

**PART VII**

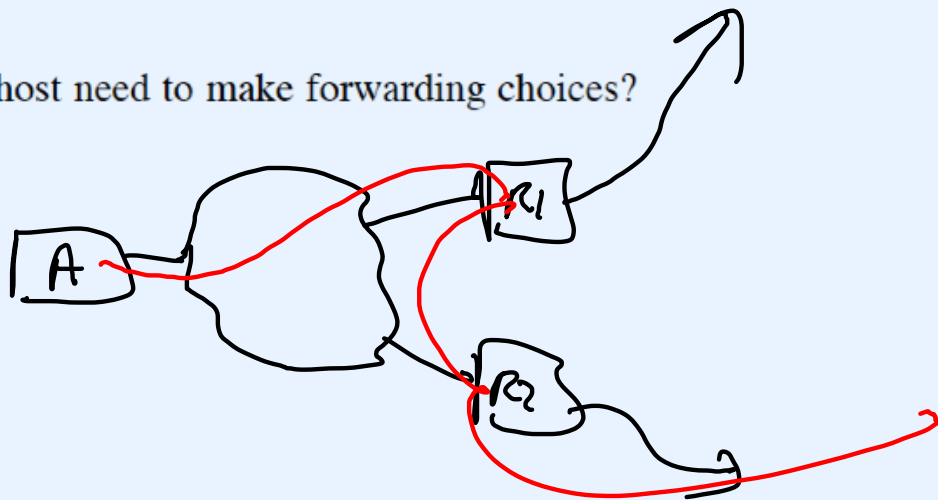
**INTERNET PROTOCOL:  
FORWARDING IP DATAGRAMS**

## **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?

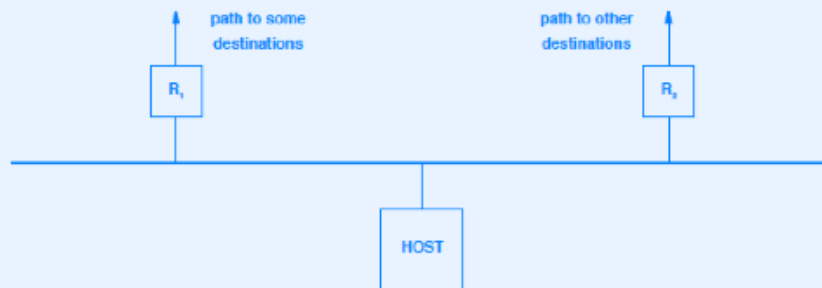


## **Question**

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

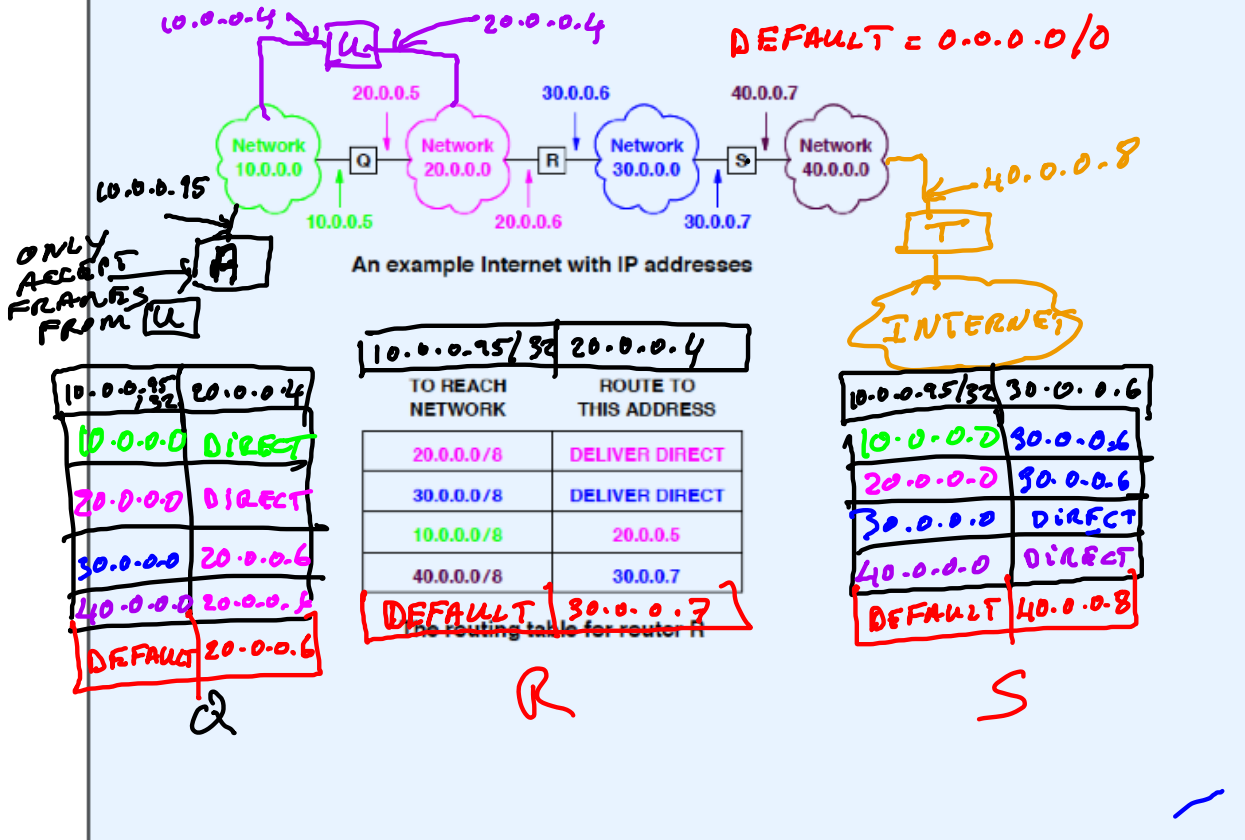
## Important Idea

- 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*

# Conceptual Contents Of Routing Table Found In An IP Router



10.0.0.0/8	20.0.0.4
10.0.0.0	DIRECT
20.0.0.0	DIRECT
30.0.0.0	20.0.0.6
40.0.0.0	20.0.0.8
DEFAULT	20.0.0.6

10.0.0.0/8	20.0.0.4
TO REACH NETWORK	ROUTE TO THIS ADDRESS
20.0.0.0/8	DELIVER DIRECT
30.0.0.0/8	DELIVER DIRECT
10.0.0.0/8	20.0.0.5
40.0.0.0/8	30.0.0.7
DEFAULT	30.0.0.7

The routing table for router R

10.0.0.0/8	30.0.0.6
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	40.0.0.8

## Special Cases

- Default route
- Host-specific route

## **Default Route**

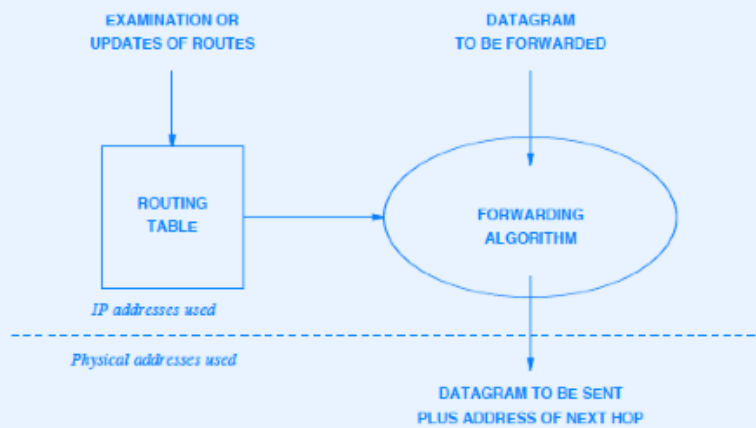
- Special entry in IP routing table
- Matches “any” destination address
- Only one default permitted
- Only selected if no other match in table



## **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