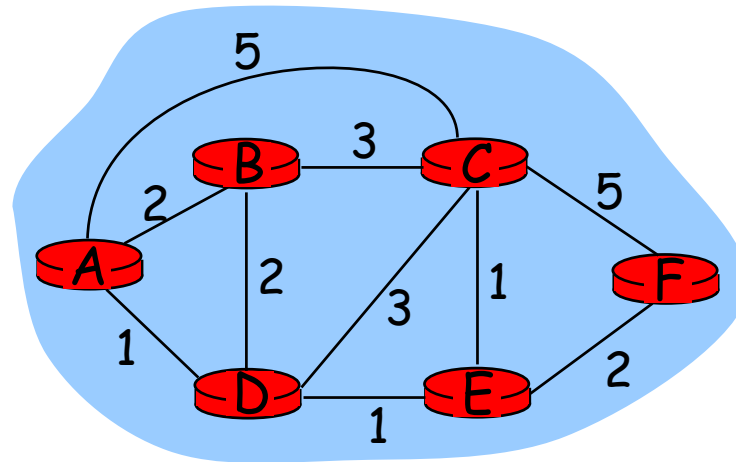


More on Network Routing and Internet Protocol



Dept. of Computer Science, University of Rochester

Distance Vector Routing



- routing table (at each host): the next hop for each destination in the network
- distance vector routing: the routing table is constructed from a distance vector at each node
- distance vectors can be maintained in a decentralized fashion



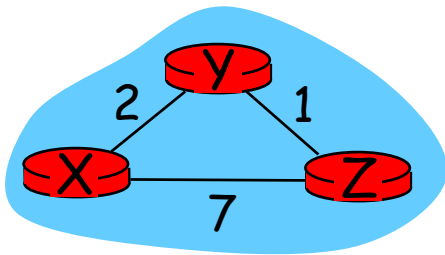
Distance Vector Routing: Constructing Distance Vector

At node X , each entry $D(X,Y,Z)$ includes:

- the distance from X to neighbor Y
- the shortest distance from Y to Z

Distance vector can be built on information about local links and neighbors' routing tables!

Distance Vector Algorithm: An Example



		cost via	
		Y	Z
d e s t	D ^X		
	Y	2	∞
Z	∞	7	

		cost via	
		X	Z
d e s t	D ^Y		
	X	2	∞
Z	∞	1	

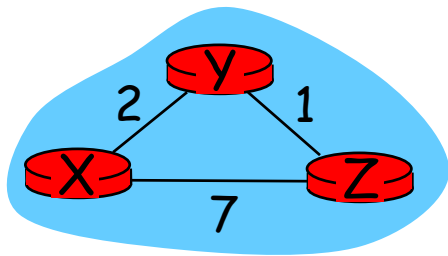
		cost via	
		X	Y
d e s t	D ^Z		
	X	7	∞
Y	∞	1	

		cost via	
		Y	Z
d e s t	D ^X		
	Y	2	8
Z	3	7	

$$D(X,Z,Y) = c(X,Z) + \text{shortest}(Z,Y) \\ = 7 + 1 = 8$$

$$D(X,Y,Z) = c(X,Y) + \text{shortest}(Y,Z) \\ = 2 + 1 = 3$$

Distance Vector Algorithm: An Example



		cost via	
		Y	Z
d e s t	D ^X	Y	Z
	Y	2	∞
Z	∞	7	

		cost via	
		Y	Z
d e s t	D ^X	Y	Z
	Y	2	8
Z	3	7	

		cost via	
		Y	Z
d e s t	D ^X	Y	Z
	Y		
Z			

		cost via	
		X	Z
d e s t	D ^Y	X	Z
	X	2	∞
Z	∞	1	

		cost via	
		X	Z
d e s t	D ^Y	X	Z
	X	2	8
Z	9	1	

		cost via	
		X	Z
d e s t	D ^Y	X	Z
	X		
Z			

		cost via	
		X	Y
d e s t	D ^Z	X	Y
	X	7	∞
Y	∞	1	

		cost via	
		X	Y
d e s t	D ^Z	X	Y
	X	7	3
Y	9	1	

		cost via	
		X	Y
d e s t	D ^Z	X	Y
	X		
Y			

Distance Vector Routing: Maintaining Distance Vector

Information:

- local link cost
- distance vector → routing table

Recompute caused by:

- local link cost change
- message from neighbor: its routing table has changed

Notify neighbor:

- if my own routing table has changed, notify my neighbors

Each node:

wait for (change in local link cost or msg from neighbor)

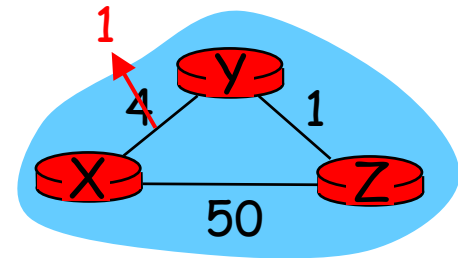
recompute distance vector

if the local routing table has changed, notify neighbors

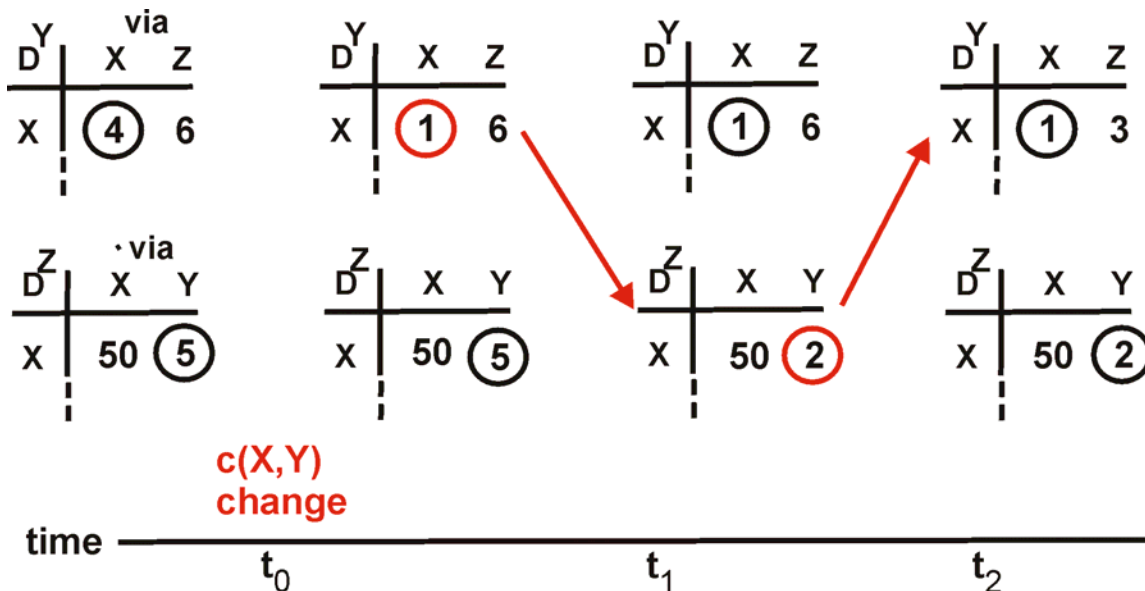
Distance Vector: Link Cost Changes

Link cost changes:

- node detects local link cost change
- recompute - updates local distance vector
- if cost change in least cost path, notify neighbors



"good news travels fast"

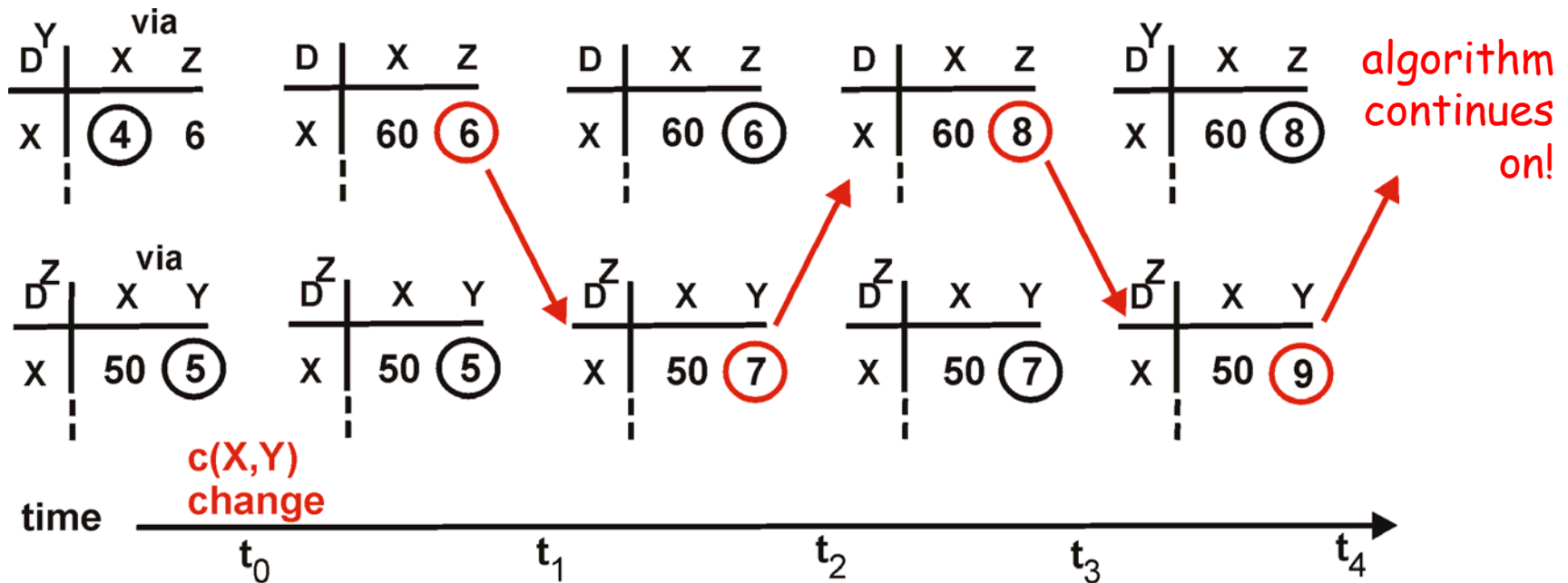
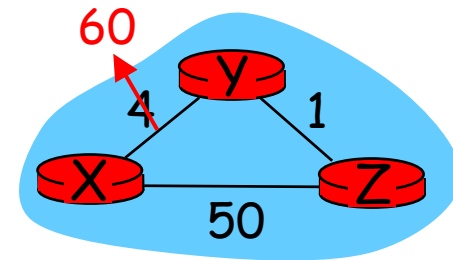


algorithm terminates

Distance Vector: Link Cost Changes

Link cost changes:

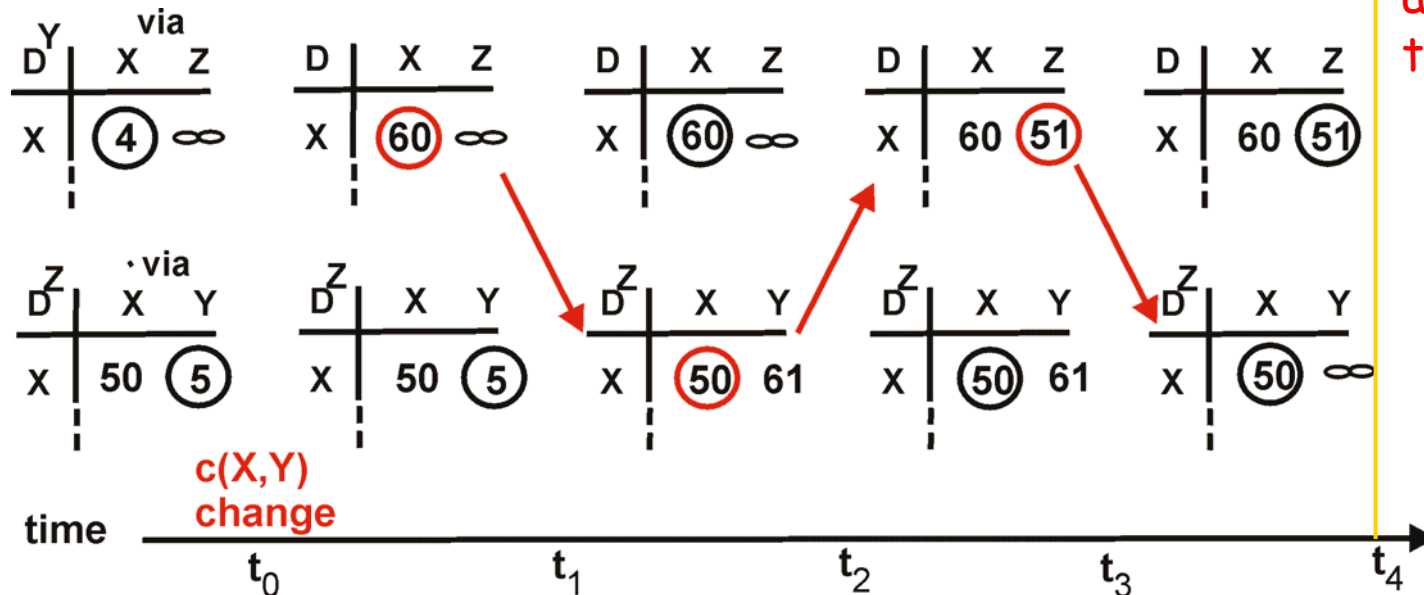
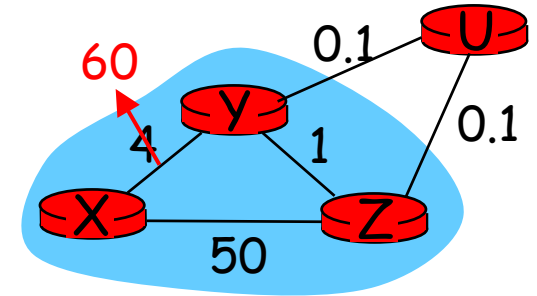
- good news travels fast
- bad news travels slow - "count to infinity" problem!



Distance Vector: Poisoned Reverse

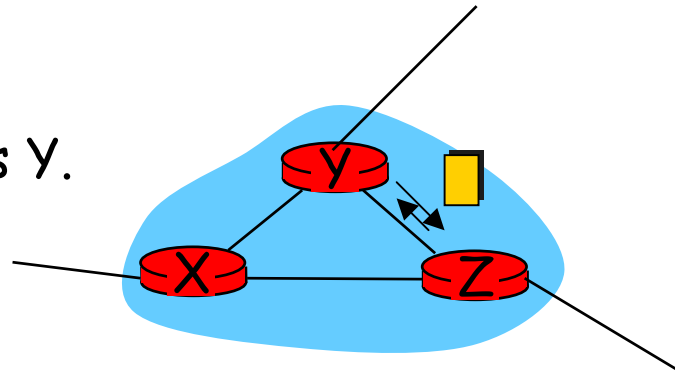
If Z routes through Y to get to X :

- Z tells Y its (Z's) distance to X is infinity (so Y won't route to X via Z)
- Will this completely solve count to infinity problem?



Routing Loops

- In packet switching networks, each node computes its own routing table independently
- What if?
 - Y's next hop to X is Z;
 - and Z's next hop to X is Y.



- Routing loops
 - during count-to-infinity
 - unsynchronized information updates in dynamic networks



Comparison of LS and DV Algorithms

Speed of convergence

- LS:
 - $O(n \log n)$ algorithm in local computation
 - may have oscillations
- DV:
 - convergence time at startup?
 - count-to-infinity problem at link cost change

Robustness: what happens if router malfunctions?

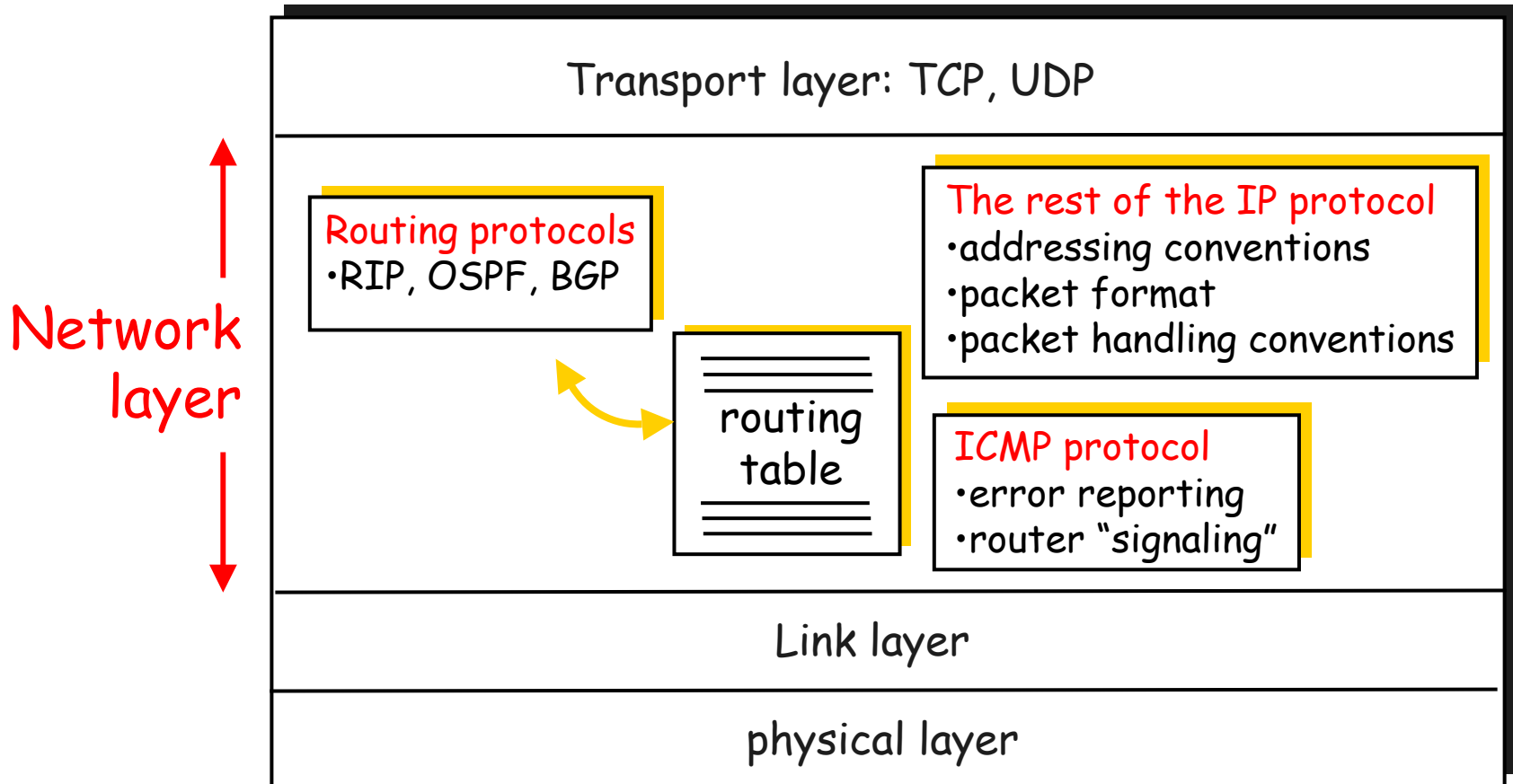
LS:

- node can advertise incorrect link cost

DV:

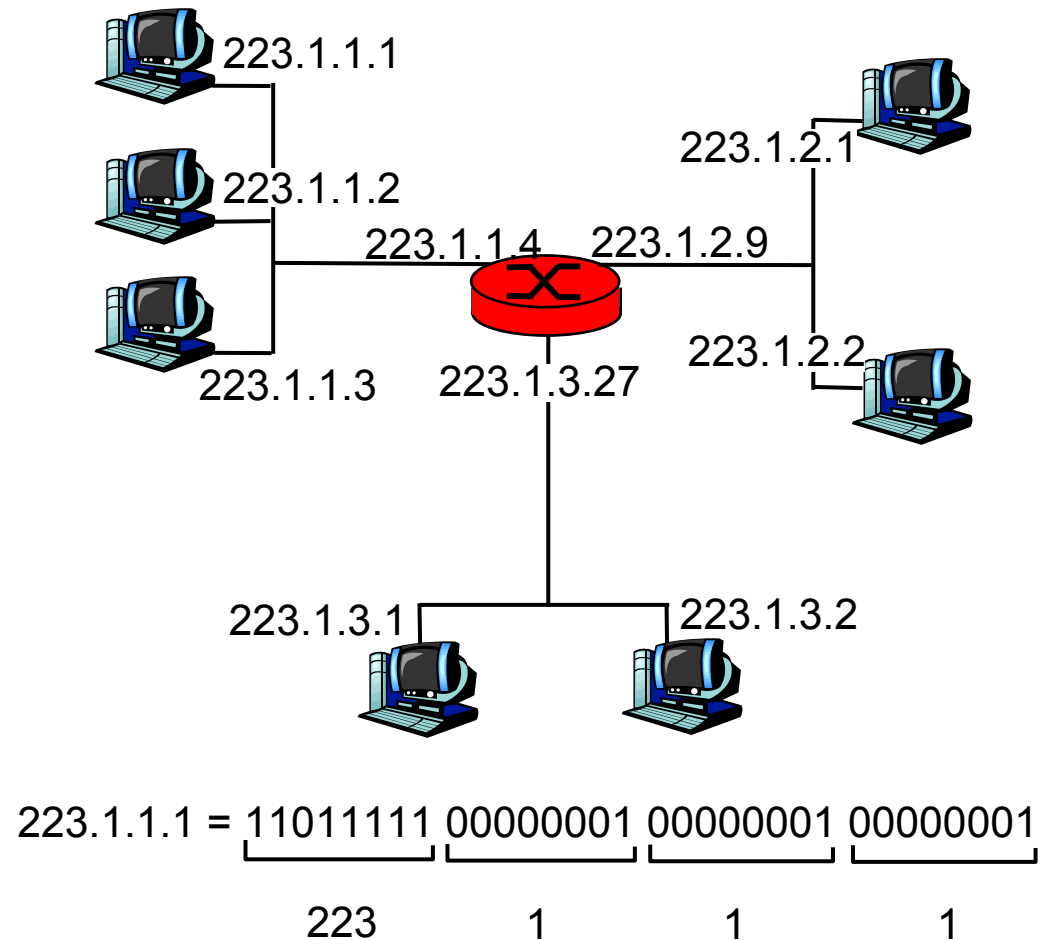
- node can advertise incorrect routing table

The Internet Network Layer



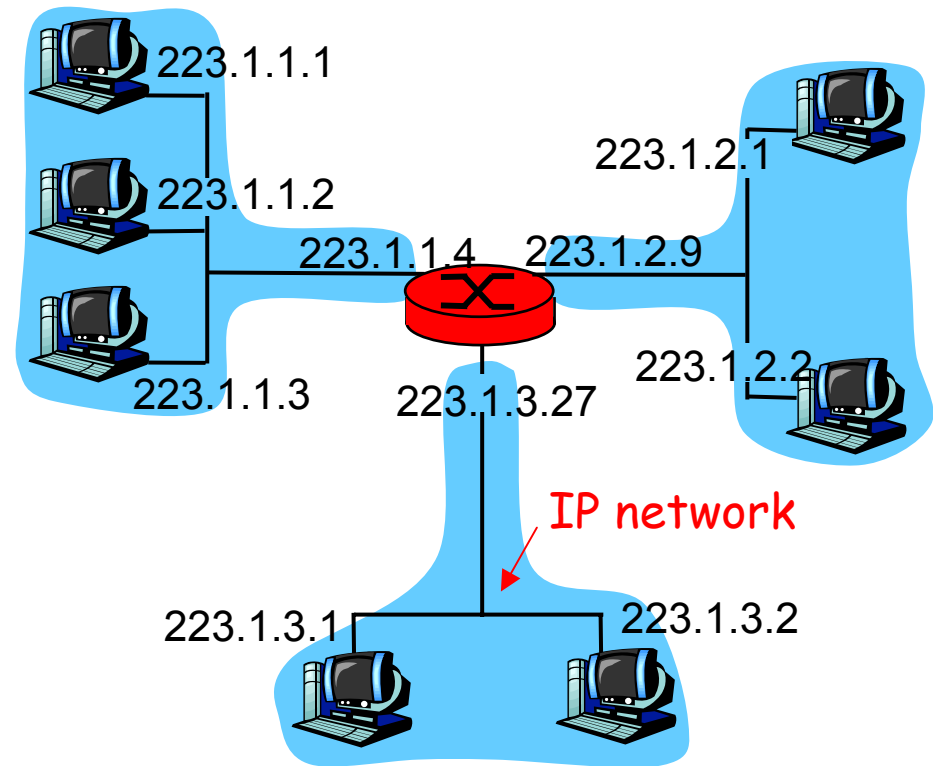
IP Addressing: Introduction

- **IP address:**
 - 32-bit identifier for each host, router interface
- **interface:** connecting point into each data link
 - routers typically have multiple interfaces
 - hosts often have single interfaces



IP Network and Hierarchical Addressing

- What's an IP network?
 - can physically reach each other without intervening router (*intervening switches?*)
- IP address:
 - network part (high order bits); host part (low order bits)
 - devices with same network part of IP address are in the same IP network



network consisting of 3 IP networks

IP Addresses: Original Standard

Given notion of "network", let's re-examine IP addresses:

"class"-based 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 →

IP Addressing: CIDR

- "Class"-based 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
- **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



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DHCP: Dynamic Host Configuration Protocol

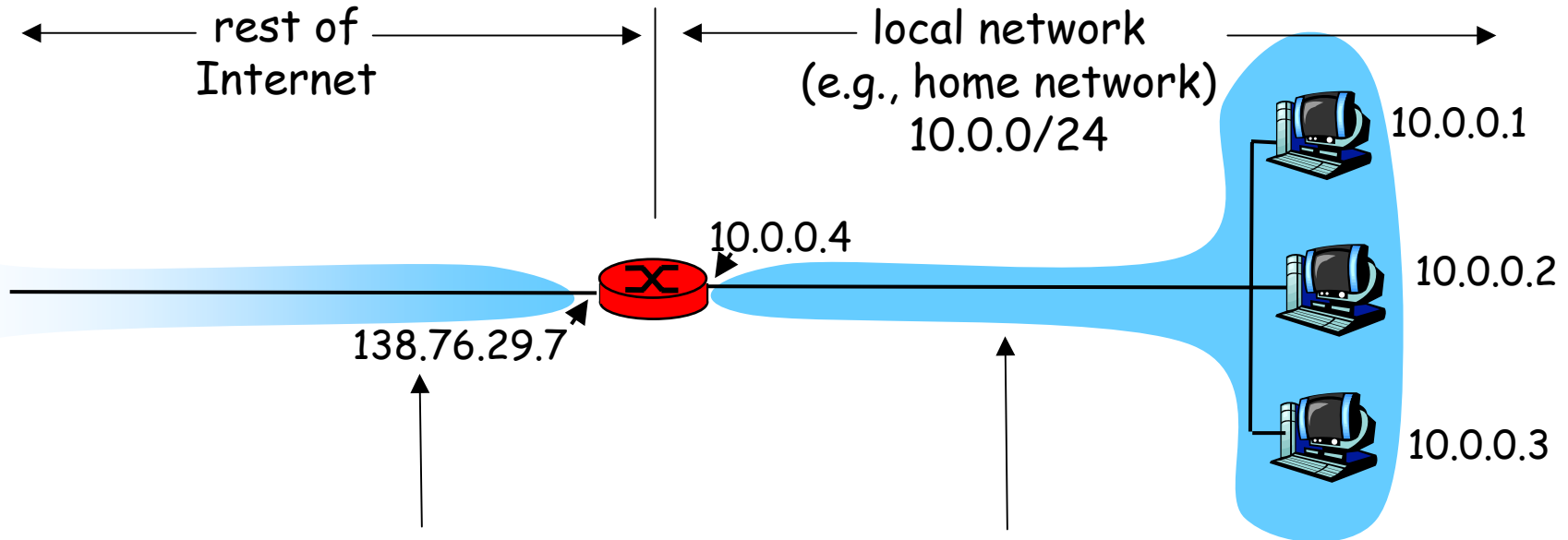
Goal: allow host to *dynamically* obtain its IP address from network server when it joins network

- Can renew its lease on address in use
- Allows reuse of addresses (only hold address while connected)

DHCP protocol messages:

- host broadcasts "DHCP discover" msg
- DHCP server responds with "DHCP offer" msg
- host requests IP address: "DHCP request" msg
- DHCP server sends address: "DHCP ack" msg

NAT: Network Address Translation



All IP packets *leaving* local network have *same* single source NAT IP address: 138.76.29.7, different source port numbers

Packets with source or destination in this network have 10.0.0/24 address for source, destination



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