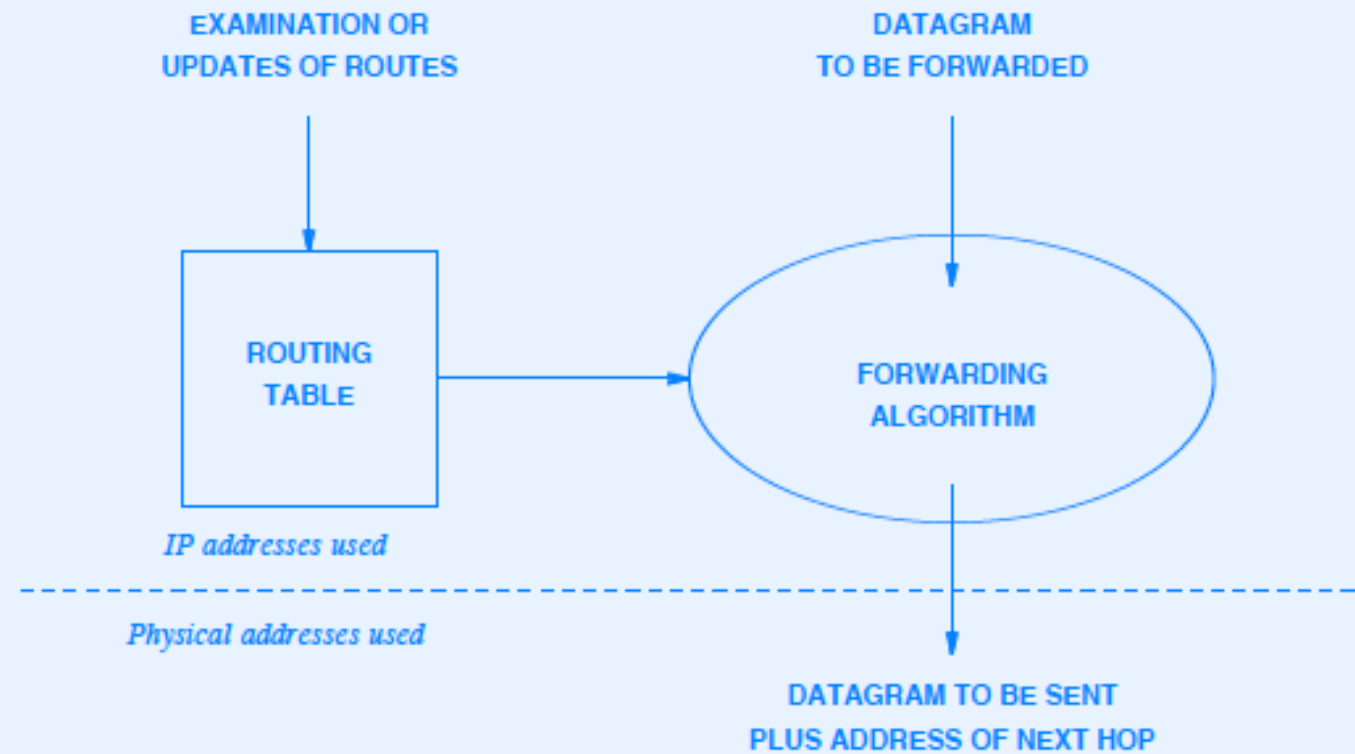
- Special entry in IP routing table
- Matches “any” destination address
- Only one default permitted
- Only selected if no other match in table



## Host-Specific Route

- Entry in routing table
- Matches entire 32-bit value
- Can be used to send traffic for a specific host along a specific path (i.e., can differ from the network route)
- More later in the course

# Level Of Forwarding Algorithm



- Routing table uses IP addresses, not physical addresses

## Summary

- IP uses routing table to forward datagrams
- Routing table
  - Stores pairs of network prefix and next hop
  - Can contain host-specific routes and a default route

