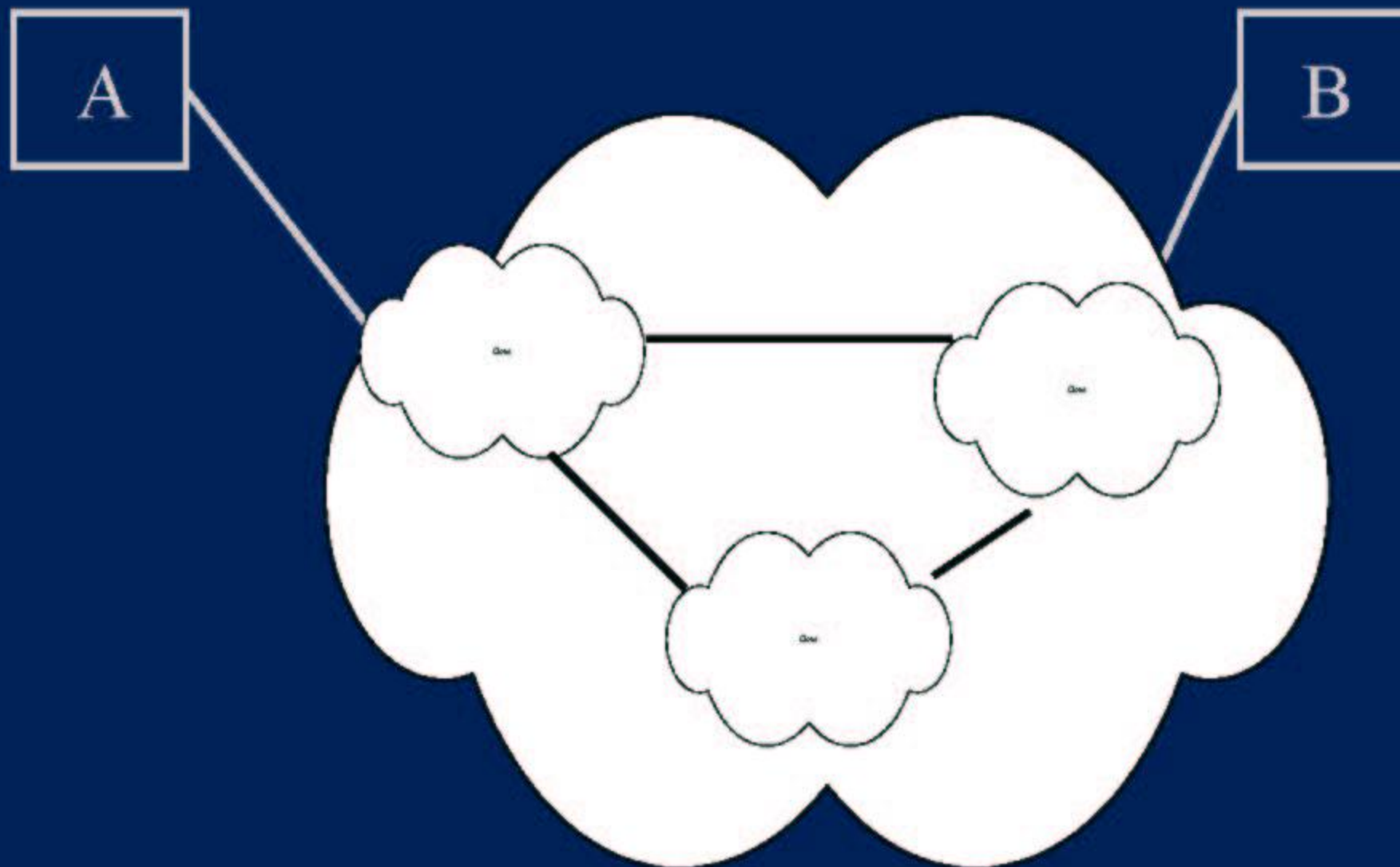


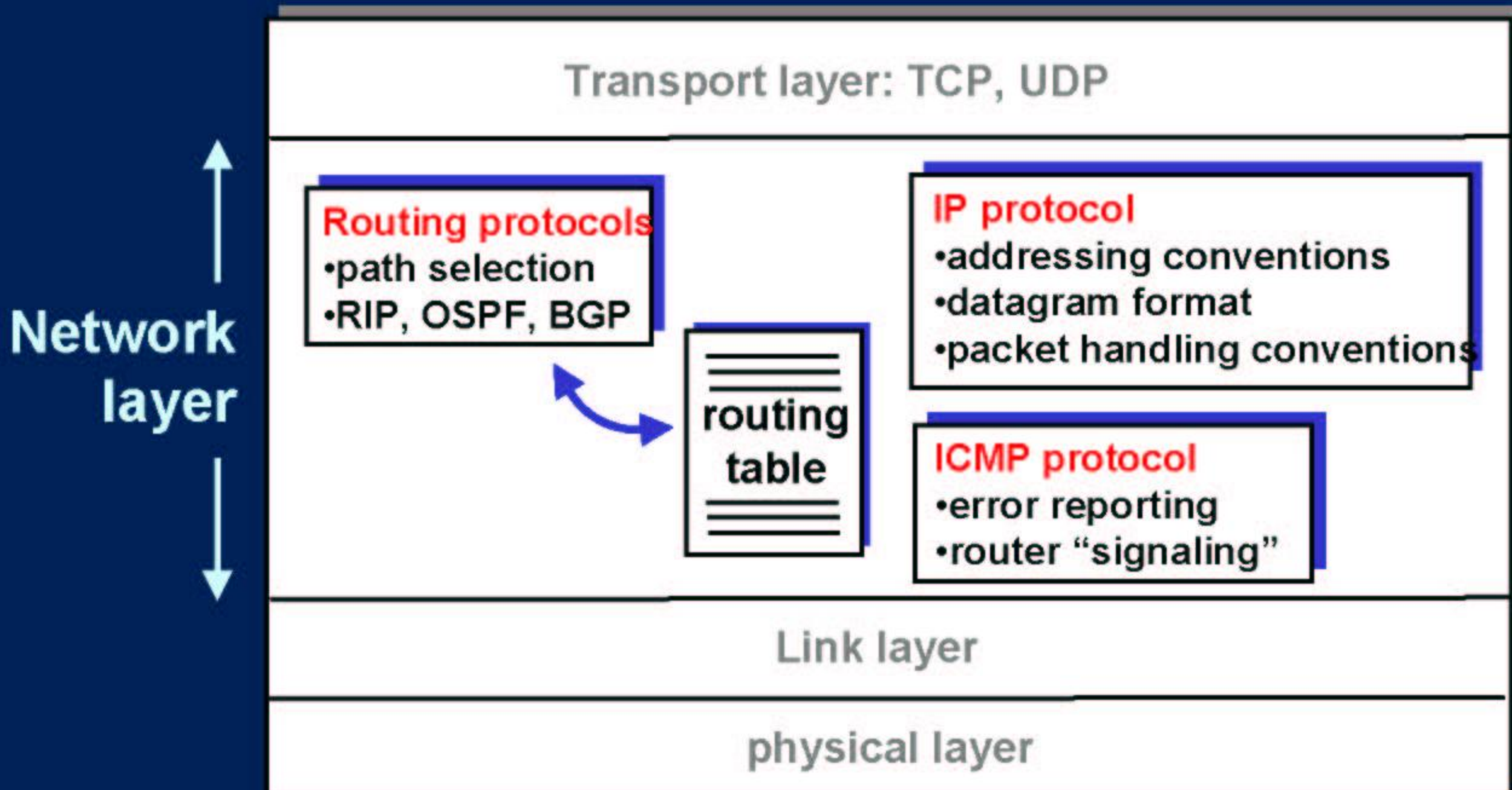
# The Internetworking Problem

- Two nodes communicating across a “*network of networks*” ...
  - How to transport packets through this heterogeneous mass ?



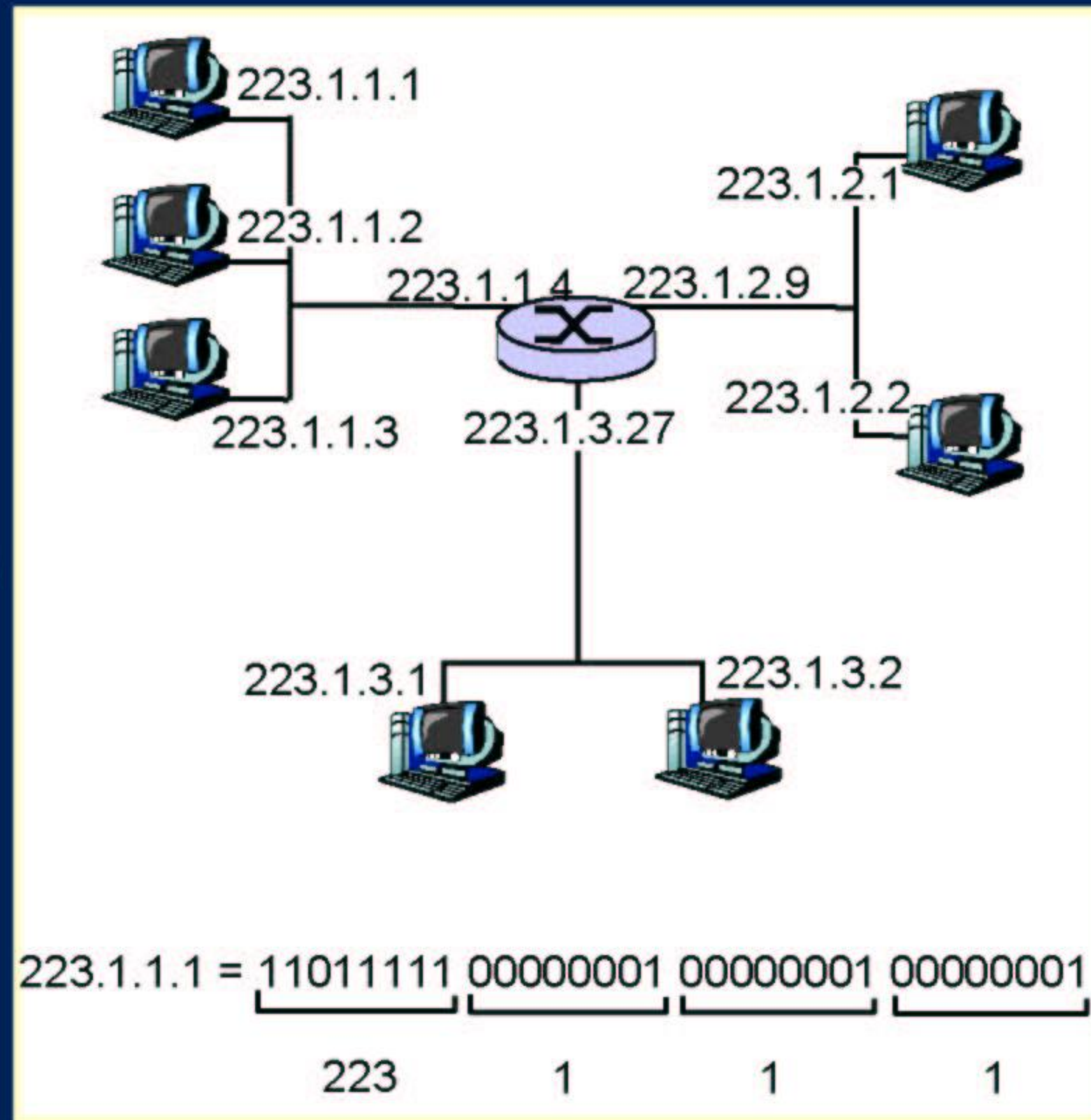
# The Internet Network layer

Host, router network layer functions:



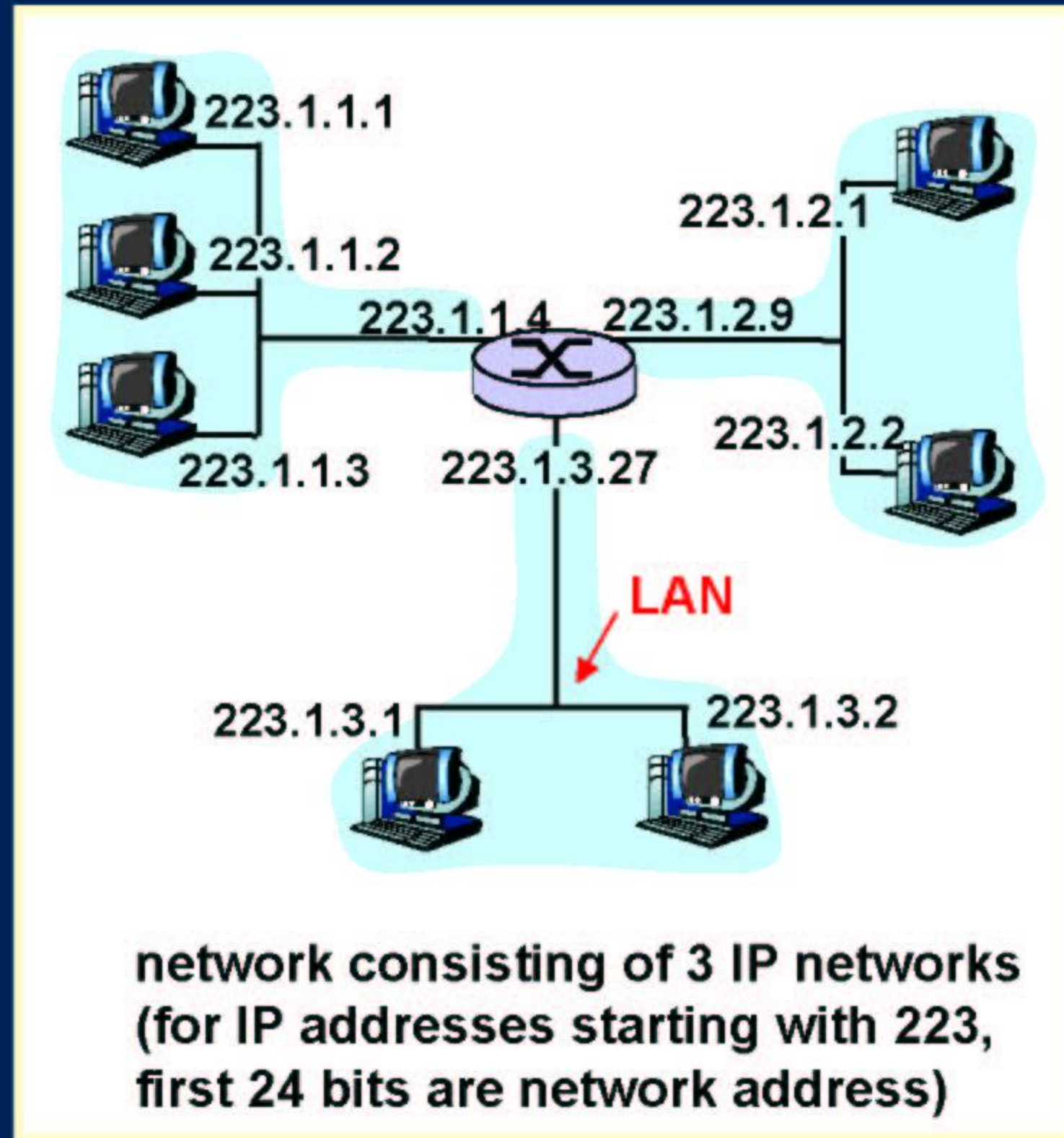
# IP Addressing: introduction

- **IP address: 32-bit identifier for host, router *interface***
- ***interface*: connection between host, router and physical link**
  - router's typically have multiple interfaces
  - host may have multiple interfaces
  - IP addresses associated with interface, not host, router



# IP Addressing - 1

- **IP address:**
  - network part (high order bits)
  - host part (low order bits)
- **What's a network ?**  
(from IP address perspective)
  - device interfaces with same network part of IP address
  - can physically reach each other without intervening router



# IP Addresses

given notion of “network”, let’s re-examine IP addresses:

## “class-full” addressing:

class

A	0	network		host		1.0.0.0 to 127.255.255.255	
B	10		network		host	128.0.0.0 to 191.255.255.255	
C	110			network		host	192.0.0.0 to 223.255.255.255
D	1110				multicast address		224.0.0.0 to 239.255.255.255

← 32 bits →

# Some Special IP Addresses

- All-0s  $\Rightarrow$  This computer
- All-1s  $\Rightarrow$  All hosts on this net (*limited broadcast: don't forward out of this net*)
- All-0 *host suffix*  $\Rightarrow$  Network Address ('0' means 'this')
- All-1 *host suffix*  $\Rightarrow$  All hosts on the destination net (directed broadcast).
- 127.\*.\*.\*  $\Rightarrow$  *Loopback* through IP layer

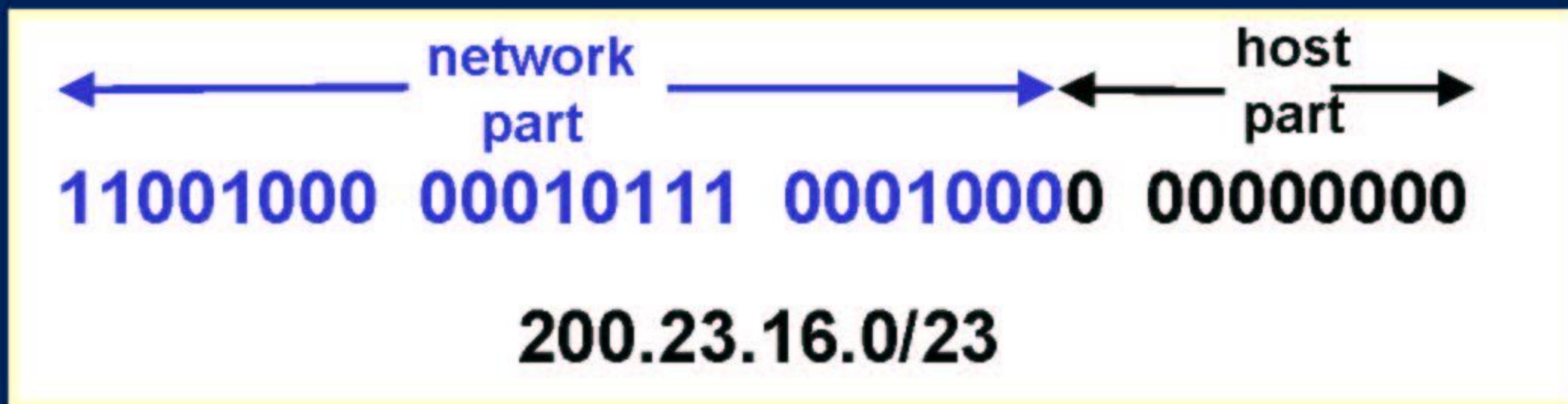
# IP addressing: CIDR - 1

- **classful addressing:**
  - inefficient use of address space, address space exhaustion
  - e.g., class B net allocated enough addresses for 65K hosts, even if only 2K hosts in that network

# IP addressing: CIDR - 2

- **CIDR: Classless InterDomain Routing**

- network portion of address of arbitrary length
- address format: **a.b.c.d/x**, where **x** is # bits in network portion of address





# Subnet Addressing

- *External routers* need to store entries only for the “network ID”
- *Internal routers & hosts* use **subnet mask** to identify “subnet ID” and route packets between “subnets” within the “network”.
- Eg: Mask: 255.255.255.0 => subnet ID = 8 bits with upto 62 hosts/subnet

# Getting a datagram from source to dest. - 1

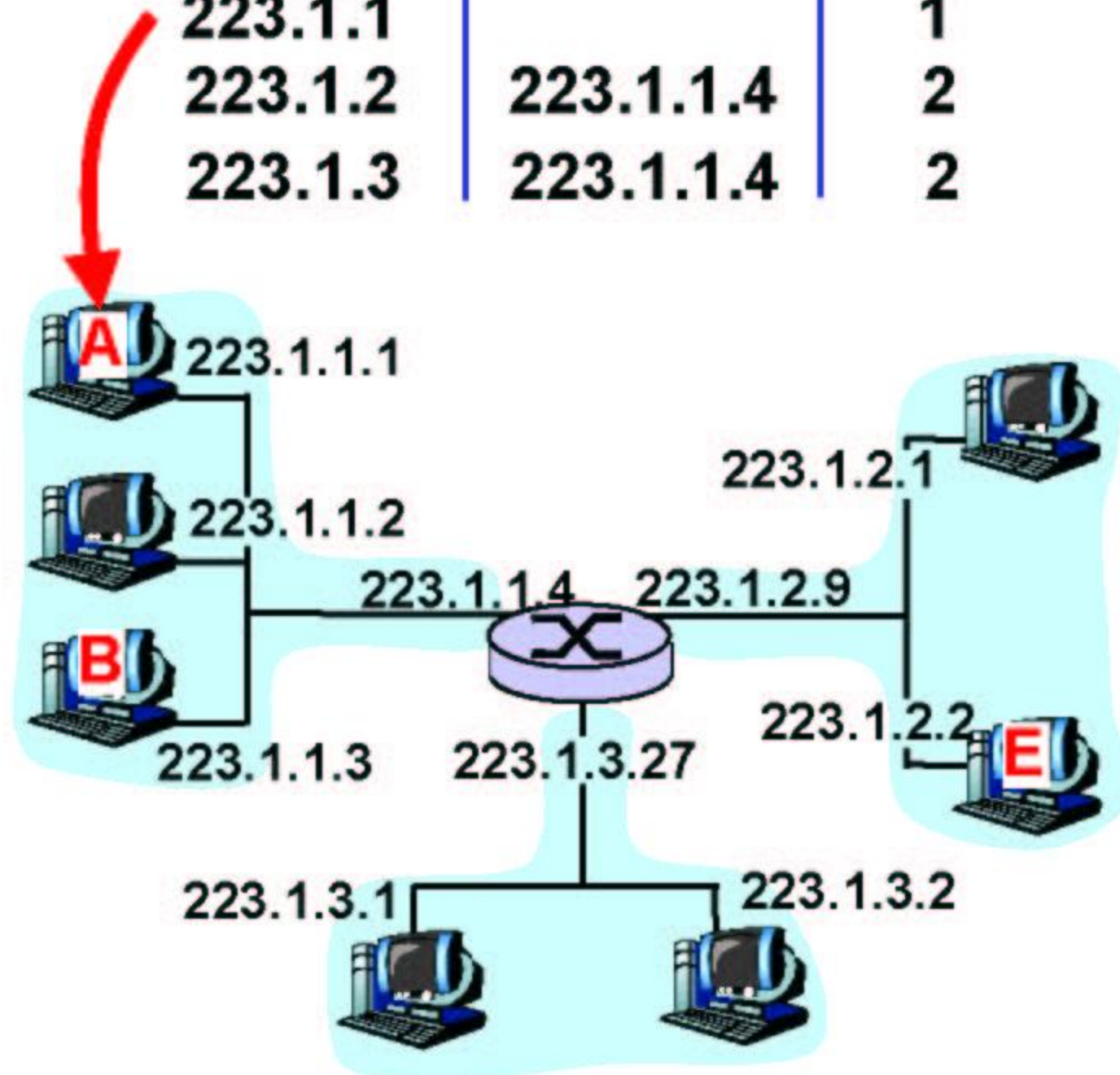
## routing table in A

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2

## IP datagram:

misc fields	source IP addr	dest IP addr	data
-------------	----------------	--------------	------

datagram remains unchanged, as it travels source to destination  
addr fields of interest here



# Getting a datagram from source to dest. - 2

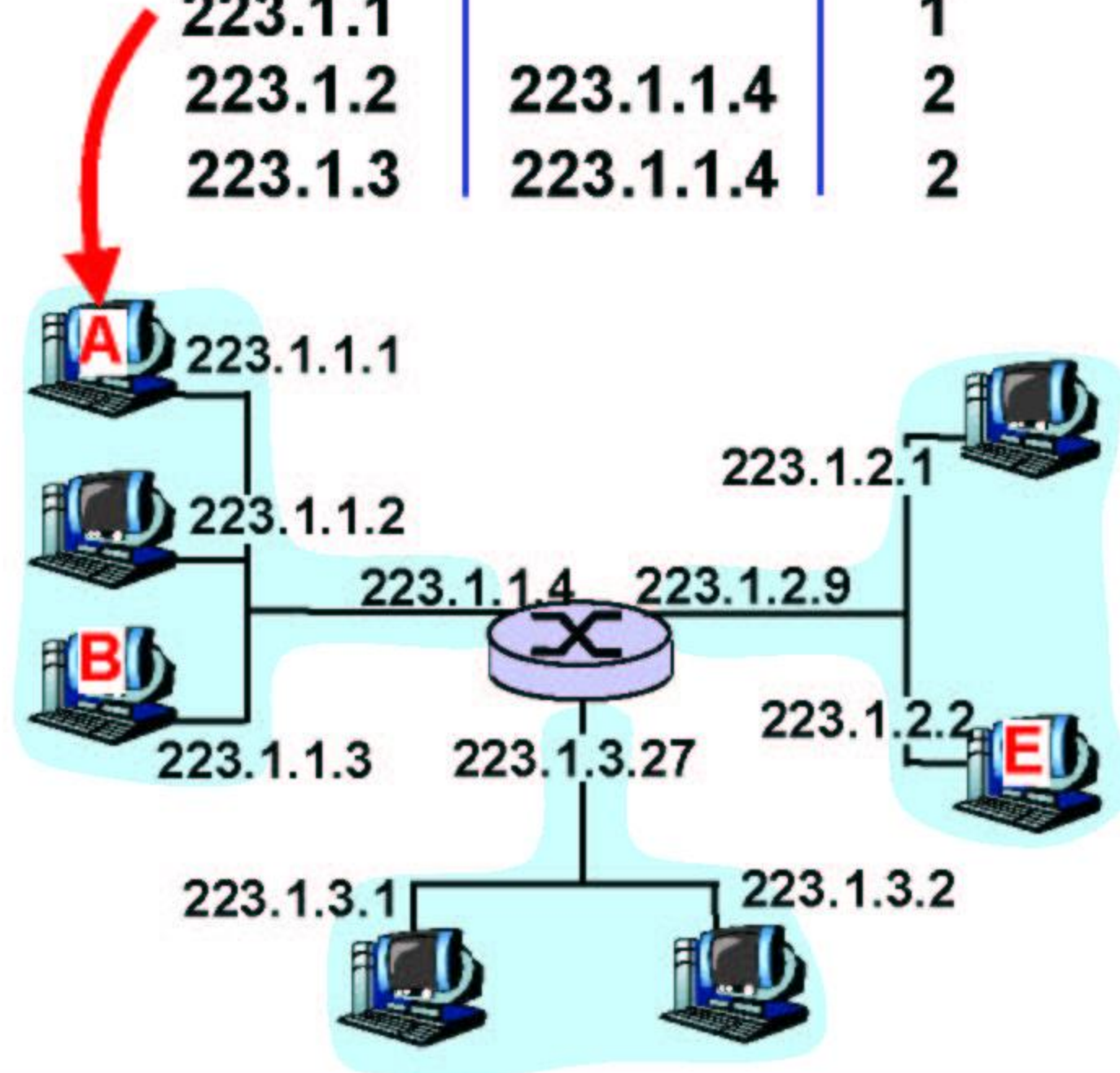
misc fields	223.1.1.1	223.1.1.3	data
-------------	-----------	-----------	------

Starting at A, given IP datagram addressed to B:

look up net. address of B  
find B is on same net. as A  
link layer will send datagram directly to B inside link-layer frame

**B and A are directly connected**

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2



# Getting a datagram from source to dest. - 3

misc fields	223.1.1.1	223.1.2.2	data
-------------	-----------	-----------	------

**Starting at A, dest. E:**

look up network address of E  
E on *different* network

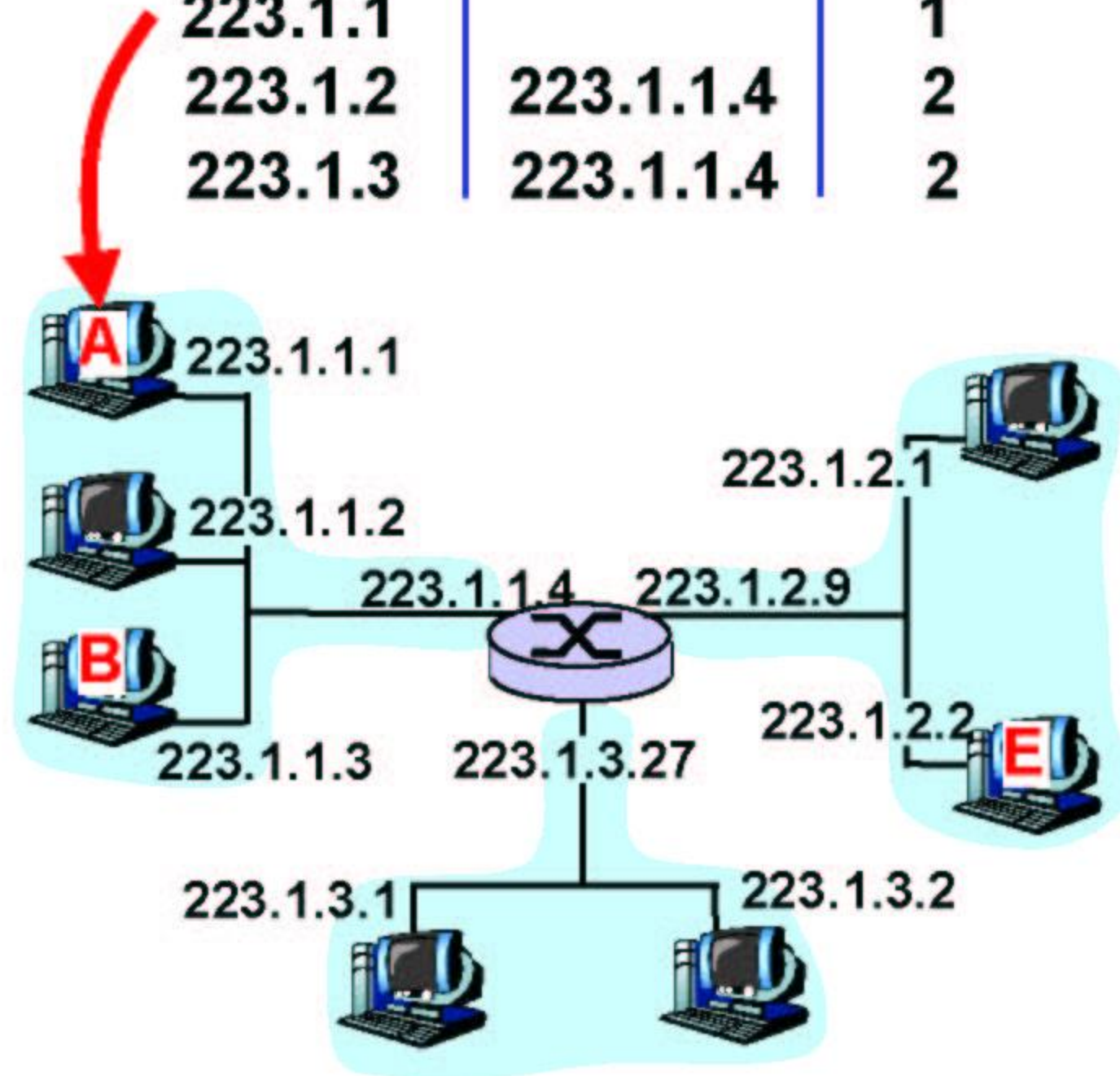
**A, E not directly  
attached**

routing table: next hop router to  
E is 223.1.1.4

link layer sends datagram to  
router 223.1.1.4 inside link-layer  
frame

datagram arrives at 223.1.1.4  
continued.....

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2



# Getting a datagram from source to dest. – 4

misc fields	223.1.1.1	223.1.2.2	data
-------------	-----------	-----------	------

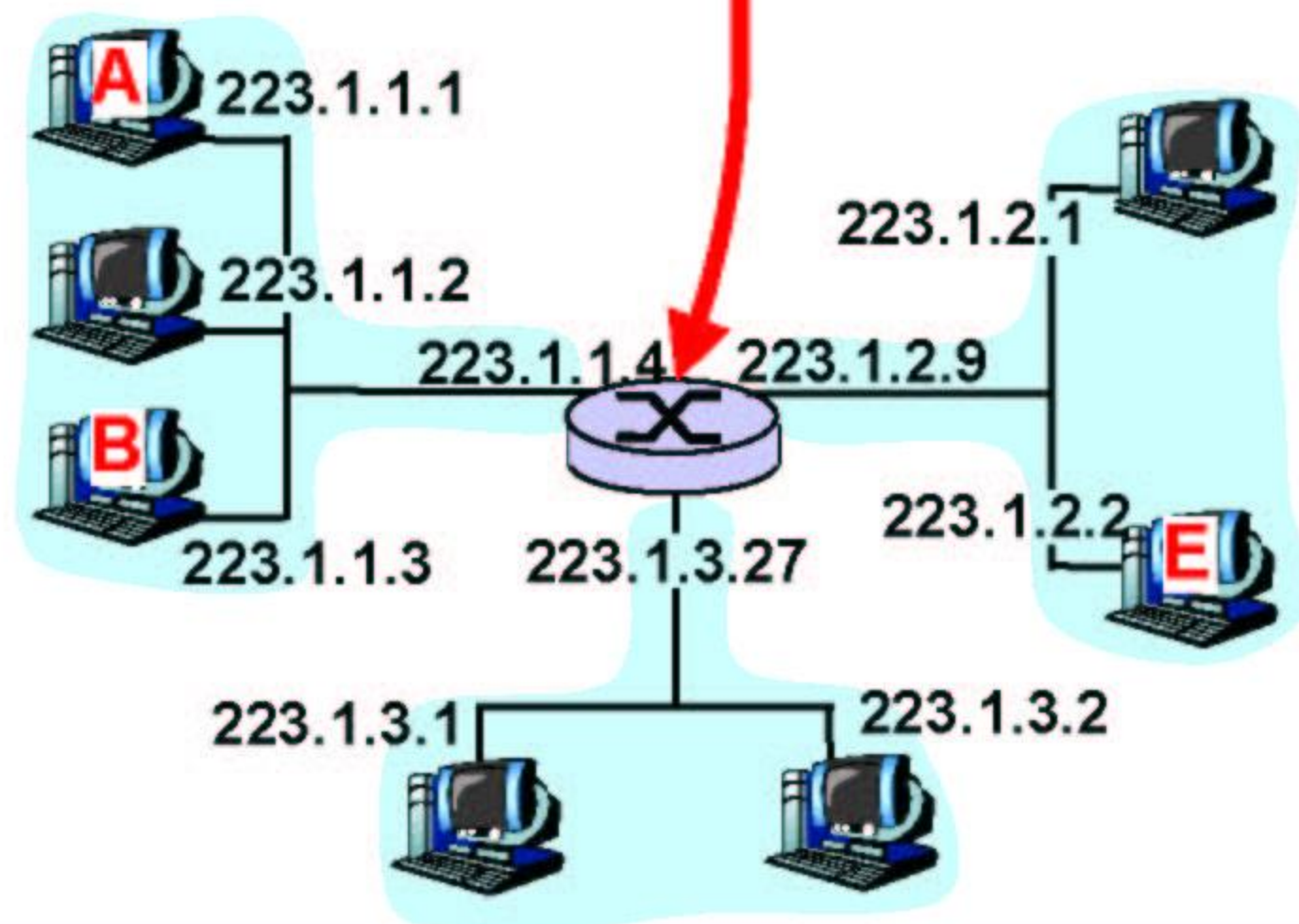
Arriving at 223.1.4,  
destined for 223.1.2.2

look up network address of E  
E on same network as router's  
interface 223.1.2.9

router, E directly  
attached

link layer sends datagram to  
223.1.2.2 inside link-layer frame  
via interface 223.1.2.9  
datagram arrives at 223.1.2.2!!!

Dest. network	next router	Nhops	interface
223.1.1	-	1	223.1.1.4
223.1.2	-	1	223.1.2.9
223.1.3	-	1	223.1.3.27



# IP datagram format

