EPL606

Internetworking

Part 2a

The majority of the slides in this course are adapted from the accompanying slides to the books by Larry Peterson and Bruce Davie and by Jim Kurose and Keith Ross. Additional slides and/or figures from other sources and from Vasos Vassiliou are also included in this presentation.

Topic 2: Network Layer

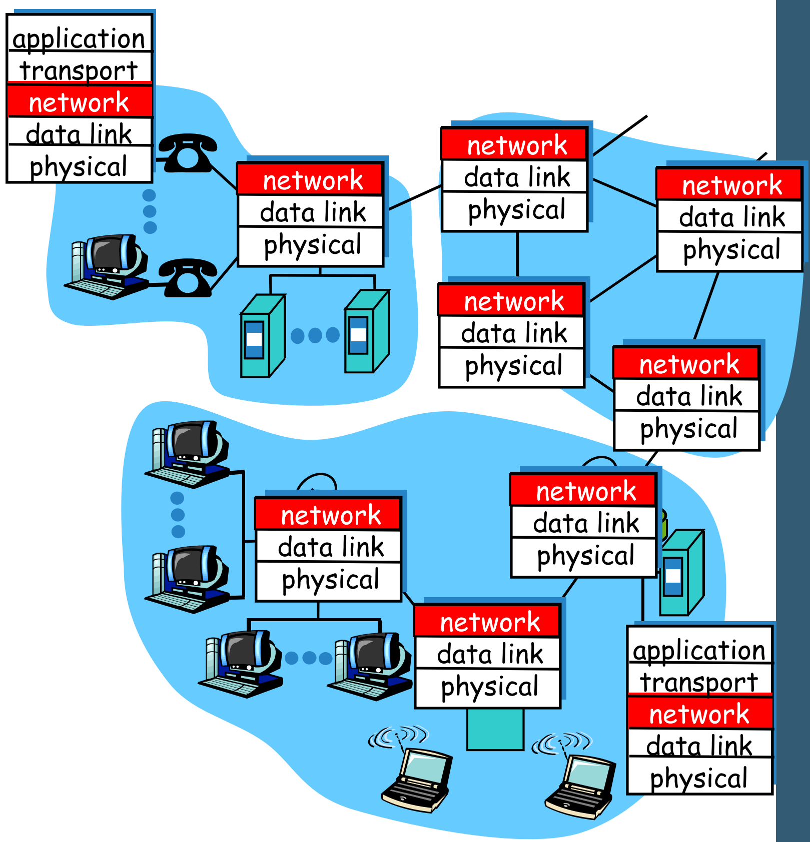
- Introduction
- Virtual circuit and datagram networks
- Bridges, switches, hubs, etc.
- IP: Internet Protocol
  - Datagram format
  - IPv4 addressing
  - IPv6
- Routing algorithms and Protocols
- MPLS

Design Principles for Internet

1. Make sure it works.
2. Keep it simple.
3. Make clear choices.
4. Exploit modularity.
5. Expect heterogeneity.
6. Avoid static options and parameters.
7. Look for a good design; it need not be perfect.
8. Be strict when sending and tolerant when receiving.
9. Think about scalability.
10. Consider performance and cost.

Network layer

- transport segment from sending to receiving host
- on sending side encapsulates segments into datagrams
- on receiving side, delivers segments to transport layer
- network layer protocols in *every* host, router
- Router examines header fields in all IP datagrams passing through it



Connection setup

- 3rd important function in *some* network architectures:
  - MPLS, ATM, frame relay, X.25
- Before datagrams flow, two hosts and intervening routers establish virtual connection
  - Routers get involved
- Network and transport layer connection-oriented service:
  - Network: between two hosts
  - Transport: between two processes

Network service model

Q: What *service model* for "channel" transporting datagrams from sender to receiver?

Example services for individual datagrams:

- guaranteed delivery
- Guaranteed delivery with less than 40 msec delay

Example services for a flow of datagrams:

- In-order datagram delivery
- Guaranteed minimum bandwidth to flow
- Restrictions on changes in inter-packet spacing

Network layer connection and connection-less service

- Datagram network provides network-layer connectionless service
- VC network provides network-layer connection service
- Analogous to the transport-layer services, but:
  - Service: host-to-host
  - No choice: network provides one or the other
  - Implementation: in the core

Virtual circuits

"source-to-dest path behaves much like telephone circuit"

- performance-wise
- network actions along source-to-dest path

- call setup, teardown for each call *before* data can flow
- each packet carries VC identifier (not destination host address)
- *every* router on source-dest path maintains "state" for each passing connection
- link, router resources (bandwidth, buffers) may be *allocated* to VC

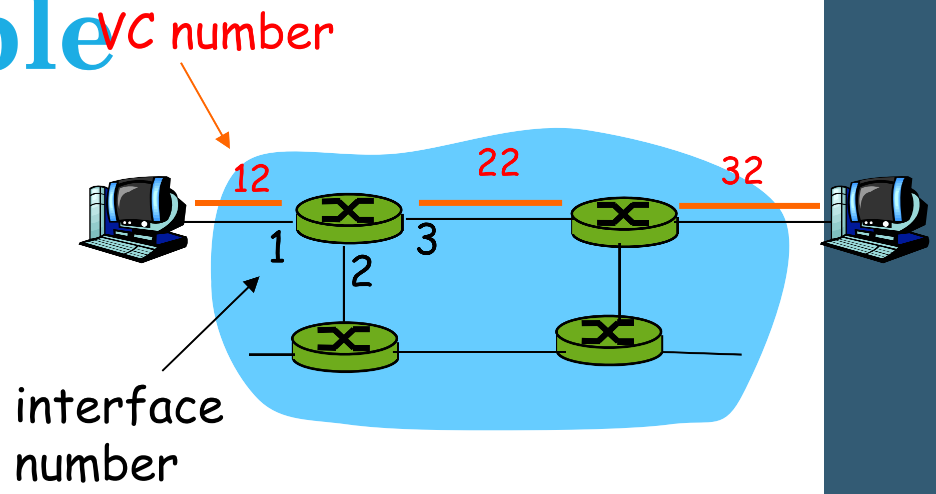
VC implementation

A VC consists of:

1. Path from source to destination
2. VC numbers, one number for each link along path
3. Entries in forwarding tables in routers along path

- Packet belonging to VC carries a VC number.
- VC number must be changed on each link.
  - New VC number comes from forwarding table

Forwarding table



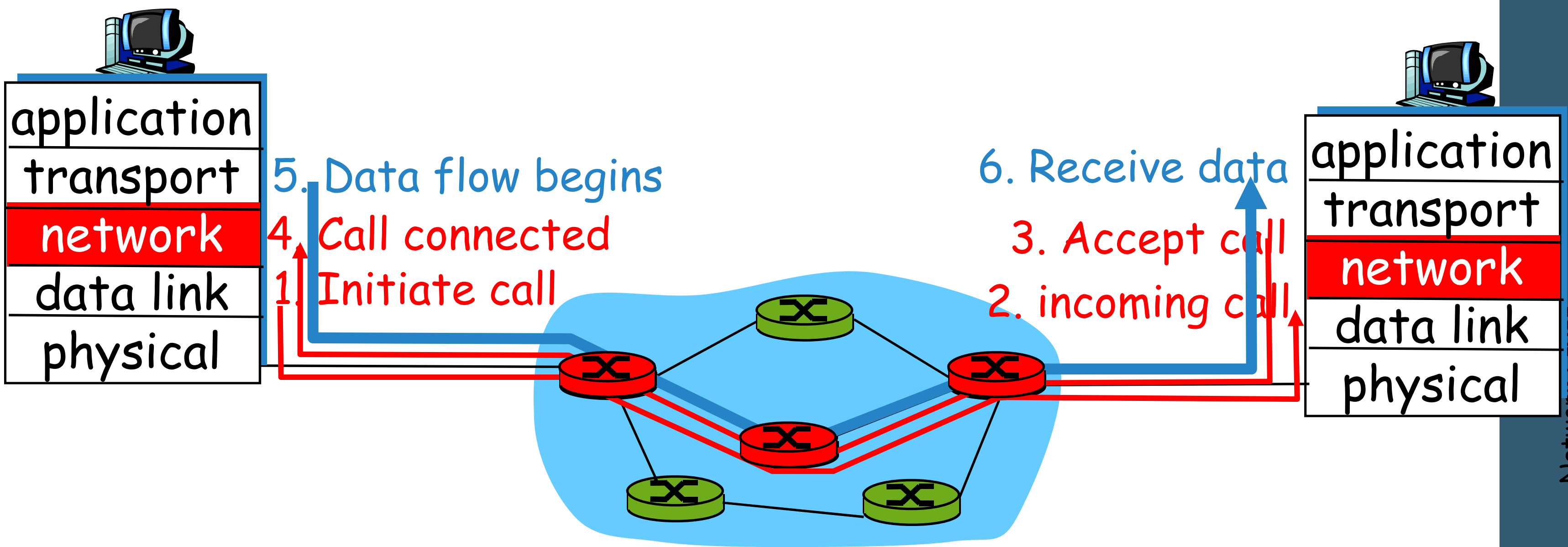
Forwarding table in northwest router:

Incoming interface	Incoming VC #	Outgoing interface	Outgoing VC #
1	12	3	22
2	63	1	18
3	7	2	17
1	97	3	87
…	…	…	…

Routers maintain connection state information!

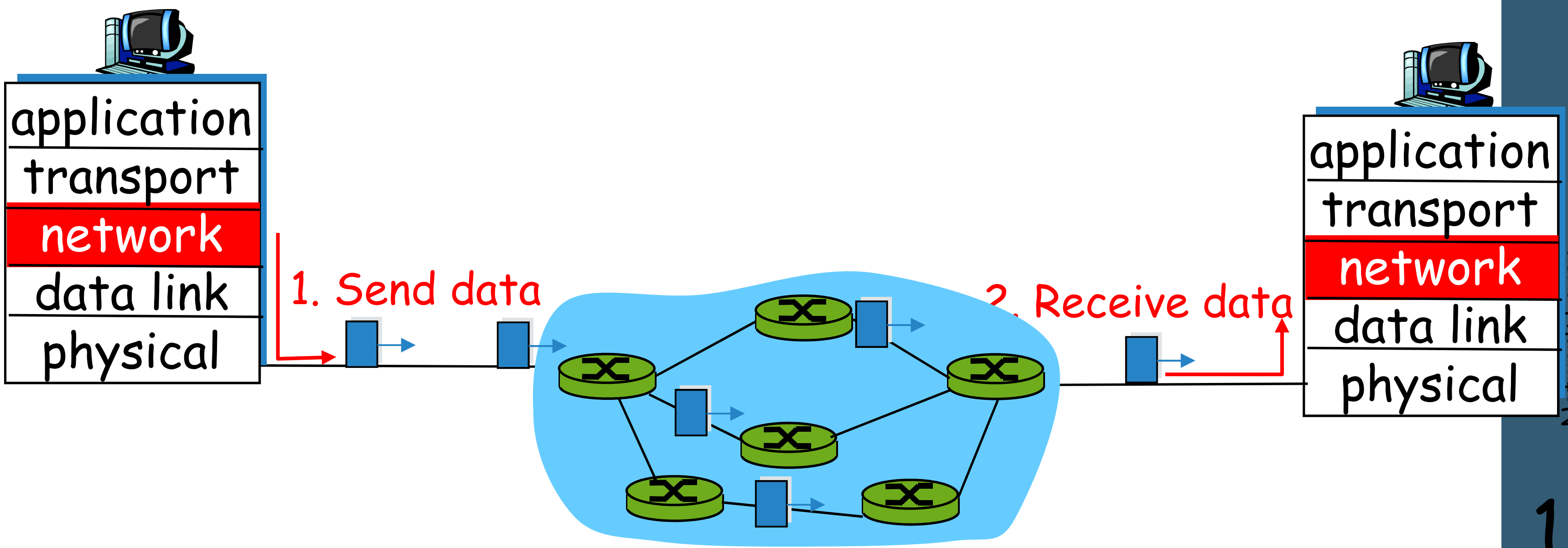
Virtual circuits: signaling protocols

- used to setup, maintain teardown VC
- used in MPLS, ATM, frame-relay, X.25



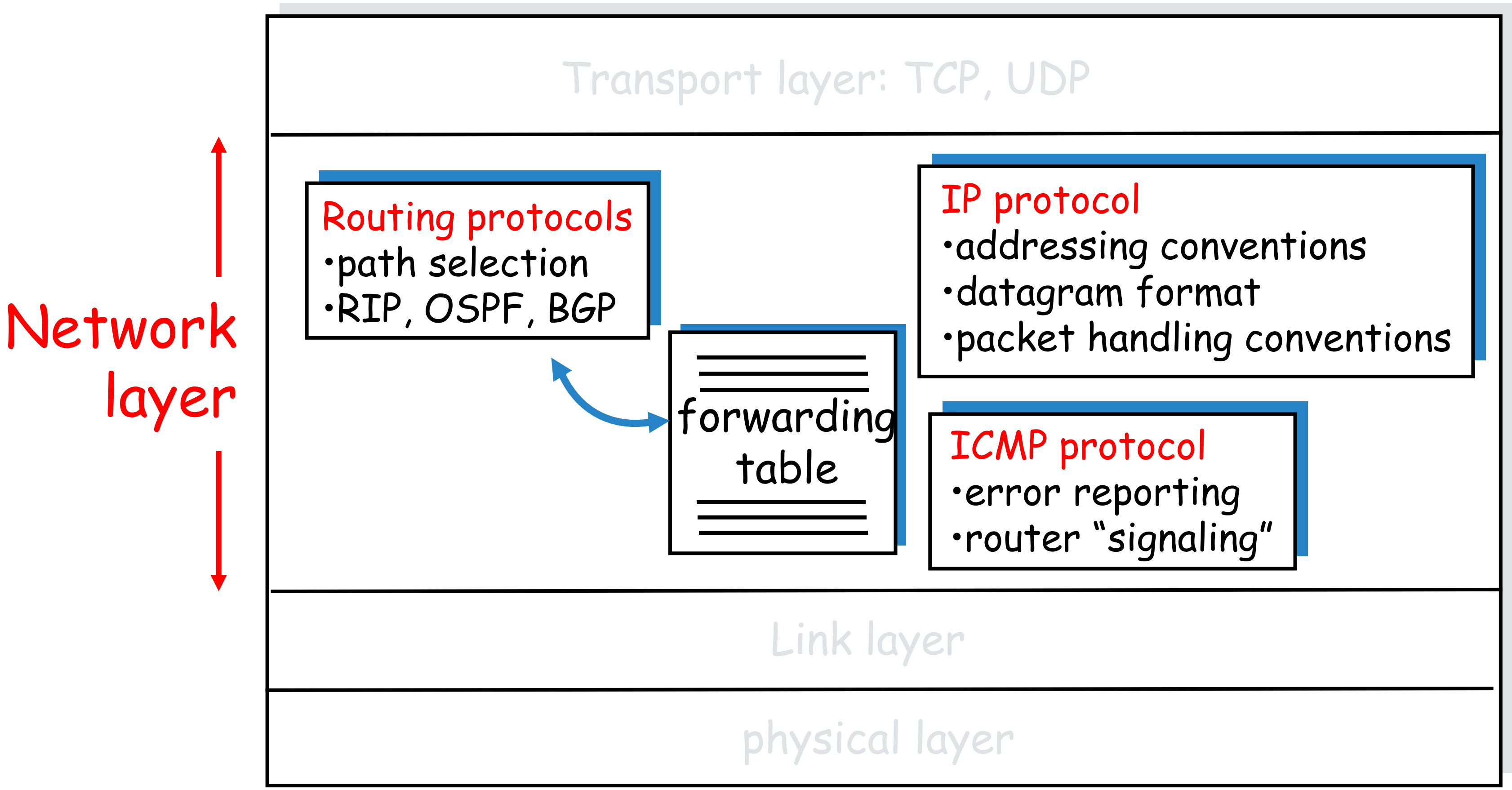
Datagram networks

- no call setup at network layer
- routers: no state about end-to-end connections
  - no network-level concept of "connection"
- packets forwarded using destination host address
  - packets between same source-dest pair may take different paths



The Internet Network layer

Host, router network layer functions:



Service Model

- Connectionless (datagram-based)
- Best-effort delivery (unreliable service)
  - packets are lost
  - packets are delivered out of order
  - duplicate copies of a packet are delivered
  - packets can be delayed for a long time

Comparison of Virtual-Circuit and Datagram Subnets

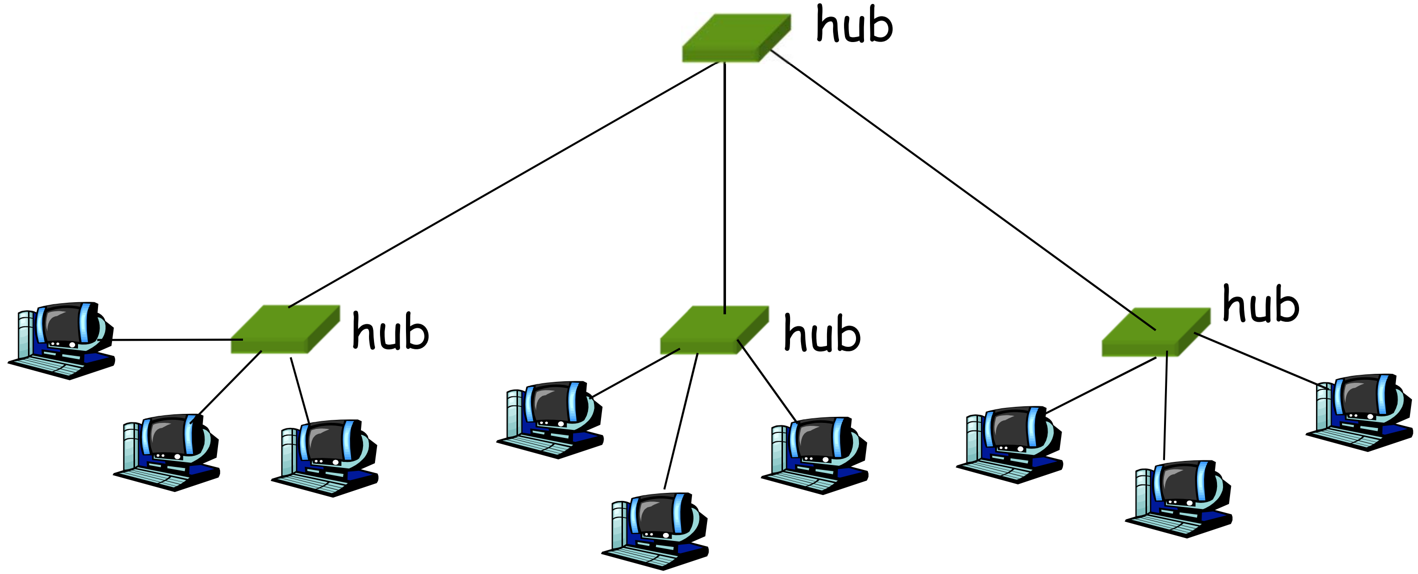
Issue	Datagram subnet	Virtual-circuit subnet
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

Inter - Networking

- Hubs
- Bridges
- Switches
- Routers

Interconnecting with hubs

- Backbone hub interconnects LAN segments
- Extends max distance between nodes
- But individual segment collision domains become one large collision domain
- Can't interconnect 10BaseT & 100BaseT



Bridges and LAN Switches

- Bridges and LAN Switches
  - Class of switches that is used to forward packets between shared-media LANs such as Ethernets
    - Known as LAN switches
    - Referred to as Bridges

  - Suppose you have a pair of Ethernets that you want to interconnect
    - One approach is put a repeater in between them
      - It might exceed the physical limitation of the Ethernet
        - No more than four repeaters between any pair of hosts
        - No more than a total of 2500 m in length is allowed
    - An alternative would be to put a node between the two Ethernets and have the node forward frames from one Ethernet to the other
      - This node is called a **Bridge**
      - A collection of LANs connected by one or more bridges is usually said to form an **Extended LAN**

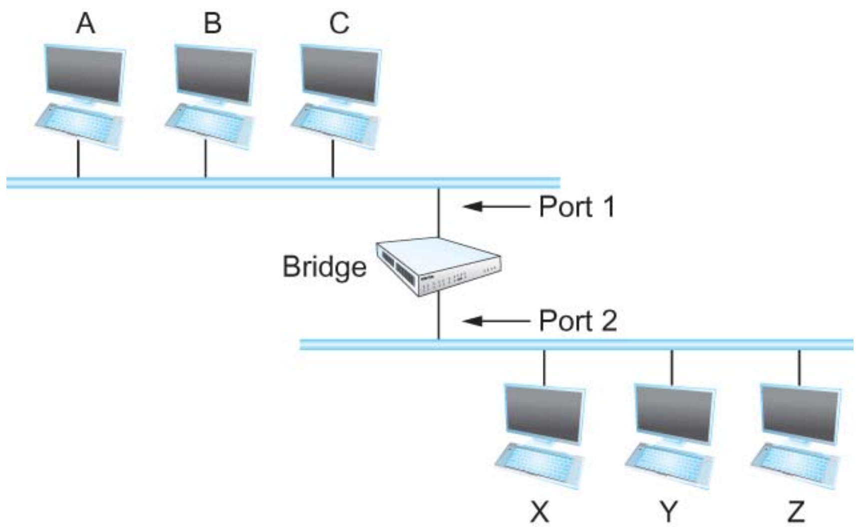
Bridges and LAN Switches

- Simplest Strategy for Bridges
  - Accept LAN frames on their inputs and forward them out to all other outputs
  - Used by early bridges

- Learning Bridges
  - Observe that there is no need to forward all the frames that a bridge receives

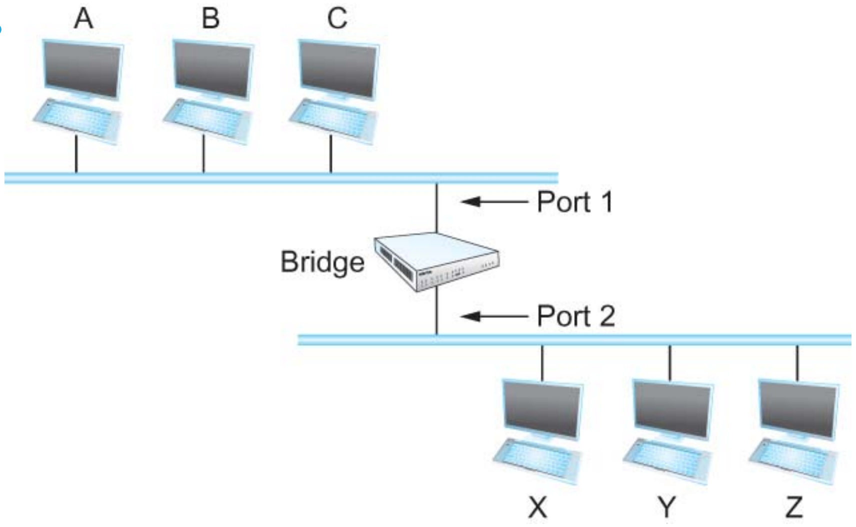
Bridges and LAN Switches

- Consider the following figure
  - When a frame from host A that is addressed to host B arrives on port 1, there is no need for the bridge to forward the frame out over port 2.



  - How does a bridge come to learn on which port the various hosts reside?

Bridges and LAN Switches

- 

Host	Port
A	1
B	1
C	1
X	2
Y	2
Z	2

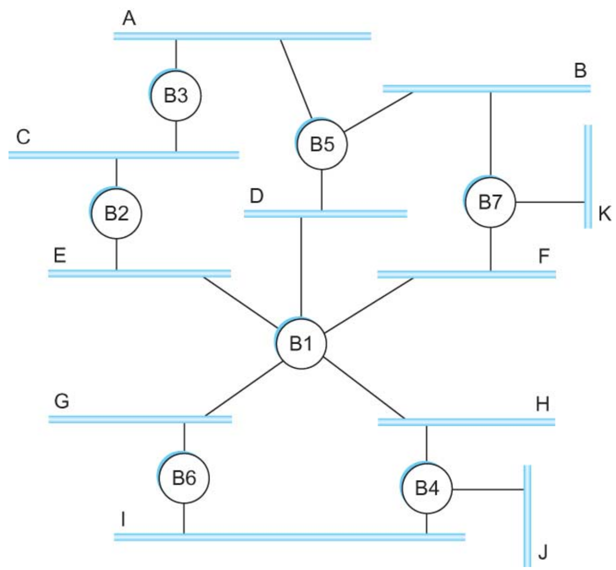
- Who does the download?
  - Human
    - Too much work for maintenance

Bridges and LAN Switches

- Can the bridge learn this information by itself?
  - Yes
- How
  - Each bridge inspects the source address in all the frames it receives
  - Record the information at the bridge and build the table
  - When a bridge first boots, this table is empty
  - Entries are added over time
  - A timeout is associated with each entry
  - The bridge discards the entry after a specified period of time
    - To protect against the situation in which a host is moved from one network to another
- If the bridge receives a frame that is addressed to host not currently in the table
  - Forward the frame out on all other ports

Bridges and LAN Switches

- Strategy works fine if the extended LAN does not have a loop in it
- Why?
  - Frames potentially loop through the extended LAN forever



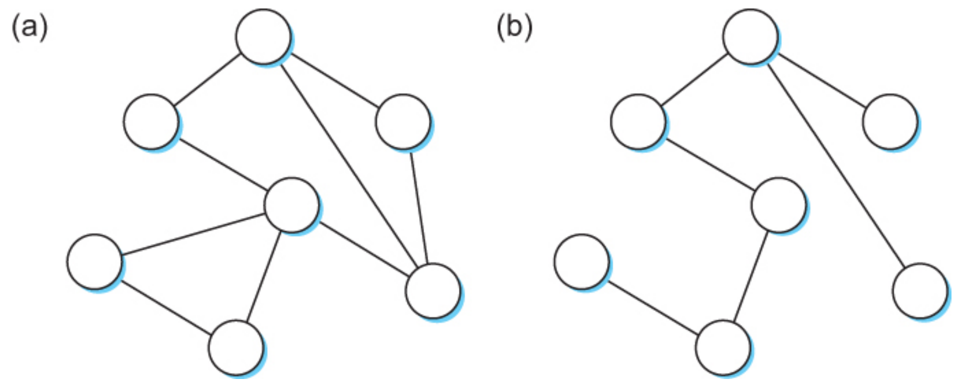
  - Bridges B1, B4, and B6 form a loop

Bridges and LAN Switches

- How does an extended LAN come to have a loop in it?
  - Network is managed by more than one administrator
    - For example, it spans multiple departments in an organization
    - It is possible that no single person knows the entire configuration of the network
      - A bridge that closes a loop might be added without anyone knowing
  - Loops are built into the network to provide redundancy in case of failures
- Solution
  - Distributed Spanning Tree Algorithm

Spanning Tree Algorithm

- Think of the extended LAN as being represented by a graph that possibly has loops (cycles)
- A spanning tree is a sub-graph of this graph that covers all the vertices but contains no cycles
  - Spanning tree keeps all the vertices of the original graph but throws out some of the edges



  - Example of (a) a cyclic graph; (b) a corresponding spanning tree.

Spanning Tree Algorithm

- Developed by Radia Perlman at Digital
  - A protocol used by a set of bridges to agree upon a spanning tree for a particular extended LAN
  - IEEE 802.1 specification for LAN bridges is based on this algorithm

  - Each bridge decides the ports over which it is and is not willing to forward frames
    - In a sense, it is by removing ports from the topology that the extended LAN is reduced to an acyclic tree
    - It is even possible that an entire bridge will not participate in forwarding frames

Spanning Tree Algorithm

- Algorithm is dynamic
  - The bridges are always prepared to reconfigure themselves into a new spanning tree if some bridges fail

- Main idea
  - Each bridge selects the ports over which they will forward the frames

Spanning Tree Algorithm

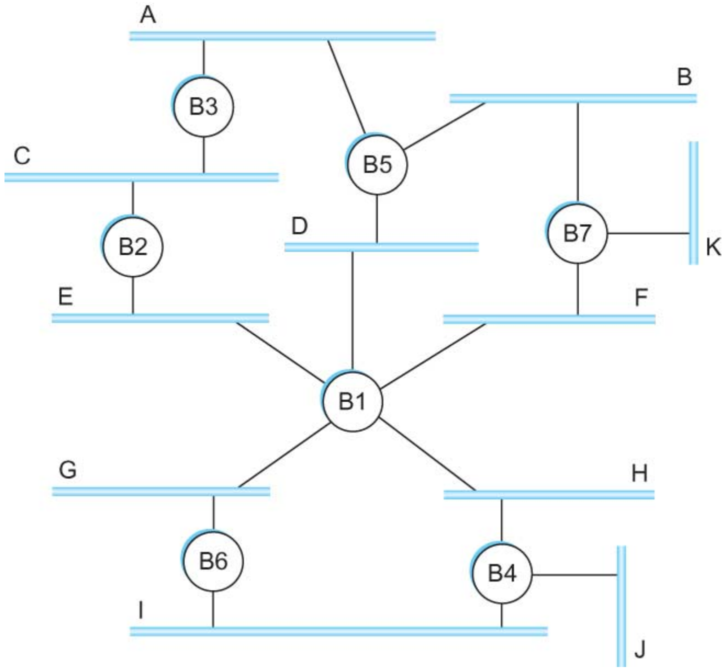
- Algorithm selects ports as follows:
  - Each bridge has a unique identifier
    - B1, B2, B3,…and so on.
  - Elect the bridge with the smallest id as the root of the spanning tree
  - The root bridge always forwards frames out over all of its ports
  - Each bridge computes the shortest path to the root and notes which of its ports is on this path
    - This port is selected as the bridge's preferred path to the root
  - Finally, all the bridges connected to a given LAN elect a single designated bridge that will be responsible for forwarding frames toward the root bridge

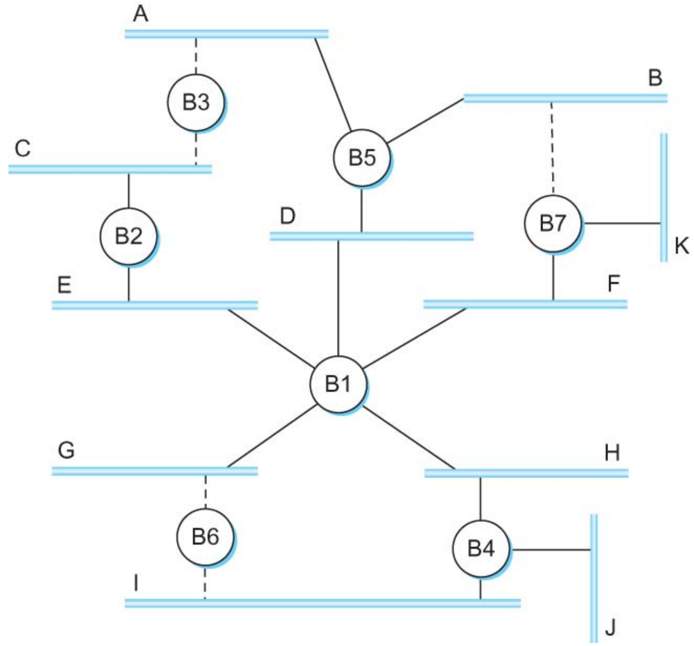
Spanning Tree Algorithm

- Each LAN's designated bridge is the one that is closest to the root
- If two or more bridges are equally close to the root,
  - Then select bridge with the smallest id
- Each bridge is connected to more than one LAN
  - So it participates in the election of a designated bridge for each LAN it is connected to.
  - Each bridge decides if it is the designated bridge relative to each of its ports
  - The bridge forwards frames over those ports for which it is the designated bridge

Spanning Tree Algorithm

- B1 is the root bridge
- B3 and B5 are connected to LAN A, but B5 is the designated bridge
- B5 and B7 are connected to LAN B, but B5 is the designated bridge





Spanning Tree Algorithm

- Initially each bridge thinks it is the root, so it sends a configuration message on each of its ports identifying itself as the root and giving a distance to the root of 0
- Upon receiving a configuration message over a particular port, the bridge checks to see if the new message is better than the current best configuration message recorded for that port
- The new configuration is better than the currently recorded information if
  - It identifies a root with a smaller id or
  - It identifies a root with an equal id but with a shorter distance or
  - The root id and distance are equal, but the sending bridge has a smaller id

Spanning Tree Algorithm

- If the new message is better than the currently recorded one,
  - The bridge discards the old information and saves the new information
  - It first adds 1 to the distance-to-root field

- When a bridge receives a configuration message indicating that it is not the root bridge (that is, a message from a bridge with smaller id)
  - The bridge stops generating configuration messages on its own
  - Only forwards configuration messages from other bridges after 1 adding to the distance field

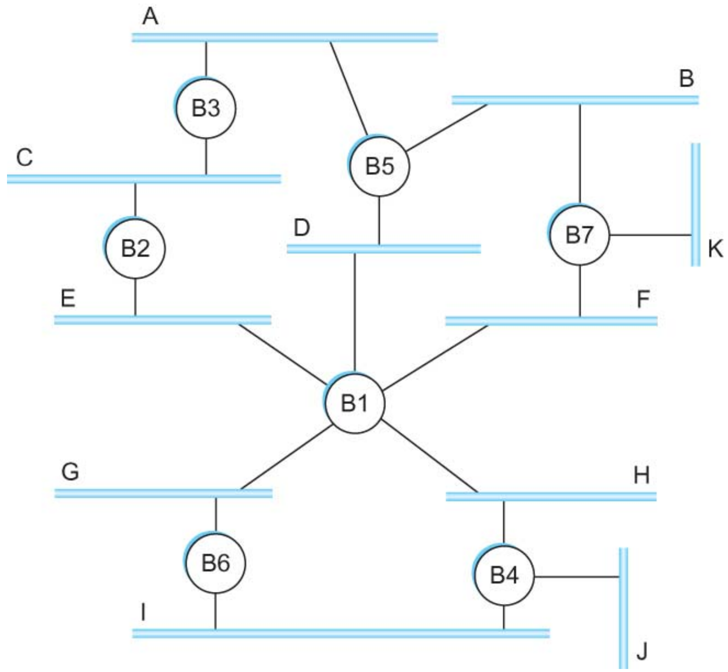
Spanning Tree Algorithm

- When a bridge receives a configuration message that indicates it is not the designated bridge for that port
  - => a message from a bridge that is closer to the root or equally far from the root but with a smaller id
    - The bridge stops sending configuration messages over that port

- When the system stabilizes,
  - Only the root bridge is still generating configuration messages.
  - Other bridges are forwarding these messages only over ports for which they are the designated bridge

Spanning Tree Algorithm

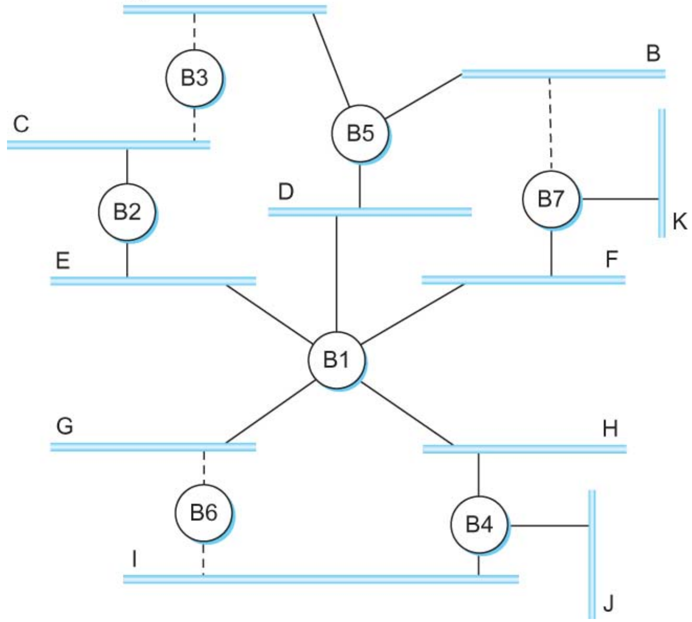
- Consider the situation when the power had just been restored to the building housing the following network



- All bridges would start off by claiming to be the root

Spanning Tree Algorithm

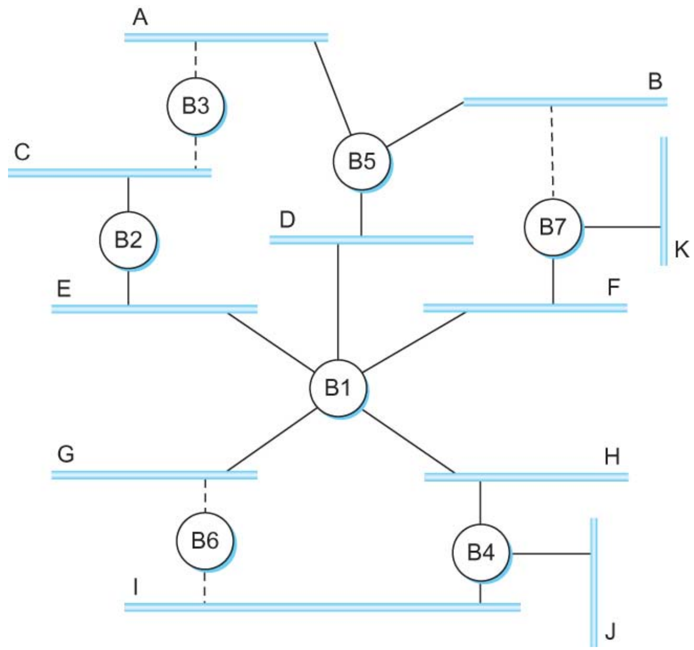
- Denote a configuration message from node X in which it claims to be distance d from the root node Y as (Y, d, X)



- Consider the activity at node B3

Spanning Tree Algorithm

- B3 receives (B2, 0, B2)
- Since 2 < 3, B3 accepts B2 as root
- B3 adds 1 to the distance advertised by B2 and sends (B2, 1, B3) to B5
- Meanwhile B2 accepts B1 as root because it has the lower id and it sends (B1, 1, B2) toward B3
- B5 accepts B1 as root and sends (B1, 1, B5) to B3
- B3 accepts B1 as root and it notes that both B2 and B5 are closer to the root than it is.
  - Thus B3 stops forwarding messages on both its interfaces
  - This leaves B3 with both ports not selected



Spanning Tree Algorithm

- Even after the system has stabilized, the root bridge continues to send configuration messages periodically
  - Other bridges continue to forward these messages
- When a bridge fails, the downstream bridges will not receive the configuration messages
- After waiting a specified period of time, they will once again claim to be the root and the algorithm starts again
- Note
  - Although the algorithm is able to reconfigure the spanning tree whenever a bridge fails, it is not able to forward frames over alternative paths for the sake of routing around a congested bridge

Spanning Tree Algorithm

- Limitation of Bridges
  - Do not scale
    - Spanning tree algorithm does not scale
    - Broadcast does not scale
  - Do not accommodate heterogeneity

Switch

- Link layer device
  - stores and forwards Ethernet frames
  - examines frame header and selectively forwards frame based on MAC dest address
  - when frame is to be forwarded on segment, uses CSMA/CD to access segment
- transparent
  - hosts are unaware of presence of switches
- plug-and-play, self-learning
  - switches do not need to be configured

Self learning

- A switch has a switch table
- entry in switch table:
  - (MAC Address, Interface, Time Stamp)
  - stale entries in table dropped (TTL can be 60 min)
- switch *learns* which hosts can be reached through which interfaces
  - when frame received, switch "learns" location of sender: incoming LAN segment
  - records sender/location pair in switch table

Filtering/Forwarding

When switch receives a frame:

index switch table using MAC dest address

if entry found for destination
  then{

    if dest on segment from which frame arrived
      then drop the frame

      else forward the frame on interface indicated

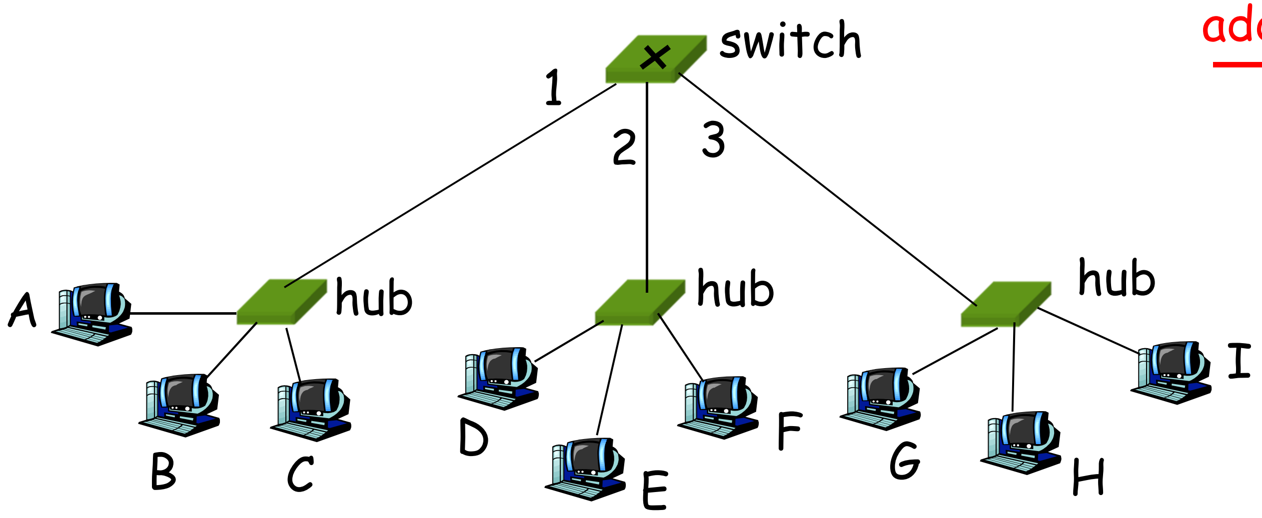
    }

  else flood

forward on all but the interface on which the frame arrived

Switch example

Suppose C sends frame to D

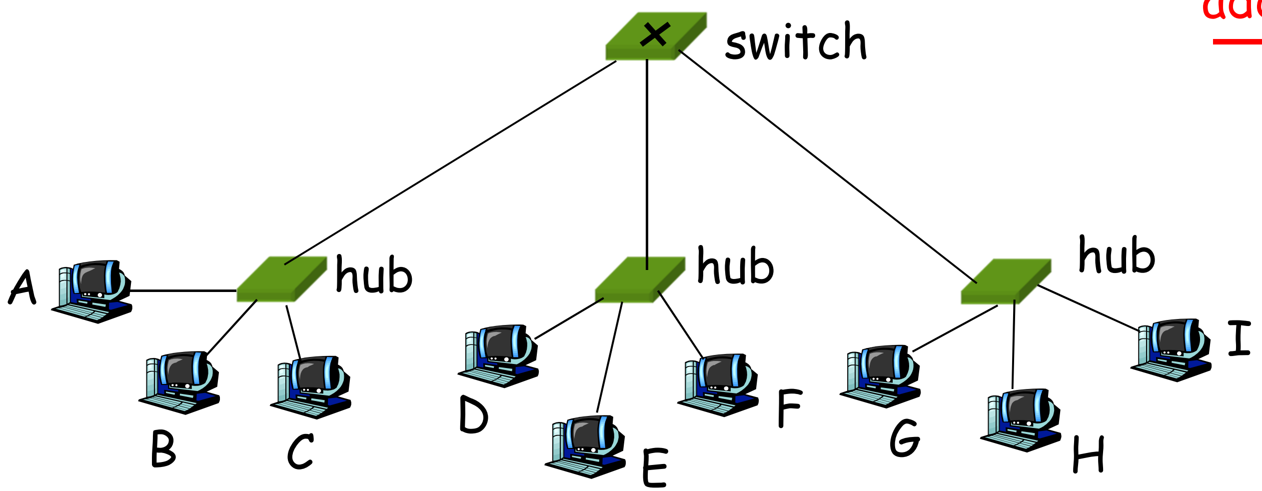


address	interface
A	1
B	1
E	2
G	3

- Switch receives frame from from C
  - notes in bridge table that C is on interface 1
  - because D is not in table, switch forwards frame into interfaces 2 and 3
- frame received by D

Switch example

Suppose D replies back with frame to C.

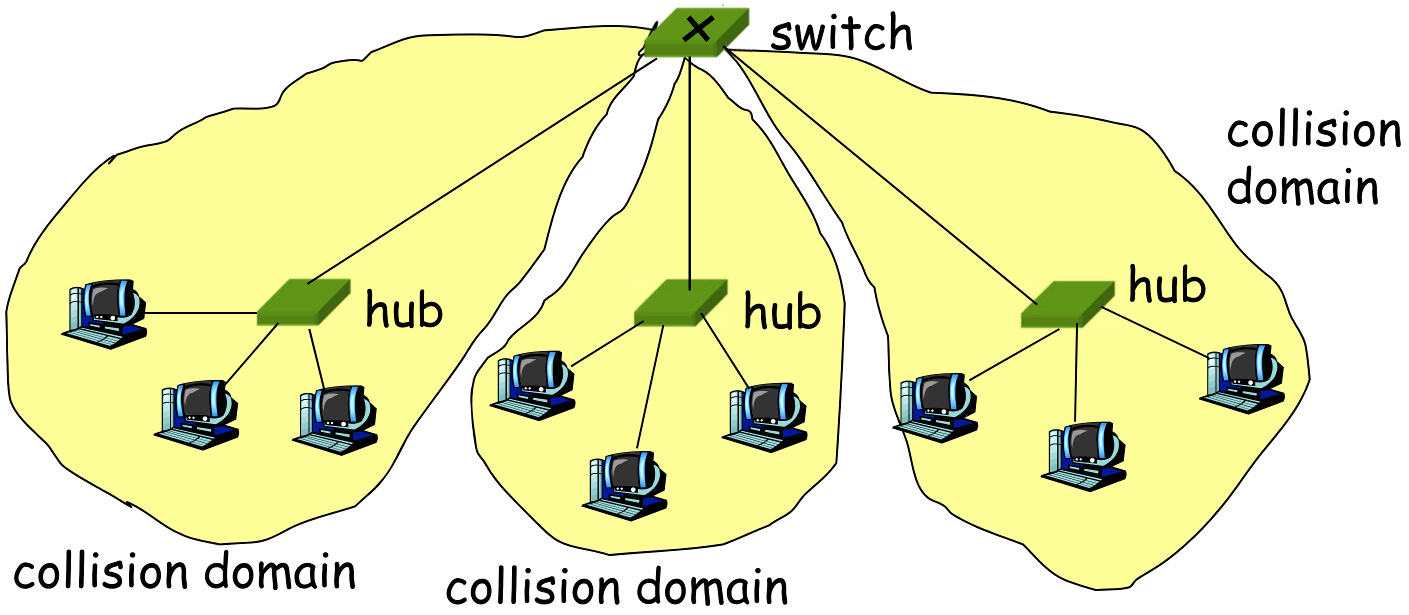


address	interface
A	1
B	1
E	2
G	3
C	1

- Switch receives frame from from D
  - notes in bridge table that D is on interface 2
  - because C is in table, switch forwards frame only to interface 1
- frame received by C

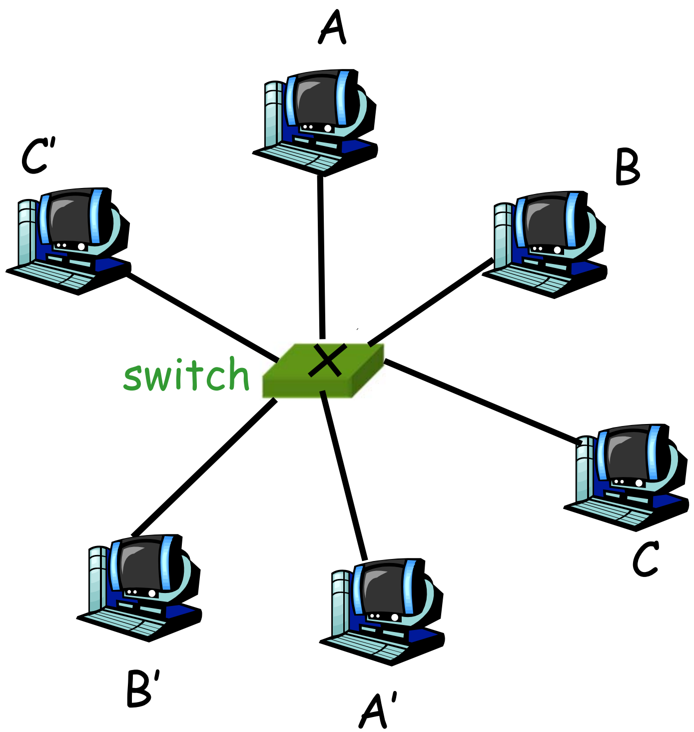
Switch: traffic isolation

- switch installation breaks subnet into LAN segments
- switch filters packets:
  - same-LAN-segment frames not usually forwarded onto other LAN segments
  - segments become separate collision domains



Switches: dedicated access

- Switch with many interfaces
- Hosts have direct connection to switch
- No collisions; full duplex

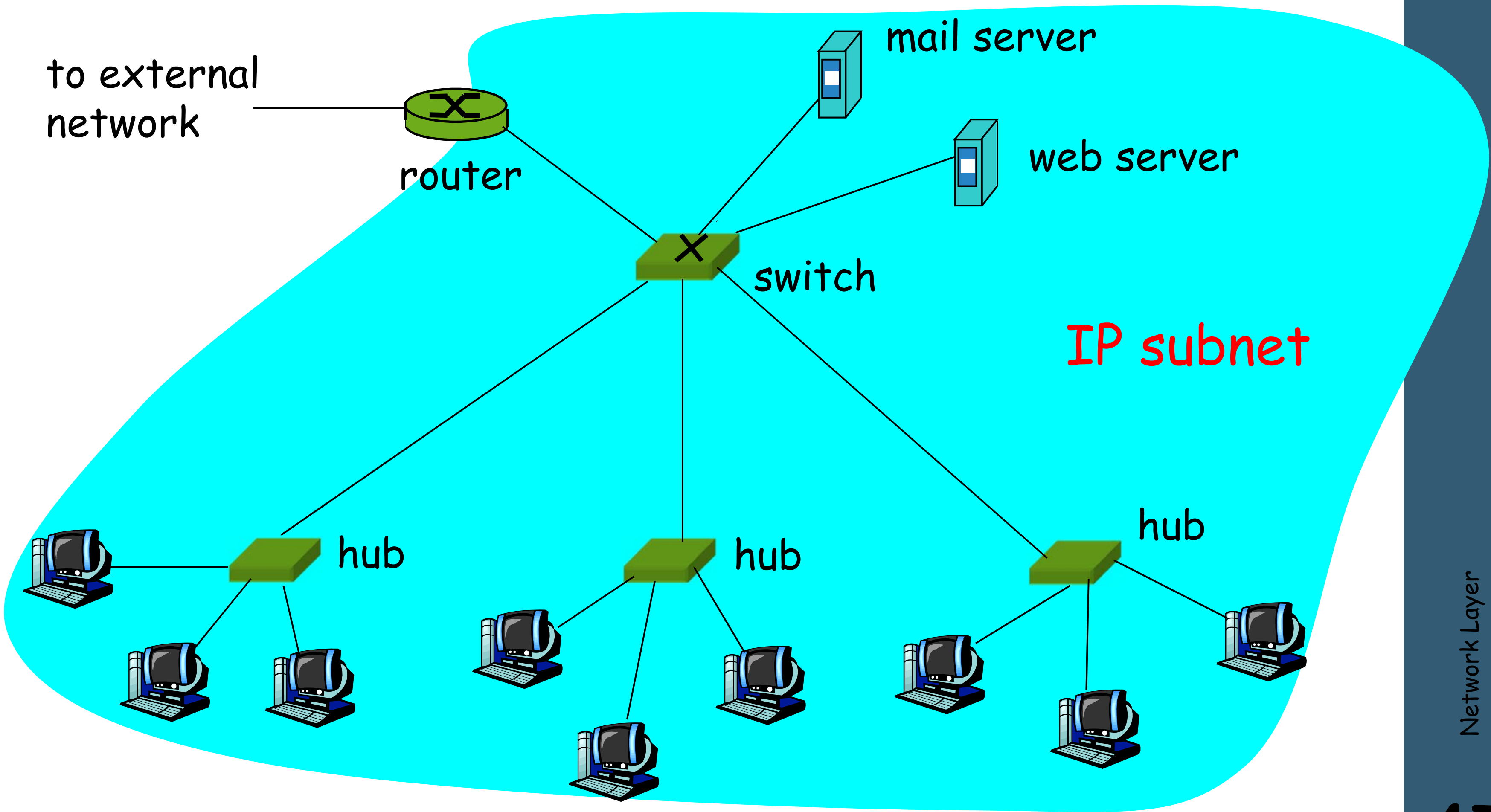


Switching: A-to-A' and B-to-B' simultaneously, no collisions

More on Switches

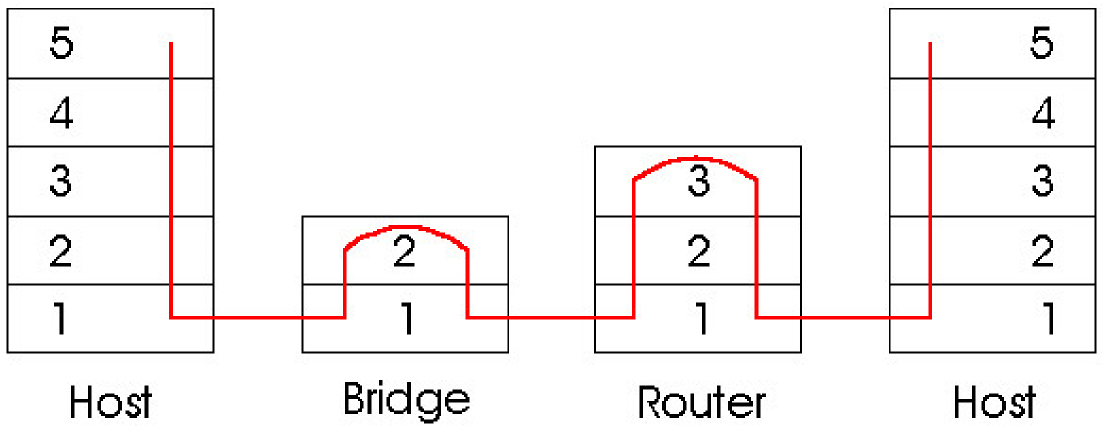
- cut-through switching: frame forwarded from input to output port without first collecting entire frame
  - slight reduction in latency
- combinations of shared/dedicated, 10/100/1000 Mbps interfaces

Institutional network



Switches vs. Routers

- both store-and-forward devices
  - routers: network layer devices (examine network layer headers)
  - switches are link layer devices
- routers maintain routing tables, implement routing algorithms
- switches maintain switch tables, implement filtering, learning algorithms

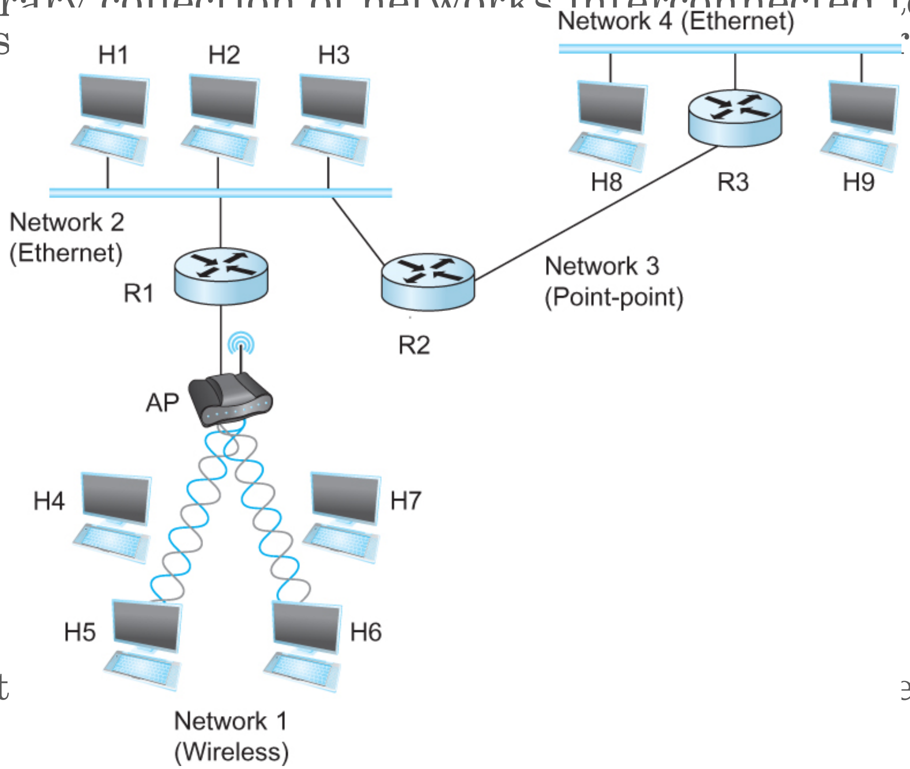


Summary comparison

	hubs	switches	routers
traffic isolation	no	yes	yes
plug & play	yes	yes	no
optimal routing	no	no	yes
cut through	yes	yes	no

Internetworking

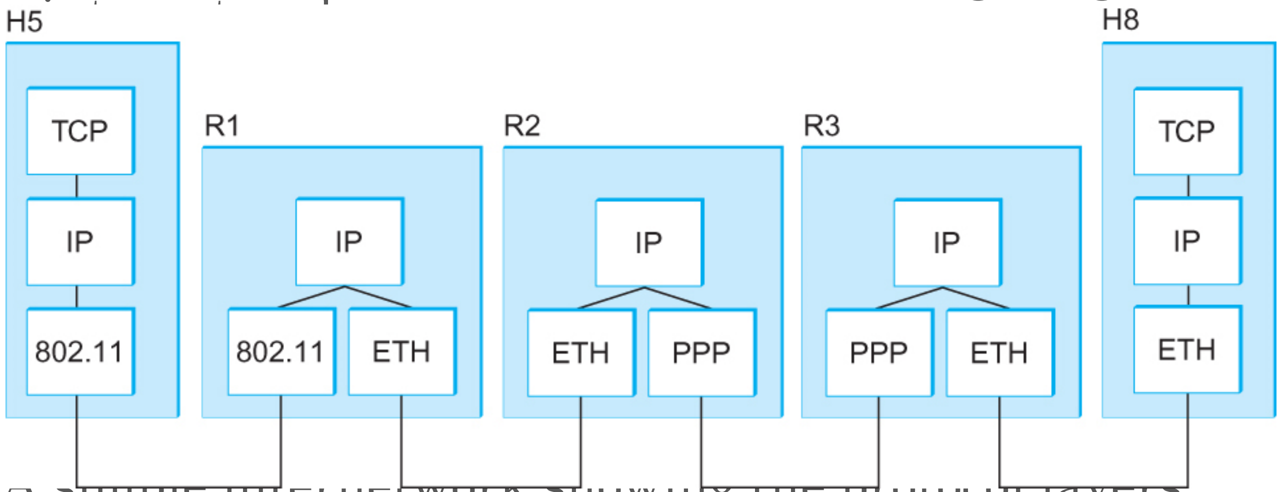
- What is internetwork
  - An arbitrary collection of networks interconnected to provide s… …rvice



A simple int… …esents routers

Internetworking

- What is IP
  - IP stands for Internet Protocol
  - Key tool used today to build scalable, heterogeneous internetworks
  - It runs on all the nodes in a collection of networks and defines the infrastructure that allows these nodes and networks to function as a single logical



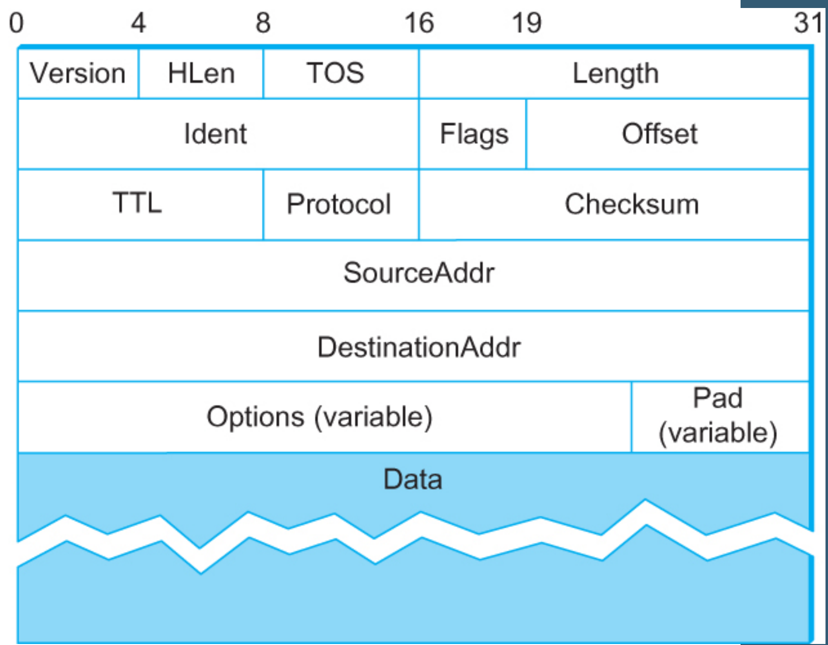
A simple internetwork showing the protocol layers

IP Service Model

- Packet Delivery Model
  - Connectionless model for data delivery
  - Best-effort delivery (unreliable service)
    - packets are lost
    - packets are delivered out of order
    - duplicate copies of a packet are delivered
    - packets can be delayed for a long time
- Global Addressing Scheme
  - Provides a way to identify all hosts in the network

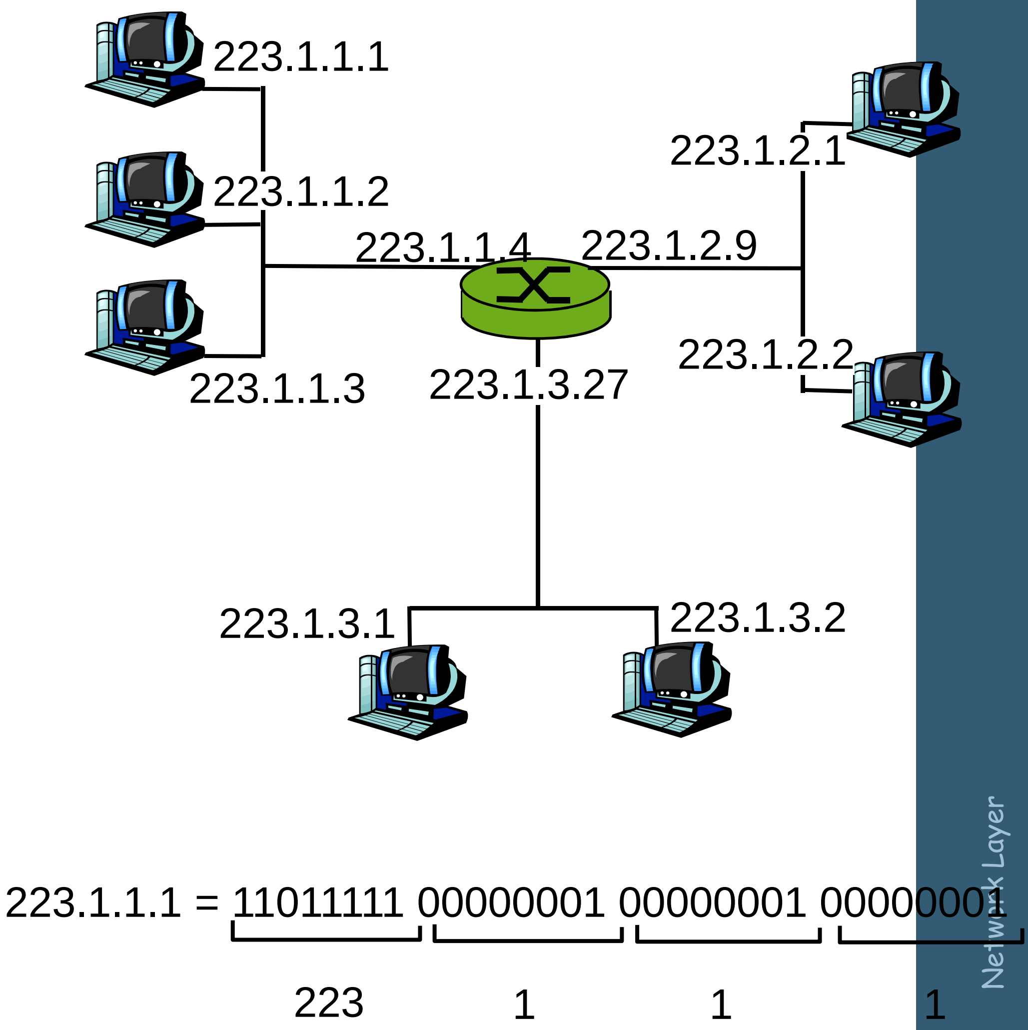
Packet Format

- Version (4): currently 4
- Hlen (4): number of 32-bit words in header
- TOS (8): type of service (not widely used)
- Length (16): number of bytes in this datagram
- Ident (16): used by fragmentation
- Flags/Offset (16): used by fragmentation
- TTL (8): number of hops this datagram has traveled
- Protocol (8): demux key (TCP=6, UDP=17)
- Checksum (16): of the header only
- DestAddr & SrcAddr (32)

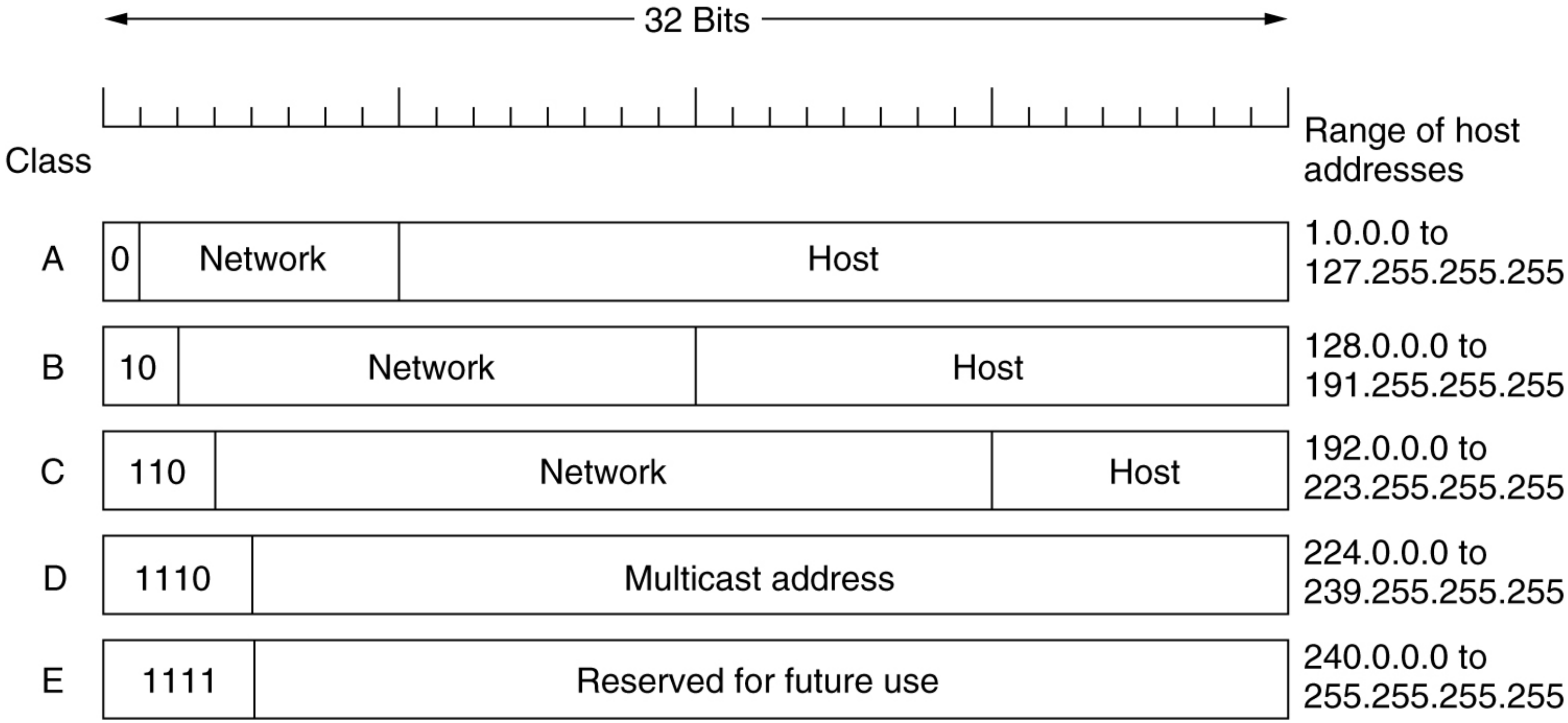


IP Addressing: introduction

- 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 each interface



IP Addresses



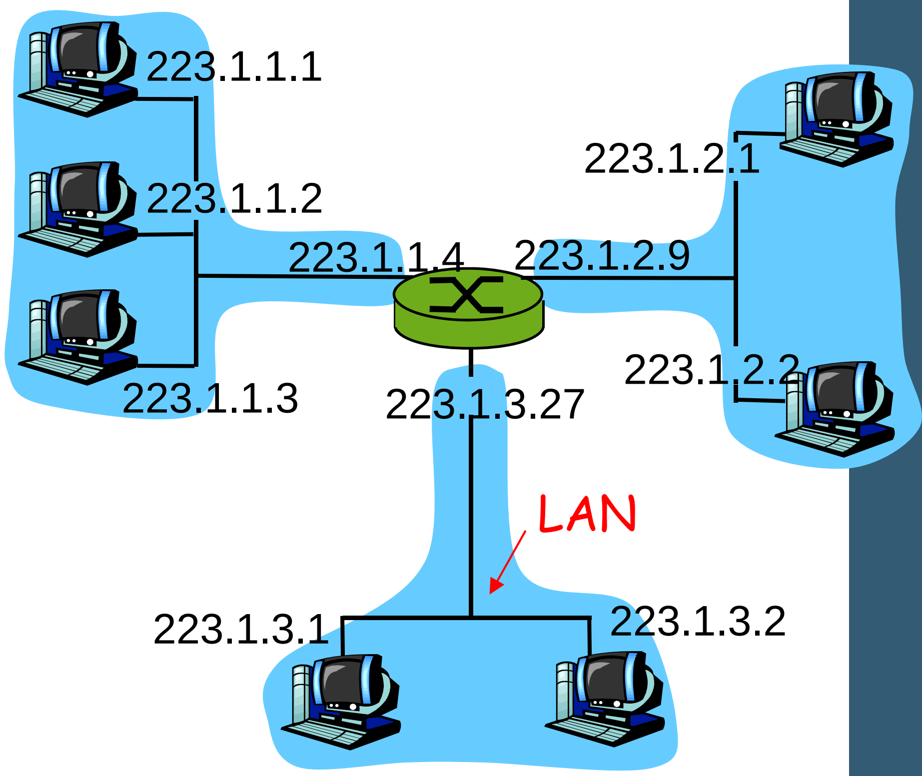
IP Addresses (2)

Special IP addresses.

Address	
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	This host
0 0 . . . 0 0 | Host	A host on this network
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Broadcast on the local network
Network | 1 1 1 1 . . . 1 1 1 1	Broadcast on a distant network
127 | (Anything)	Loopback

Subnets

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

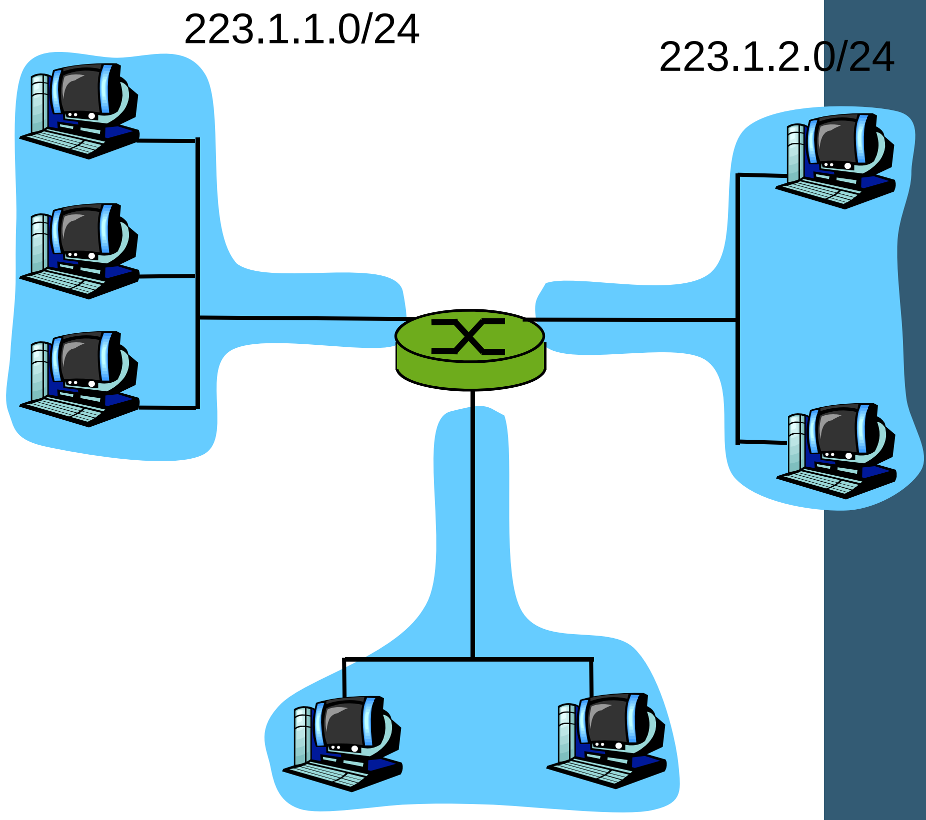


network consisting of 3 subnets

Subnets

Recipe

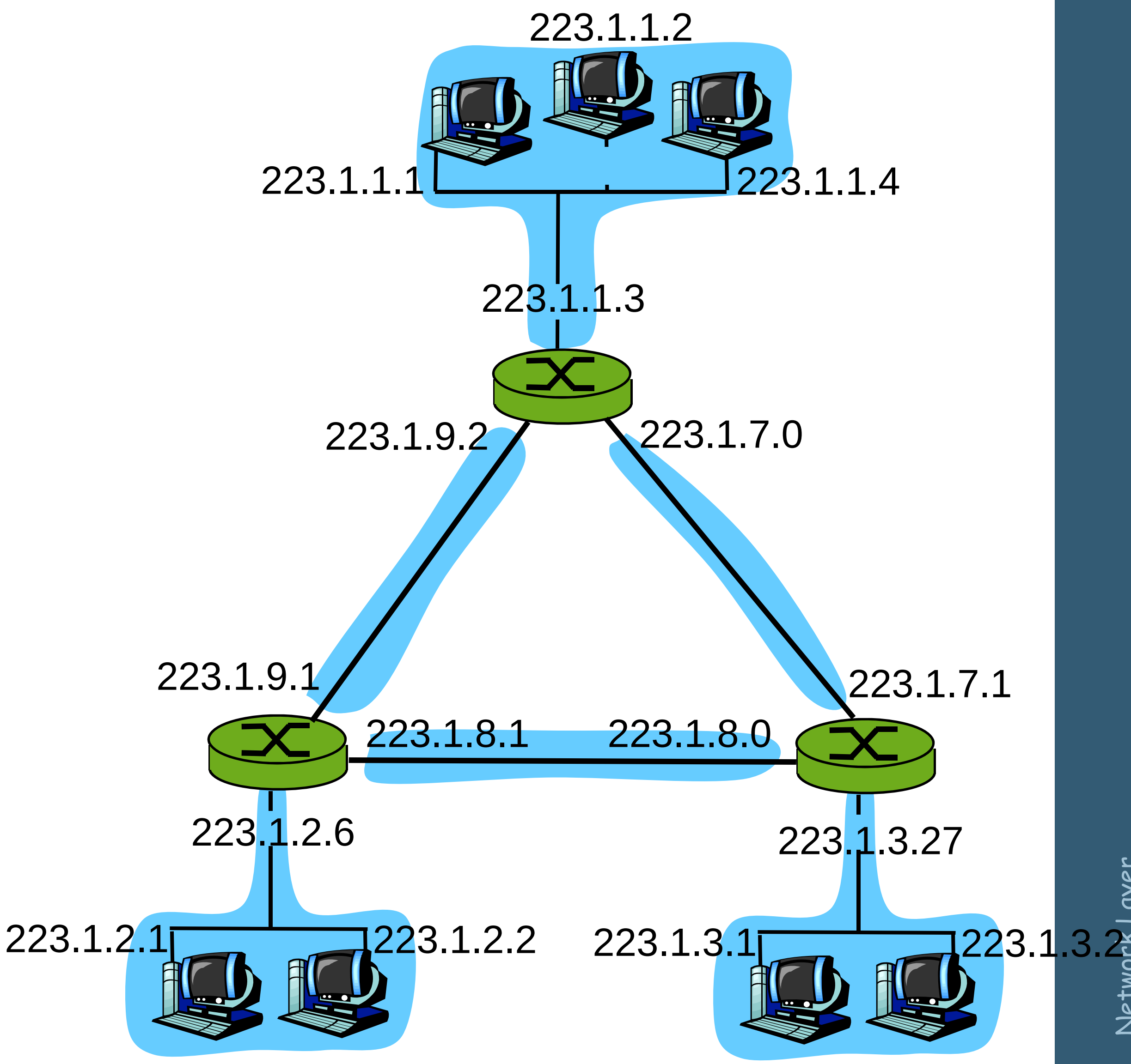
- To determine the subnets, detach each interface from its host or router, creating islands of isolated networks. Each isolated network is called a subnet.



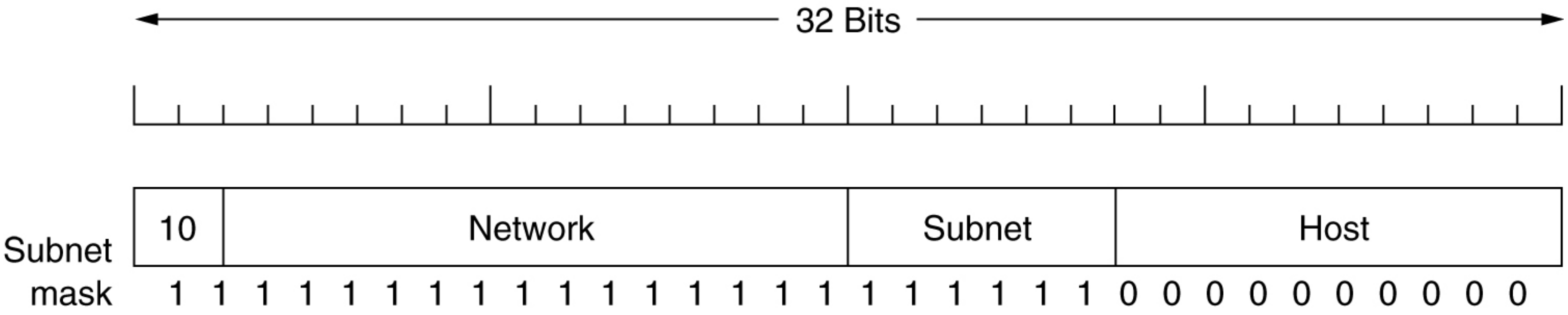
Subnet mask: /24

Subnets

How many?

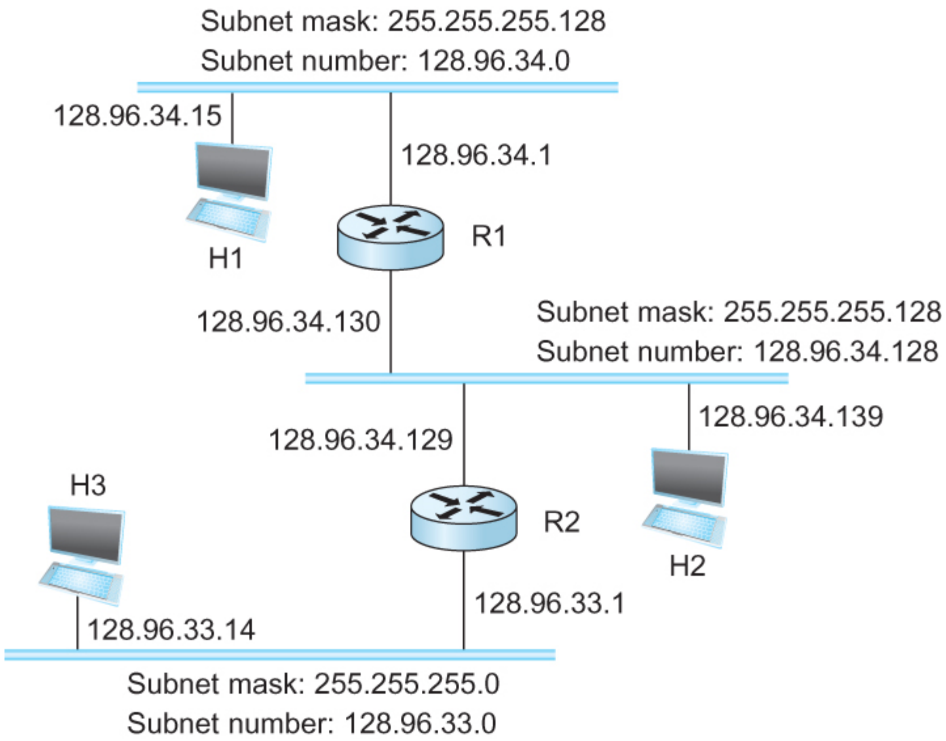


Subnets



A class B network subnetted into 64 subnets.

Subnetting



SubnetNumber	SubnetMask	NextHop
128.96.34.0	255.255.255.128	Interface 0
128.96.34.128	255.255.255.128	Interface 1
128.96.33.0	255.255.255.0	R2

- Forwar

Subnetting

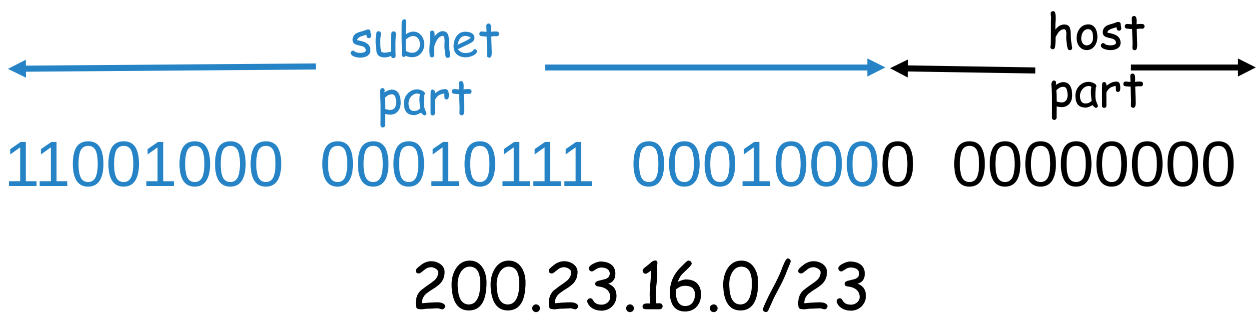
Forwarding Algorithm

```
D = destination IP address
for each entry < SubnetNum, SubnetMask,
 NextHop>
  D1 = SubnetMask & D
  if D1 = SubnetNum
    if NextHop is an interface
       deliver datagram directly to
     destination
    else
       deliver datagram to NextHop (a
     router)
```

IP addressing: CIDR

CIDR: Classless InterDomain Routing

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



CDR – Classless InterDomain Routing

A set of IP address assignments.

University	First address	Last address	How many	Written as
Cambridge	194.24.0.0	194.24.7.255	2048	194.24.0.0/21
Edinburgh	194.24.8.0	194.24.11.255	1024	194.24.8.0/22
(Available)	194.24.12.0	194.24.15.255	1024	194.24.12/22
Oxford	194.24.16.0	194.24.31.255	4096	194.24.16.0/20

IP addresses: how to get one?

Q: How does *network* get subnet part of IP addr?

A: gets allocated portion of its provider ISP's address space

ISP's block	11001000 00010111 00010000 00000000	200.23.16.0/20
Organization 0	11001000 00010111 00010000 00000000	200.23.16.0/23
Organization 1	11001000 00010111 00010010 00000000	200.23.18.0/23
Organization 2	11001000 00010111 00010100 00000000	200.23.20.0/23
...	....	....
Organization 7	11001000 00010111 00011110 00000000	200.23.30.0/23

IP addresses: how to get one?

Q: How does *host* get IP address?

- hard-coded by system admin in a file
  - Wintel: control-panel->network->configuration->tcp/ip->properties
  - UNIX: /etc/rc.config
- DHCP: Dynamic Host Configuration Protocol: dynamically get address from as server
  - "plug-and-play"

DHCP

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

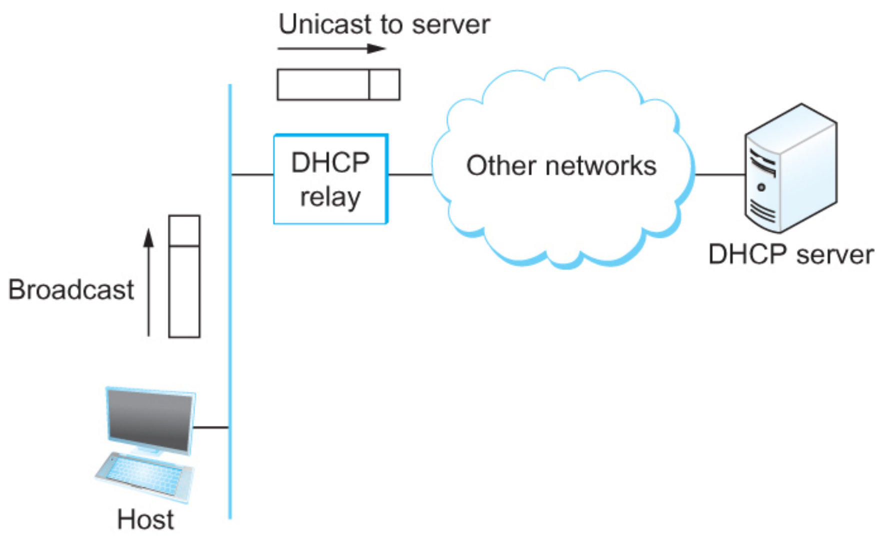
- can renew its lease on address in use
- allows reuse of addresses (only hold address while connected/ "on")
- support for mobile users who want to join network

DHCP overview:

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

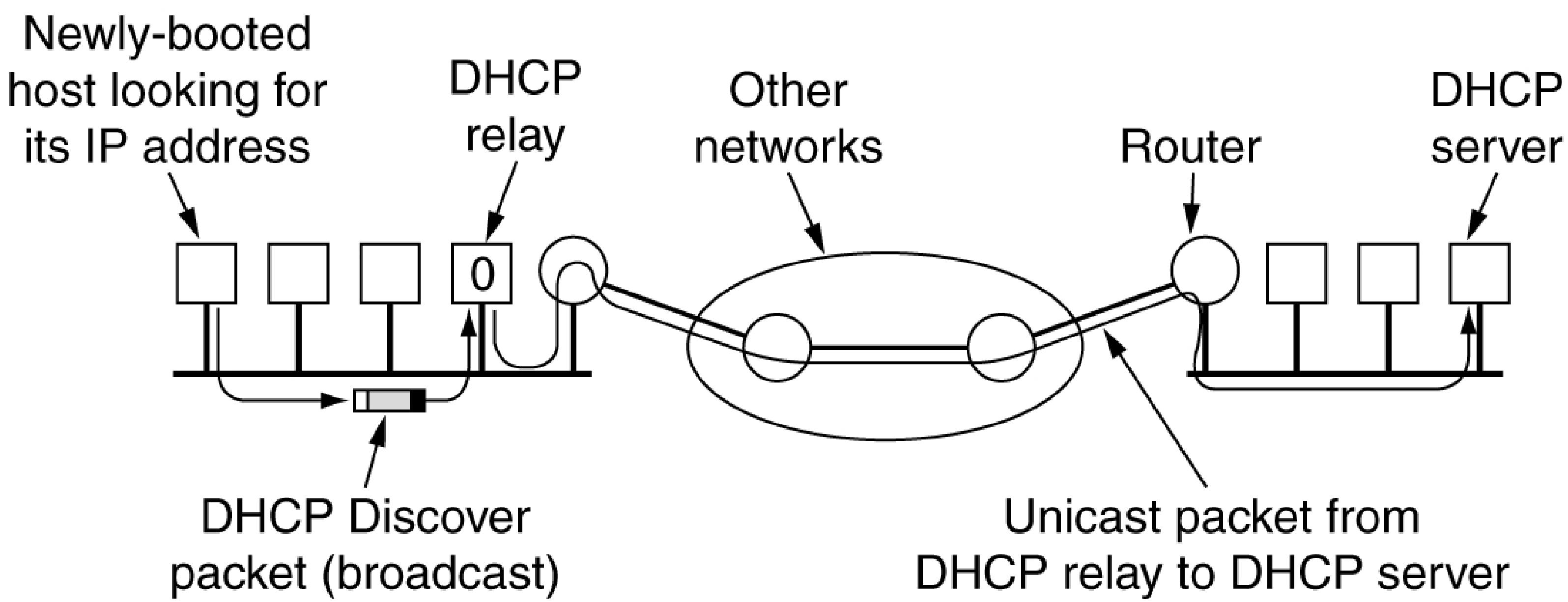
DHCP

- There is at least one DHCP server for an administrative domain
- DHCP server maintains a pool of available addresses
- Newly booted or attached host sends DHCPDISCOVER message to a special IP address (255.255.255.255)
- DHCP relay agent unicasts the message to DHCP server and waits for the response

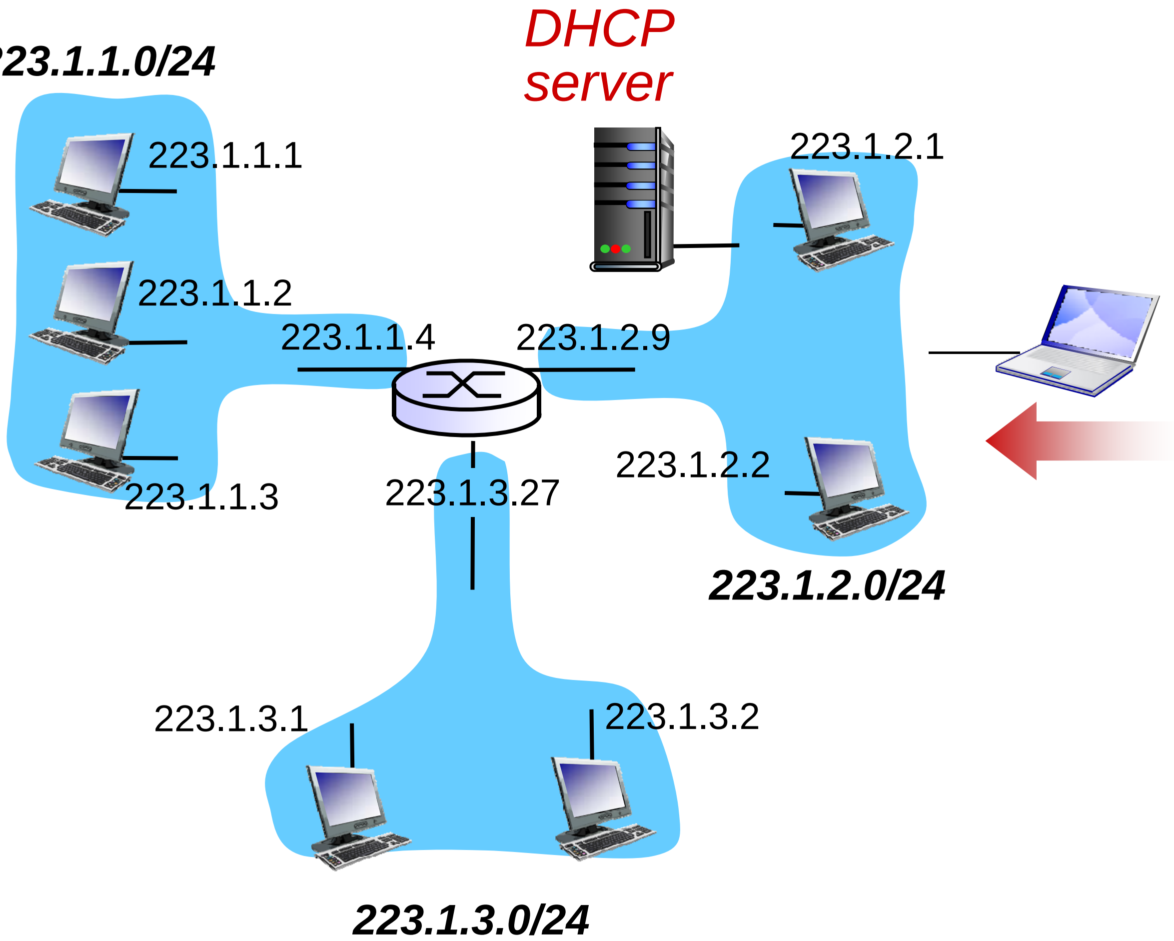


DHCP

Operation of DHCP.

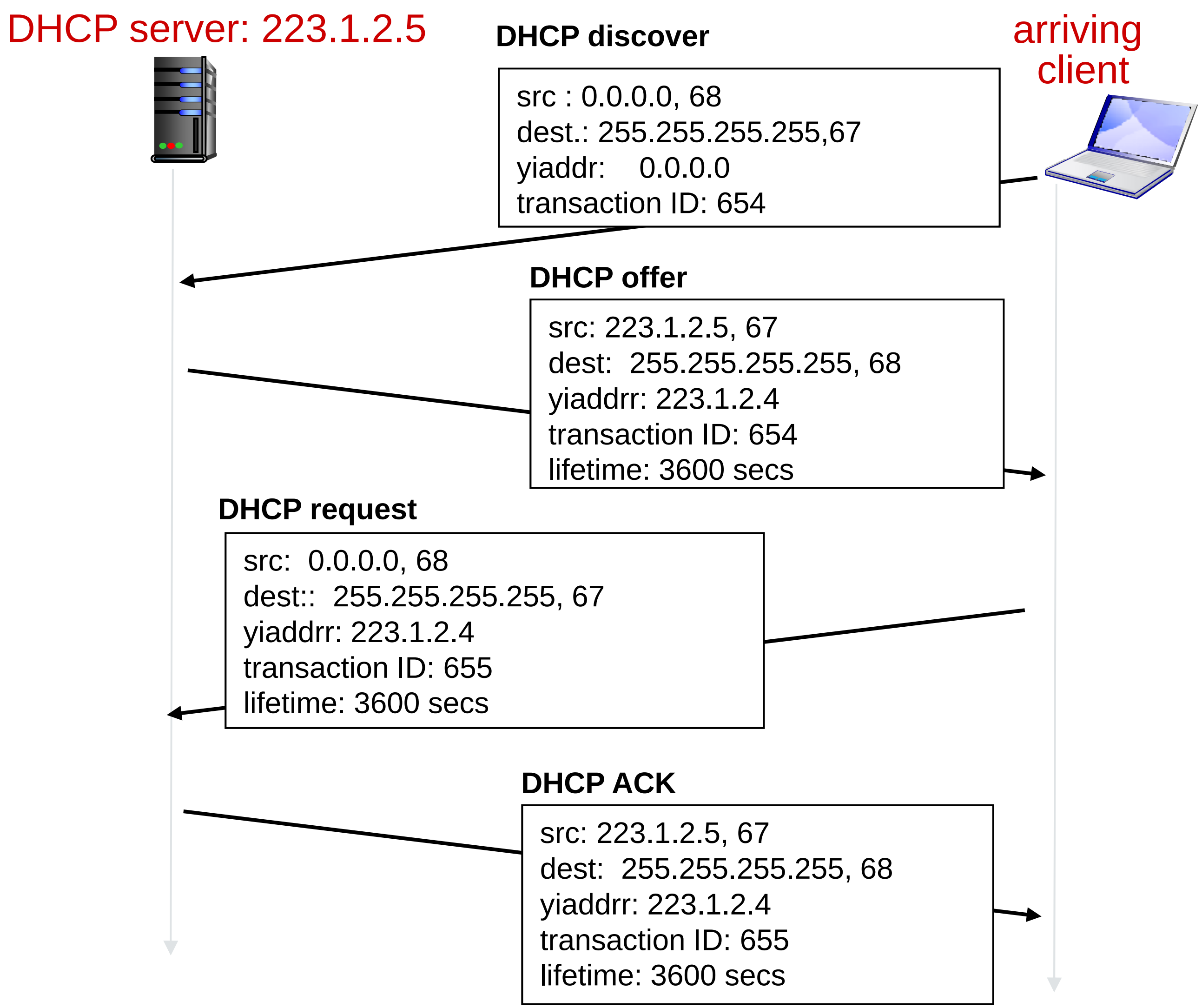


DHCP client-server scenario



arriving DHCP client needs address in this network

DHCP client-server scenario

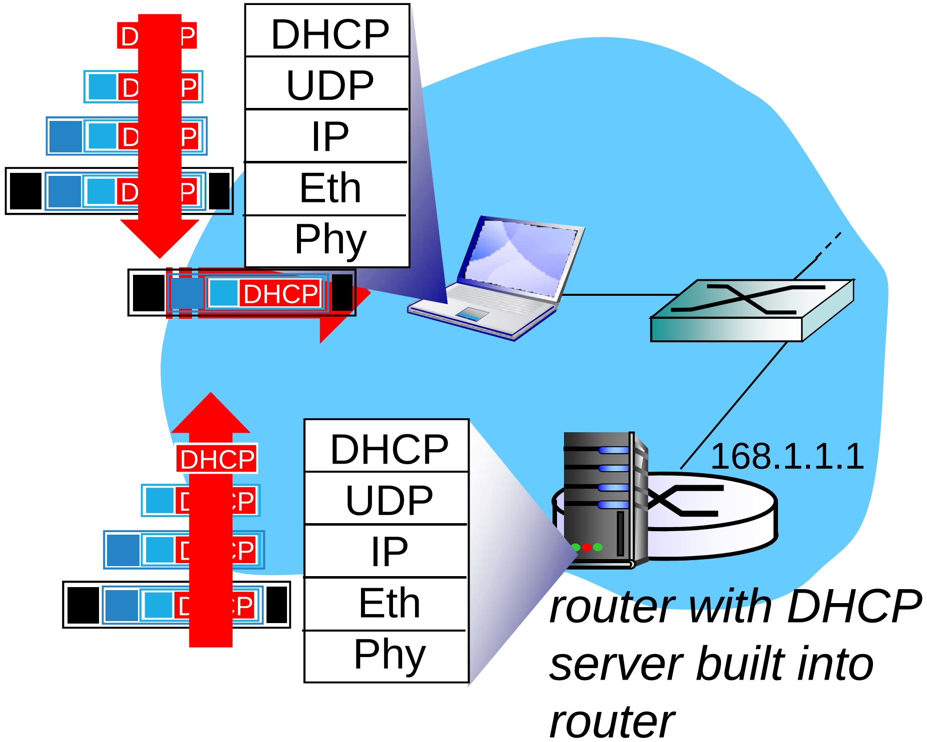


DHCP: more than IP addresses

DHCP can return more than just allocated IP address on subnet:

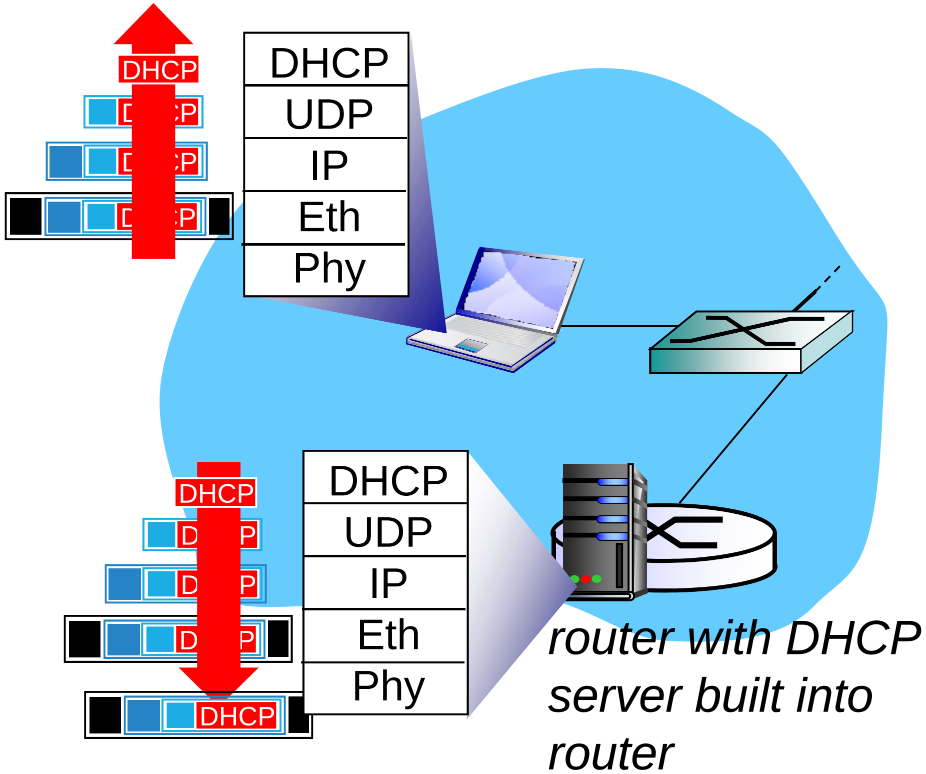
- address of first-hop router for client
- name and IP address of DNS sever
- network mask (indicating network versus host portion of address)

DHCP: example



- connecting laptop needs its IP address, addr of first-hop router, addr of DNS server: use DHCP
- DHCP request encapsulated in UDP, encapsulated in IP, encapsulated in 802.1 Ethernet
- Ethernet frame broadcast (dest: FFFFFFFFFFFF) on LAN, received at router running DHCP server
- Ethernet demuxed to IP demuxed, UDP demuxed to DHCP

DHCP: example



- DCP server formulates DHCP ACK containing client's IP address, IP address of first-hop router for client, name & IP address of DNS server
- encapsulation of DHCP server, frame forwarded to client, demuxing up to DHCP at client
- client now knows its IP address, name and IP address of DSN server, IP address of its first-hop router

DHCP: Wireshark output (home LAN)

request

Message type: **Boot Request (1)**
Hardware type: Ethernet
Hardware address length: 6
Hops: 0
Transaction ID: 0x6b3a11b7
Seconds elapsed: 0
Bootp flags: 0x0000 (Unicast)
Client IP address: 0.0.0.0 (0.0.0.0)
Your (client) IP address: 0.0.0.0 (0.0.0.0)
Next server IP address: 0.0.0.0 (0.0.0.0)
Relay agent IP address: 0.0.0.0 (0.0.0.0)
Client MAC address: Wistron_23:68:8a (00:16:d3:23:68:8a)
Server host name not given
Boot file name not given
Magic cookie: (OK)
Option: (t=53,l=1) **DHCP Message Type = DHCP Request**
Option: (61) Client identifier
    Length: 7; Value: 010016D323688A;
    Hardware type: Ethernet
    Client MAC address: Wistron_23:68:8a (00:16:d3:23:68:8a)
Option: (t=50,l=4) Requested IP Address = 192.168.1.101
Option: (t=12,l=5) Host Name = "nomad"
Option: (55) Parameter Request List
    Length: 11; Value: 010F03062C2E2F1F21F92B
    1 = Subnet Mask; 15 = Domain Name
    3 = Router; 6 = Domain Name Server
    44 = NetBIOS over TCP/IP Name Server
    ……

reply

Message type: **Boot Reply (2)**
Hardware type: Ethernet
Hardware address length: 6
Hops: 0
Transaction ID: 0x6b3a11b7
Seconds elapsed: 0
Bootp flags: 0x0000 (Unicast)
Client IP address: 192.168.1.101 (192.168.1.101)
Your (client) IP address: 0.0.0.0 (0.0.0.0)
Next server IP address: 192.168.1.1 (192.168.1.1)
Relay agent IP address: 0.0.0.0 (0.0.0.0)
Client MAC address: Wistron_23:68:8a (00:16:d3:23:68:8a)
Server host name not given
Boot file name not given
Magic cookie: (OK)
Option: (t=53,l=1) DHCP Message Type = DHCP ACK
Option: (t=54,l=4) Server Identifier = 192.168.1.1
Option: (t=1,l=4) Subnet Mask = 255.255.255.0
Option: (t=3,l=4) Router = 192.168.1.1
Option: (6) Domain Name Server
    Length: 12; Value: 445747E2445749F244574092;
    IP Address: 68.87.71.226;
    IP Address: 68.87.73.242;
    IP Address: 68.87.64.146
Option: (t=15,l=20) Domain Name = "hsd1.ma.comcast.net."

IP addressing: the last word...

Q: How does an ISP get block of addresses?

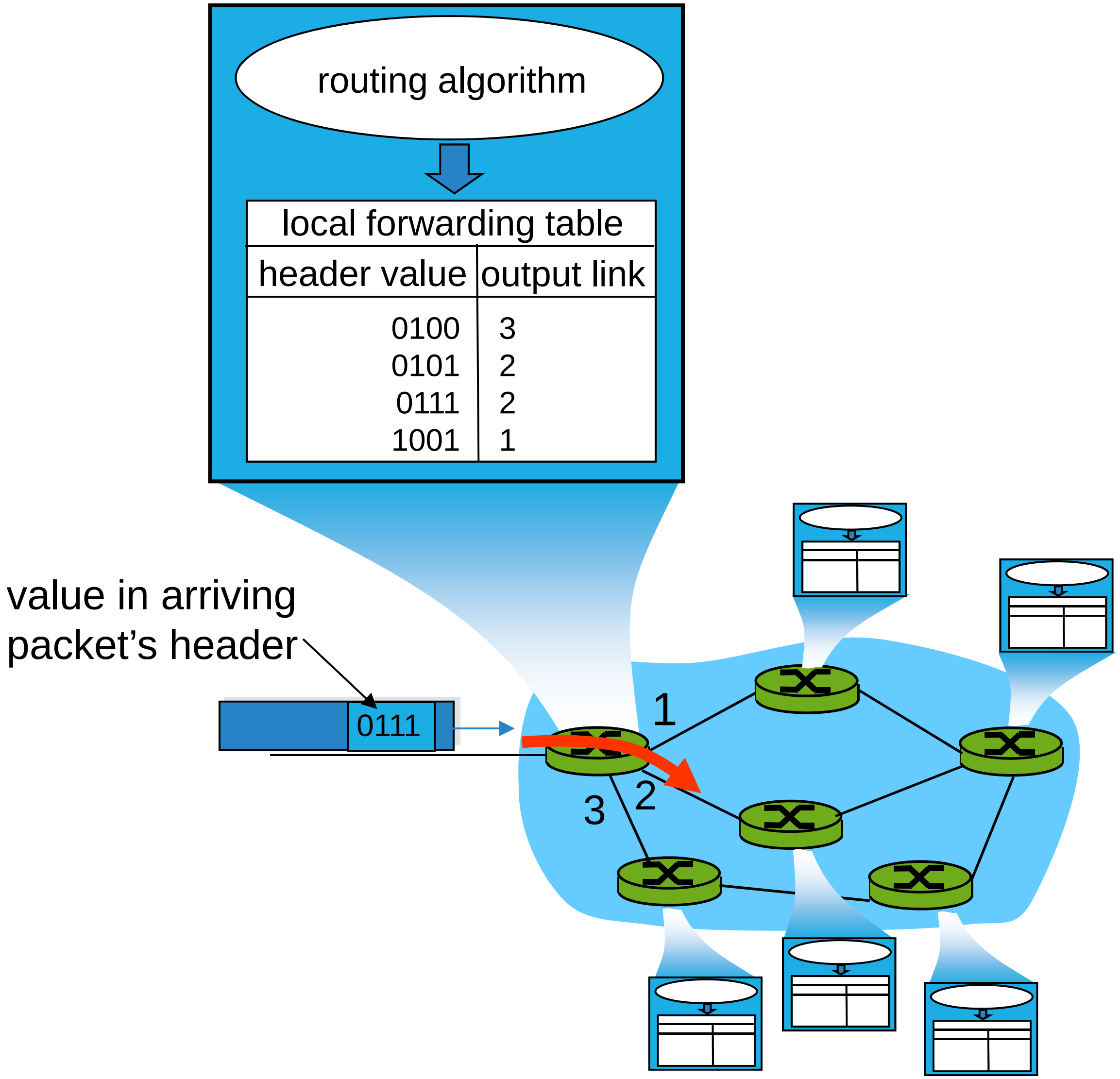
A: ICANN: Internet Corporation for Assigned Names and Numbers

- allocates addresses
- manages DNS
- assigns domain names, resolves disputes

Key Network-Layer Functions

- forwarding: move packets from router's input to appropriate router output
- routing: determine route taken by packets from source to dest.
  - Routing algorithms
- analogy:
  - routing: process of planning trip from source to dest
  - forwarding: process of getting through single interchange

Interplay between routing and forwarding



Forwarding table

4 billion possible entries

Destination Address Range	Link Interface
11001000 00010111 00010000 00000000 through 11001000 00010111 00010111 11111111	0
11001000 00010111 00011000 00000000 through 11001000 00010111 00011000 11111111	1
11001000 00010111 00011001 00000000 through 11001000 00010111 00011111 11111111	2
otherwise	3

Longest prefix matching

Prefix Match	Link Interface
11001000 00010111 00010	0
11001000 00010111 00011000	1
11001000 00010111 00011	2
otherwise	3

Examples

DA: 11001000 00010111 00010110 10100001 Which interface?

DA: 11001000 00010111 00011000 10101010 Which interface?