

Introduction to TCP/IP

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- ❑ Internetworking Protocol (IP)
- ❑ IP Addressing
- ❑ Domain Name System
- ❑ Routing Protocols: RIP, OSPF, BGP
- ❑ Transport Protocols: TCP, UDP

TCP/IP Reference Model

- ❑ TCP = Transport Control Protocol
- ❑ IP = Internet Protocol (Routing)

TCP/IP Model

TCP/IP Protocols

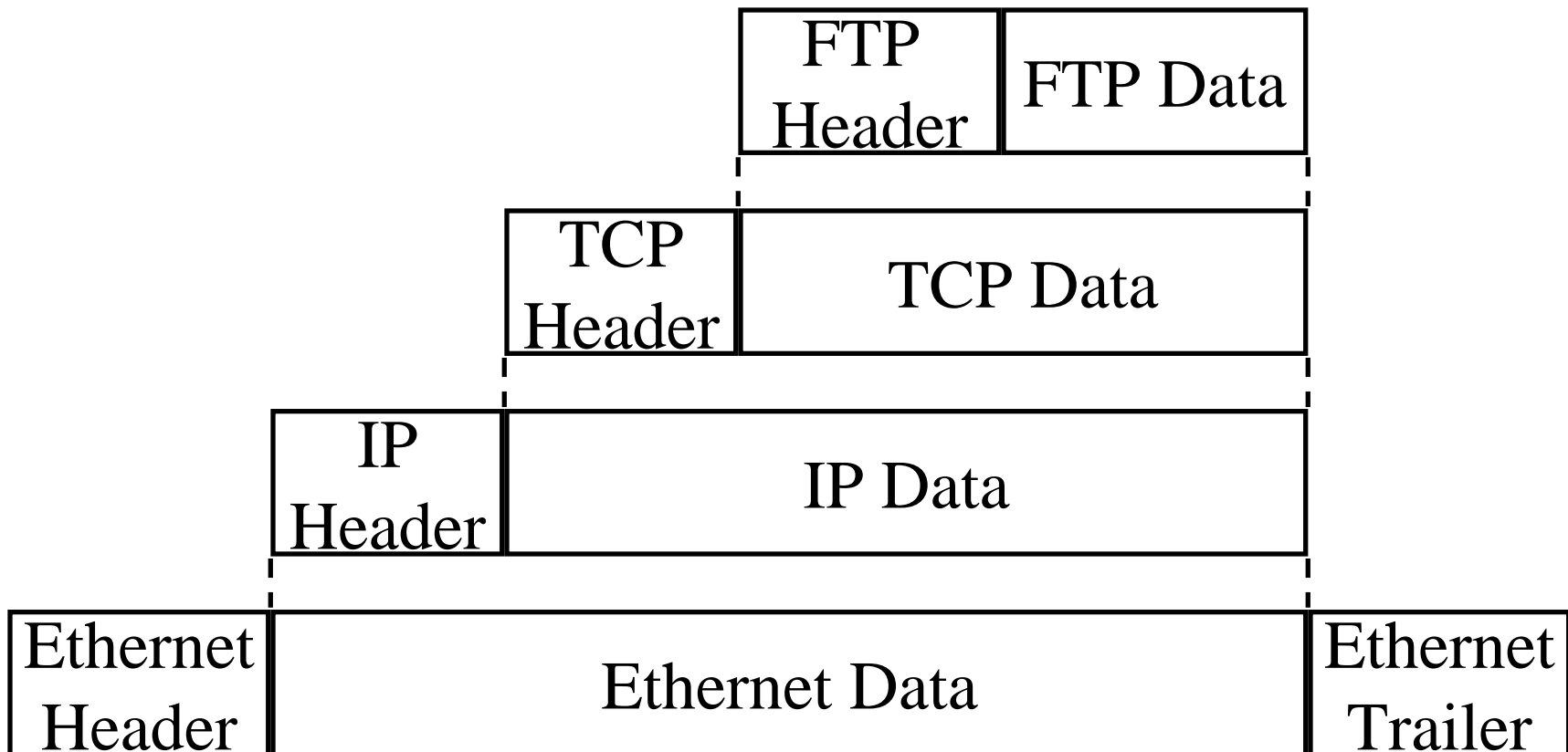
OSI Ref Model

Application	FTP	Telnet	HTTP
Transport	TCP		UDP
Internetwork	IP		
Host to Network	Ether net	Packet Radio	Point-to-Point

Application
Presentation
Session
Transport
Network
Datalink
Physical

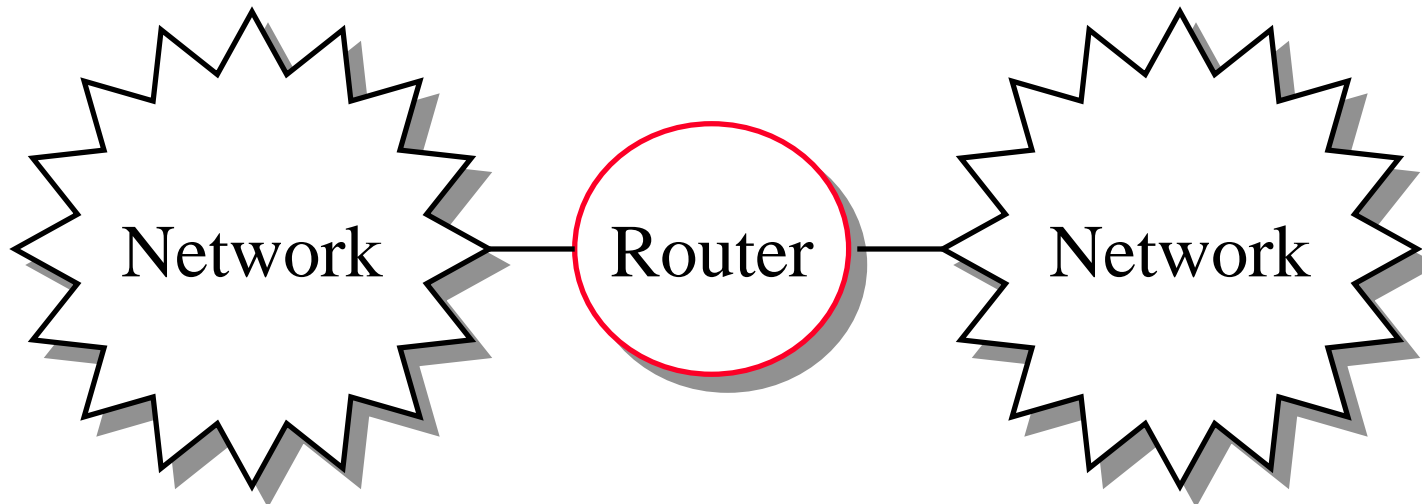
Layered Packet Format

- Nth layer control info is passed as N-1th layer data.
Example: File Transfer Protocol (FTP)



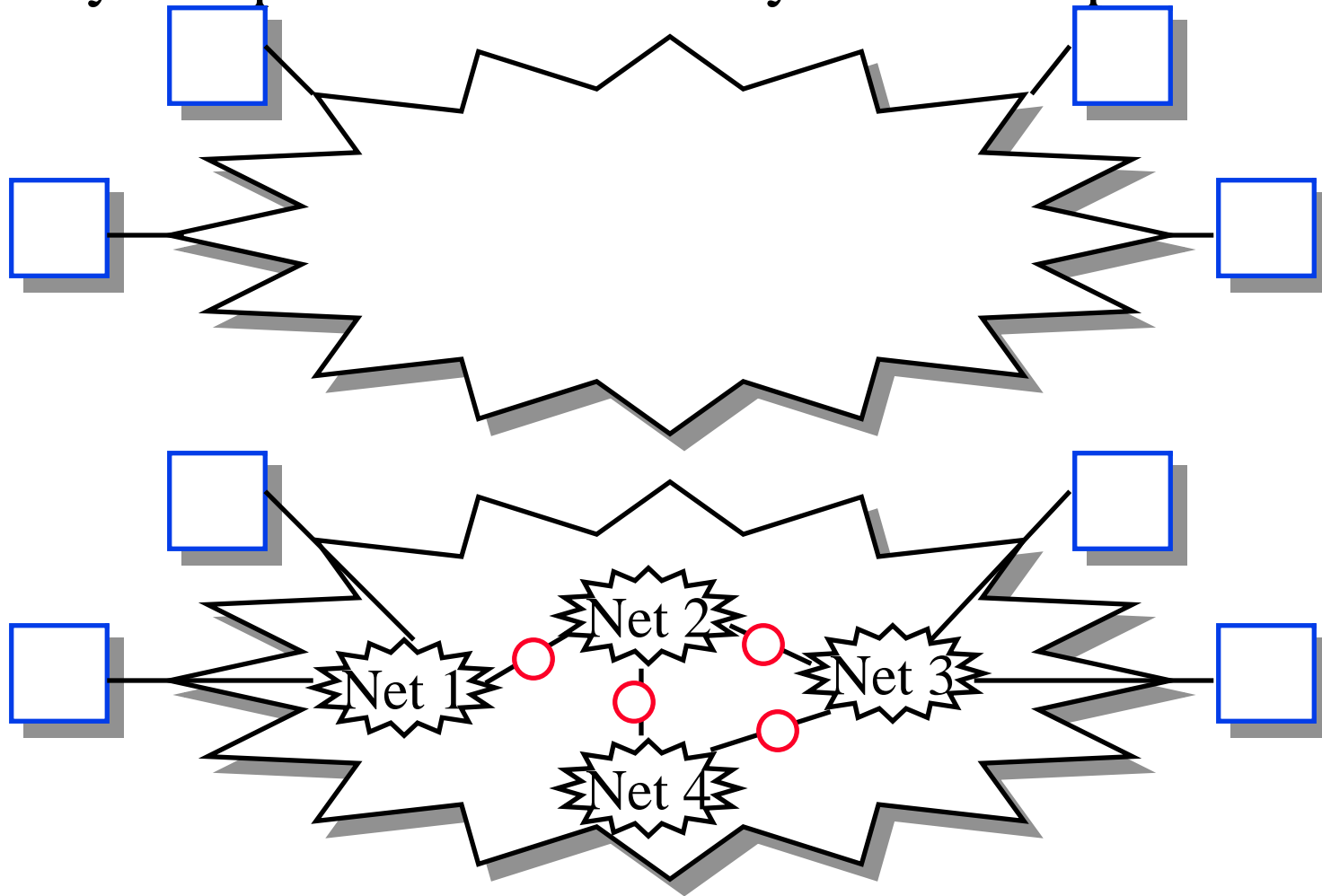
Internetworking

- ❑ Inter-network = Collection of networks
Connected via routers



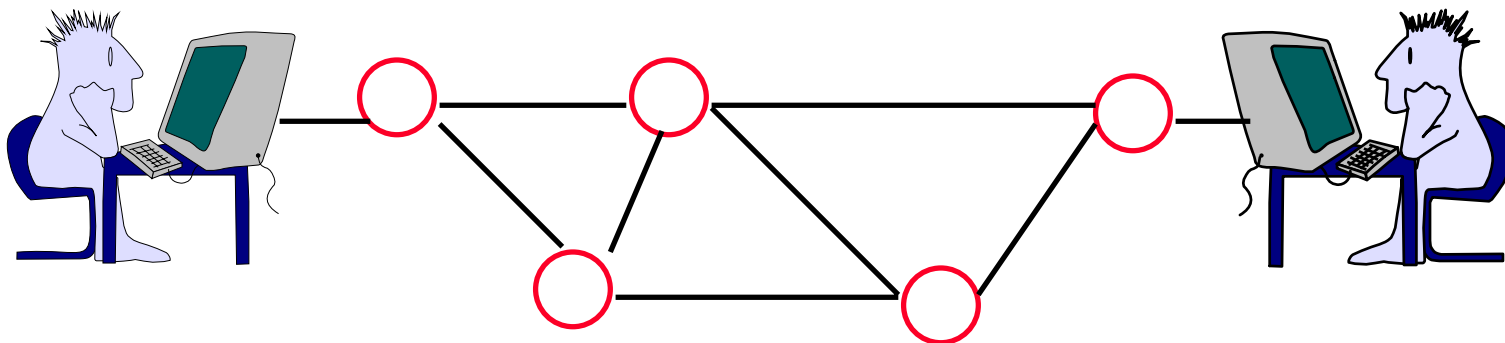
Internet = Collection of Networks

- Any computer can talk to any other computer



Internet Protocol (IP)

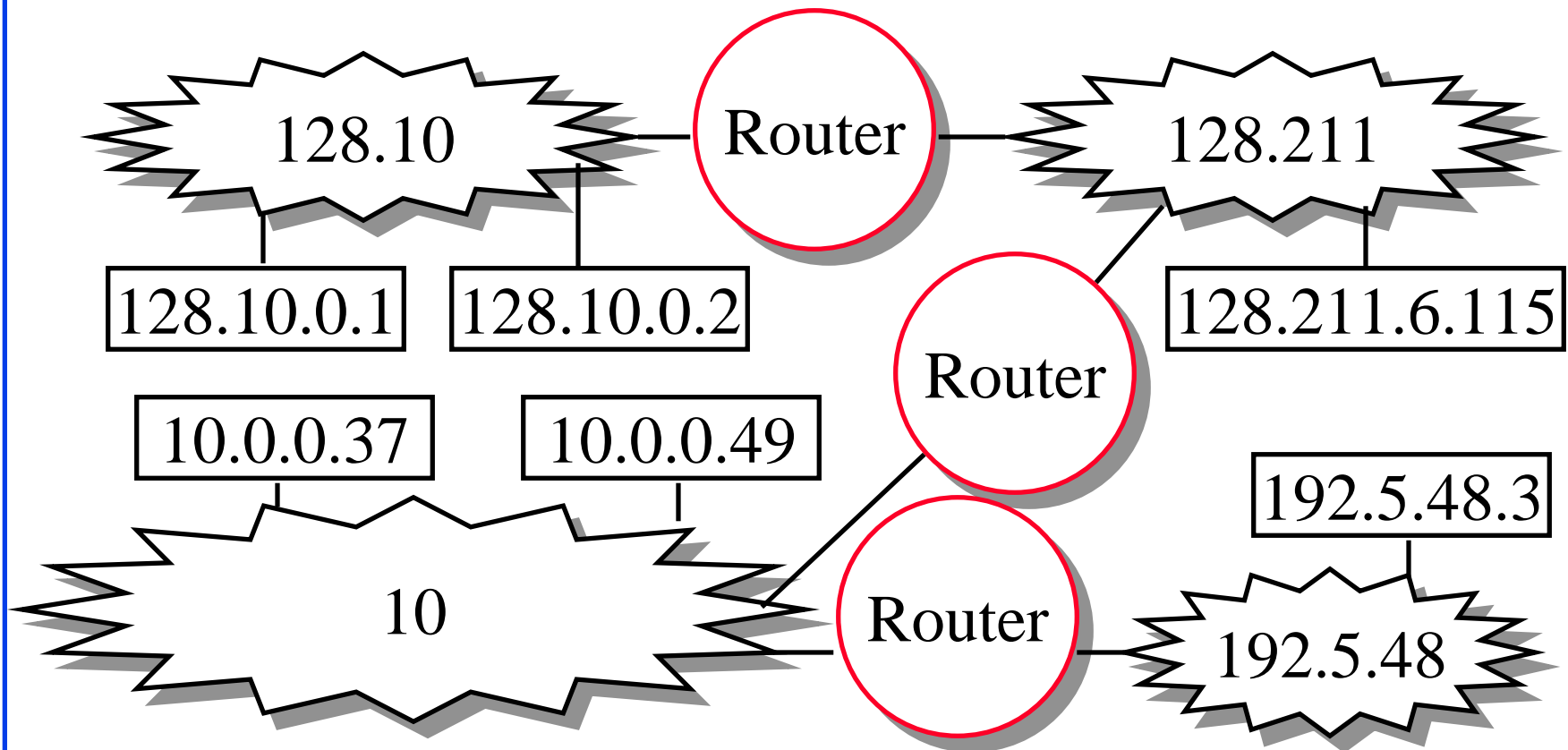
- ❑ Layer 3 protocol that *forwards* datagrams across internet
- ❑ Uses routing tables prepared by routing protocols, e.g., Open Shortest Path First (OSPF), Routing Information Protocol (RIP)
- ❑ Connectionless service vs connection-oriented (circuits)



IP Datagram Format

Version	Header Len	Service Type	Total Length	
Identification		Flags	Fragment Offset	
Time to live	Payload Type	Header Checksum		
Source IP Address				
Destination IP Address				
IP Options (May be omitted)			Padding	
Data				

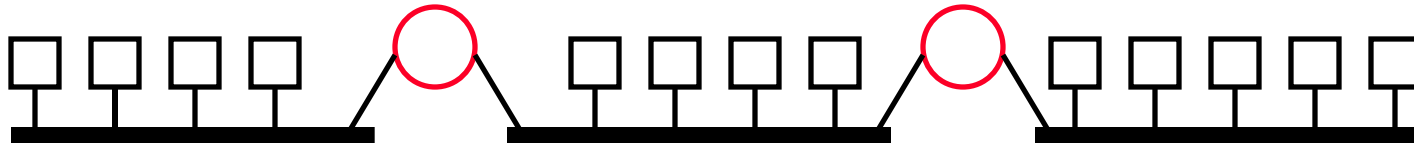
IP Addressing



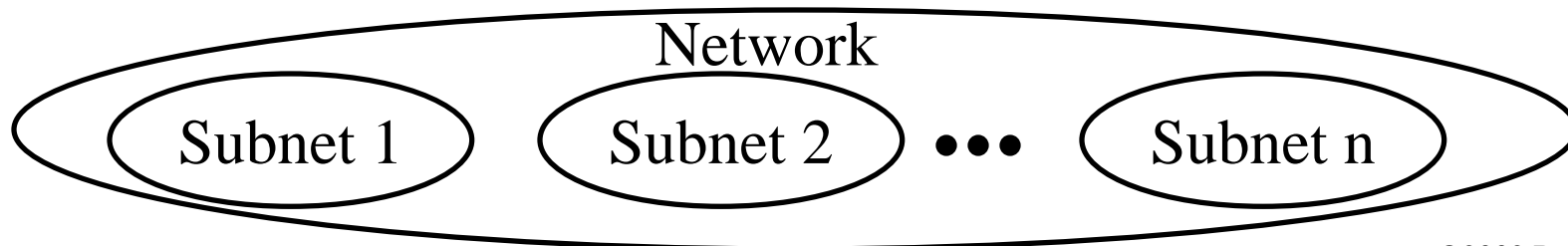
- ❑ All IP hosts have a 32-bit address. 128.10.0.1
= 1000 0000 0000 1010 0000 0000 0000 0001
- ❑ All hosts on a network have the same network prefix

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Subnetting



- All hosts on a subnetwork have the same prefix.
Position of the prefix is indicated by a “subnet mask”
- Example: First 23 bits = subnet
Address: 10010100 10101000 00010000 11110001
Mask: 11111111 11111111 11111110 00000000
.AND. 10010100 10101000 00010000 00000000



Forwarding an IP Datagram

- ❑ Delivers **datagrams** to destination network (subnet)
- ❑ Routers maintain a “routing table” of “next hops”
- ❑ Next Hop field does not appear in the datagram

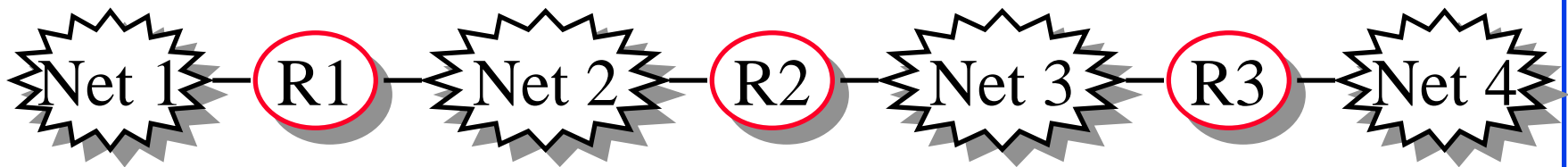


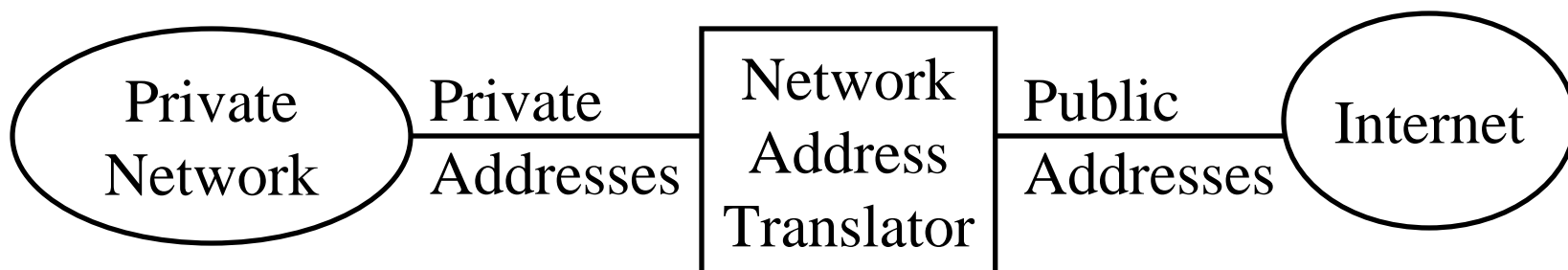
Table at R2:

Destination Next Hop

Net 1	Forward to R1
Net 2	Deliver Direct
Net 3	Deliver Direct
Net 4	Forward to R3

Private Addresses

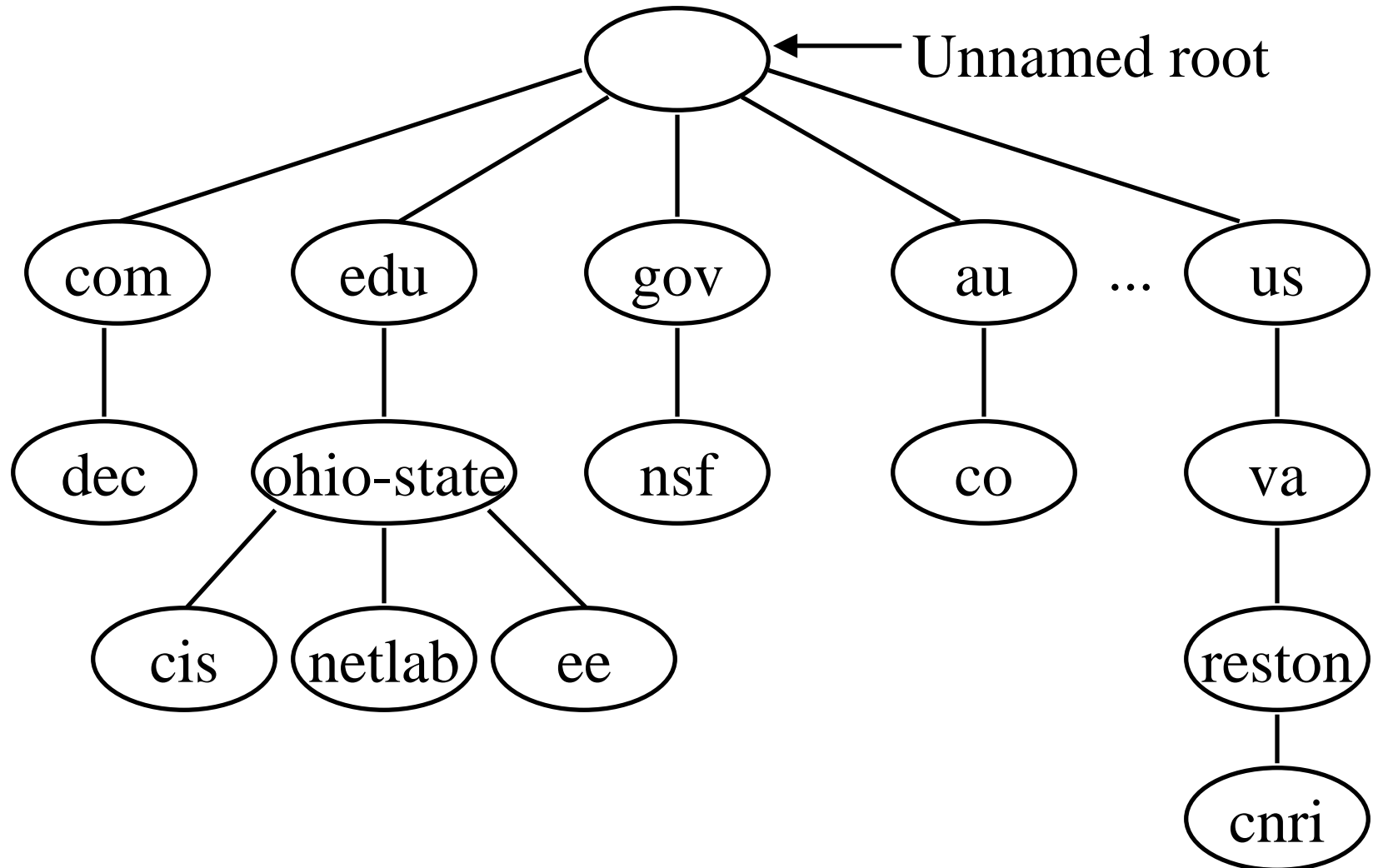
- ❑ Any organization can use these inside their network
Can't go on the internet. [RFC 1918]
- ❑ 10.0.0.0 - 10.255.255.255 (10/8 prefix)
- ❑ 172.16.0.0 - 172.31.255.255 (172.16/12 prefix)
- ❑ 192.168.0.0 - 192.168.255.255 (192.168/16 prefix)



Domain Name Service

- ❑ Computers use addresses
- ❑ Humans cannot remember IP addresses
⇒ Need names
Example, Liberia for 164.107.51.28
- ❑ Simplest Solution: Each computer has a unique name and has a built in table of name to address translation
- ❑ Problem: Not scalable
- ❑ Solution: DNS (Adopted in 1983)
- ❑ Hierarchical Names: Liberia.cis.ohio-state.edu

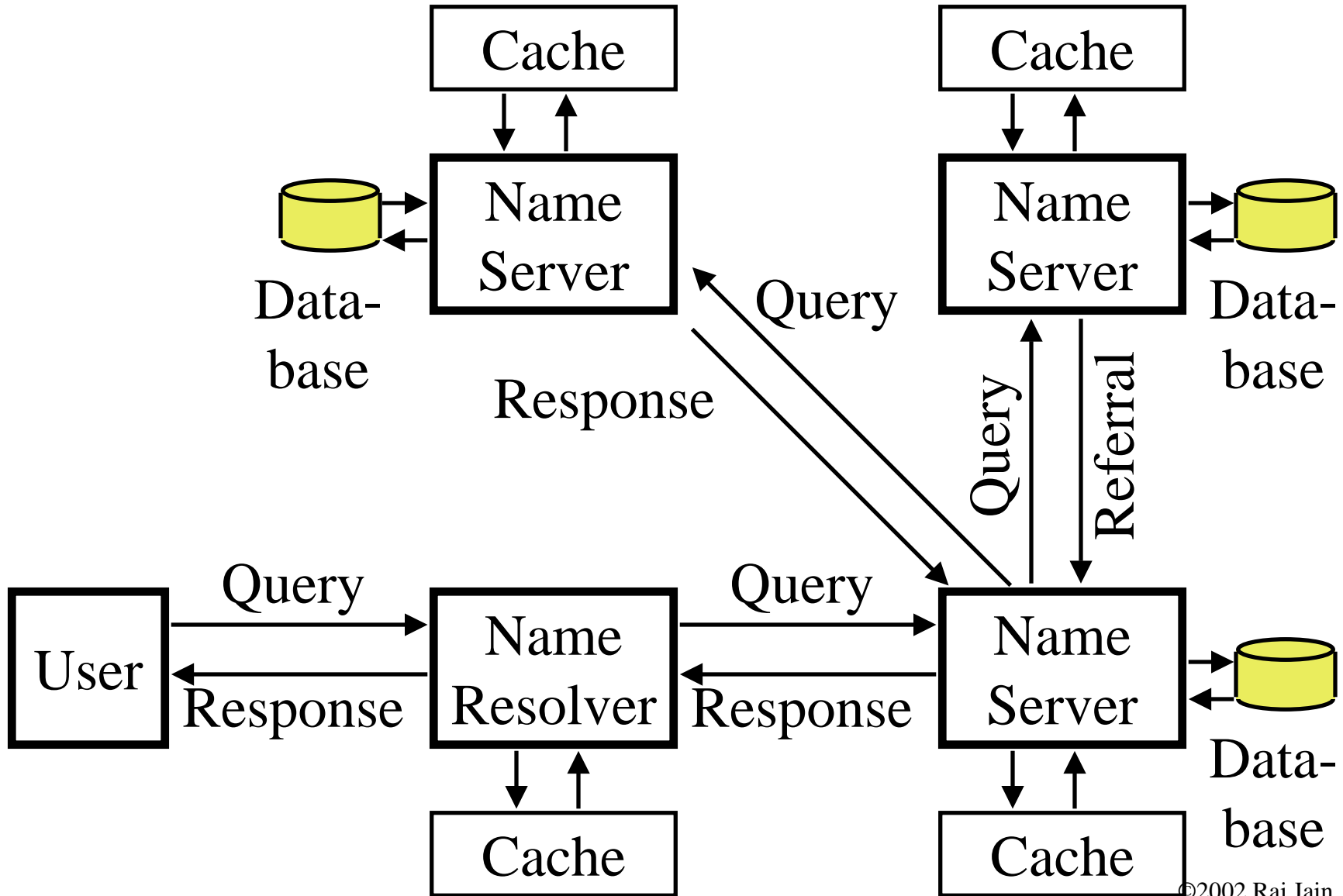
Name Hierarchy



Name Hierarchy

- ❑ Unique domain suffix is assigned by Internet Assigned Number Authority (IANA)
- ❑ The domain administrator has complete control over the domain
- ❑ No limit on number of sub-domains or number of levels
- ❑ computer.site.division.company.com
computer.site.subdivision.division.company.com
- ❑ Name space is not related to physical interconnection, e.g., math.ohio-state and cis.ohio-state could be on the same floor or in different cities

Name Resolution

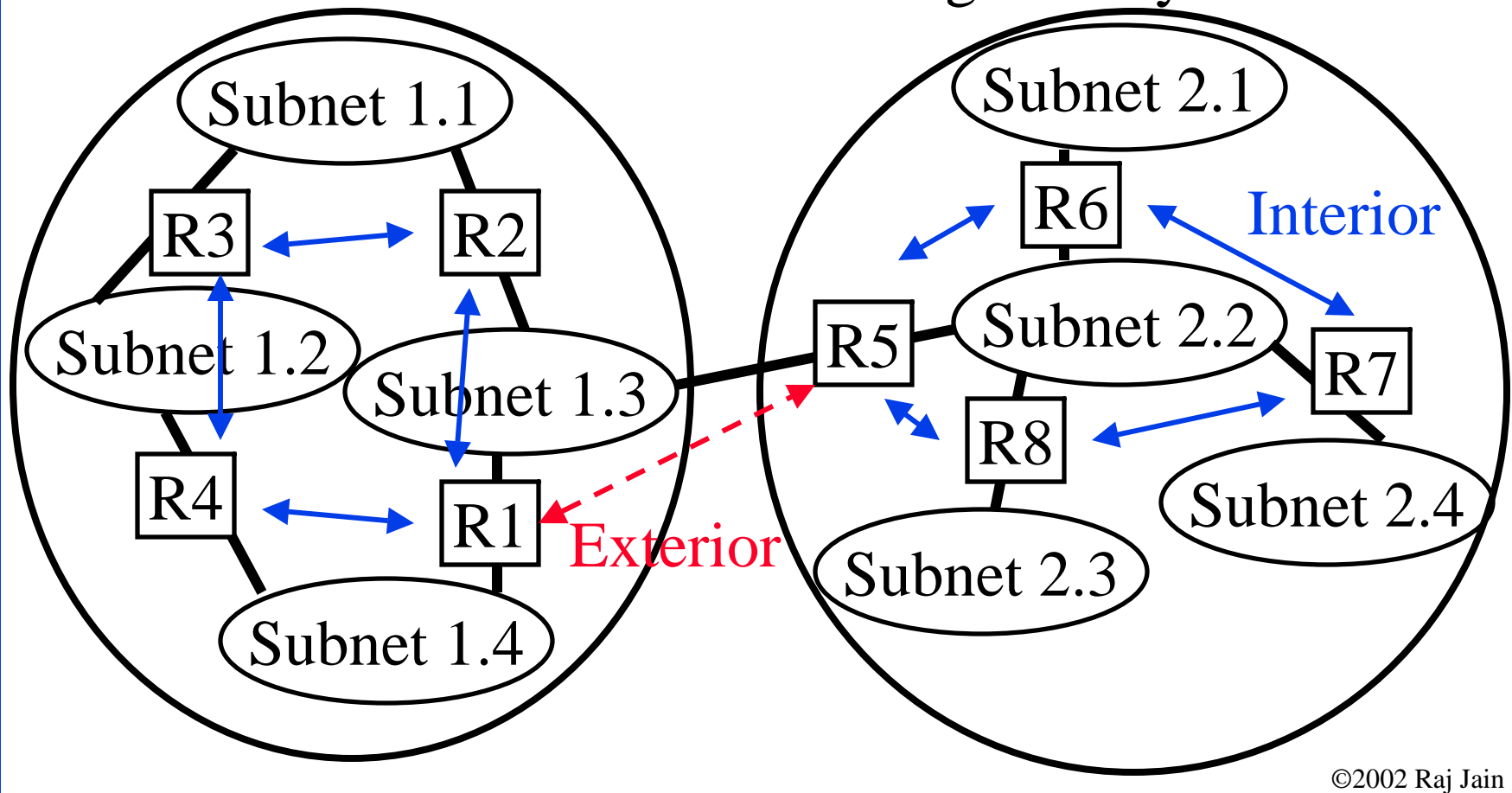


Name Resolution (Cont)

- ❑ Each computer has a name resolver routine, e.g., `gethostbyname` in UNIX
- ❑ Each resolver knows the name of a local DNS server
- ❑ Resolver sends a DNS request to the server
- ❑ DNS server either gives the answer, forwards the request to another server, or gives a referral
- ❑ Referral = Next server to whom request should be sent
- ❑ Servers respond to a full name only
However, humans may specify only a partial name
Resolvers may fill in the rest of the suffix, e.g.,
`Liberia.cis = Liberia.cis.ohio-state.edu`

Autonomous Systems

- An internet connected by homogeneous routers under the administrative control of a single entity



Routing Protocols

- ❑ Interior Router Protocol (IRP): Among routers internal to an autonomous system.
Also known as IGP.
 - ❑ Examples: Routing Information Protocol (RIP), Open Shortest Path First (OSPF)
- ❑ Exterior Router Protocol (ERP): Among routers between autonomous systems. Also known as EGP.
 - ❑ Examples: Exterior Gateway Protocol (EGP), Border Gateway Protocol (BGP), Inter-Domain Routing Protocol (IDRP)

Note: EGP is a class as well as an instance in that class.

Routing Information Protocol

- ❑ RIP uses distance vector \Rightarrow A vector of distances to all nodes is sent to neighbors every 30 seconds
- ❑ Each router computes new distances and replaces entries with new lower hop counts

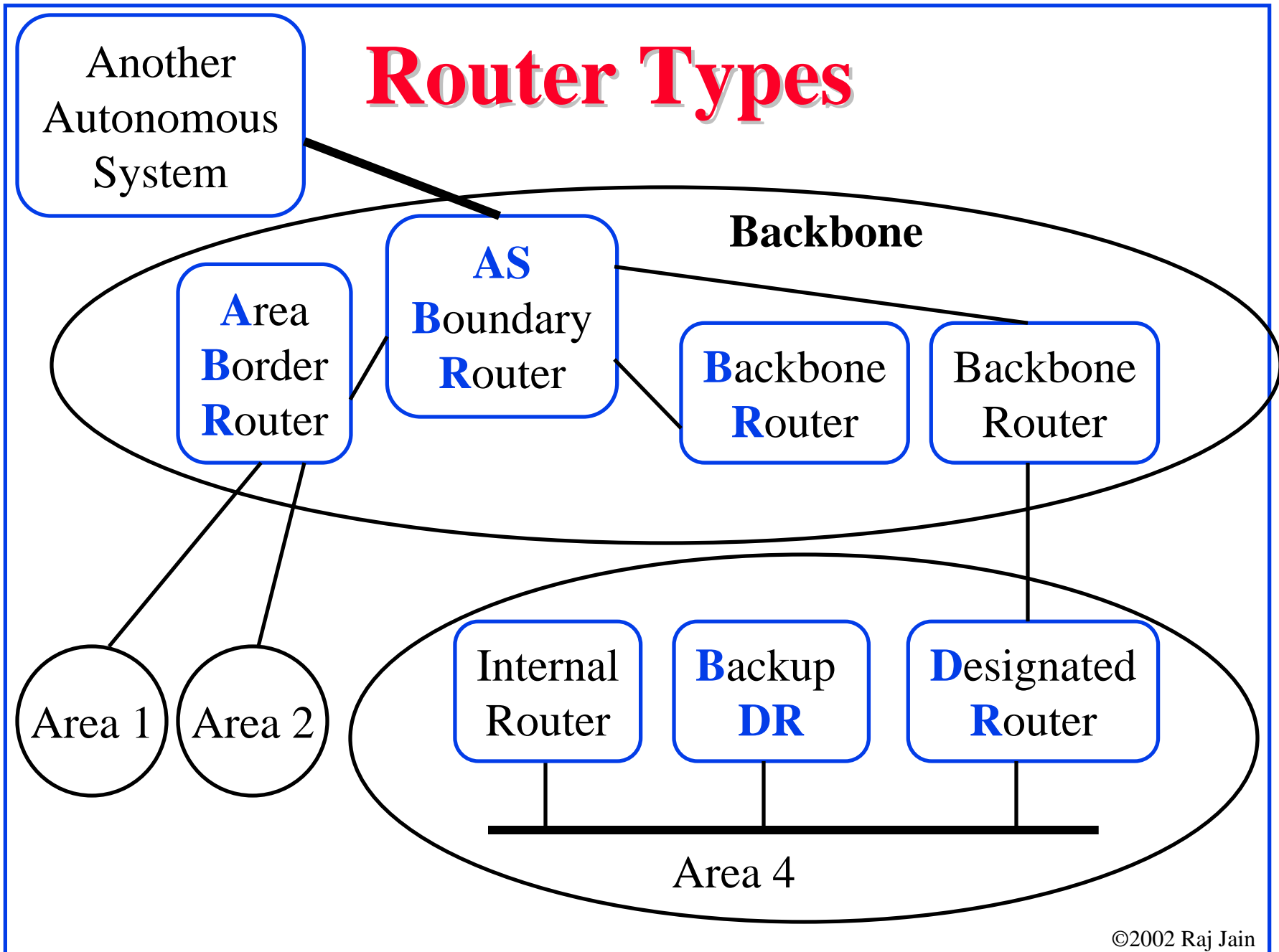
Shortcomings of RIP V1

- ❑ Maximum network diameter = 15 hops
- ❑ Cost is measured in hops
Only shortest routes. May not be the fastest route.
- ❑ Entire tables are broadcast every 30 seconds.
Bandwidth intensive.
- ❑ Uses UDP with 576-byte datagrams.
Need multiple datagrams.
300-entry table needs 12 datagrams.
- ❑ An error in one routing table is propagated to all routers
- ❑ Slow convergence

Open Shortest Path First (OSPF)

- ❑ Uses true metrics (not just hop count)
- ❑ Allows load balancing across equal-cost paths
- ❑ Authenticates route exchanges
- ❑ Quick convergence
- ❑ Large networks are subdivided into a backbone network and areas
- ❑ Each area has multiple subnets. Each subnet has a designated router.
- ❑ Link state routing \Rightarrow Each router broadcasts its connectivity with neighbors to entire area

Router Types



Router Types (Cont)

- ❑ **Internal Router (IR):** All interfaces belong to the same area
- ❑ **Area Border Router (ABR):** Interfaces to multiple areas
- ❑ **Backbone Router (BR):** Interfaces to the backbone
- ❑ **Autonomous System Boundary Router (ASBR):**
Exchanges routing info with other autonomous systems
- ❑ **Designated Router (DR):** Generates link-state info about the subnet
- ❑ **Backup Designated Router (BDR):** Becomes DR if DR fails.

OSPF Operation

- ❑ Periodic “Hello” packets are multicast on the subnet to find other routers and elect “designated router” and “backup designated router”
- ❑ Designated routers and routers on point-to-point links form “adjacency.” Exchange “Link State Advertisements (LSAs).” New info flooded to all other adjacent routers in the area.
- ❑ Area border routers (ABRs) send “summary LSAs” to other ABRs
- ❑ Autonomous system border routers (ASBRs) use exterior routing protocol to exchange routing information

Border Gateway Protocol

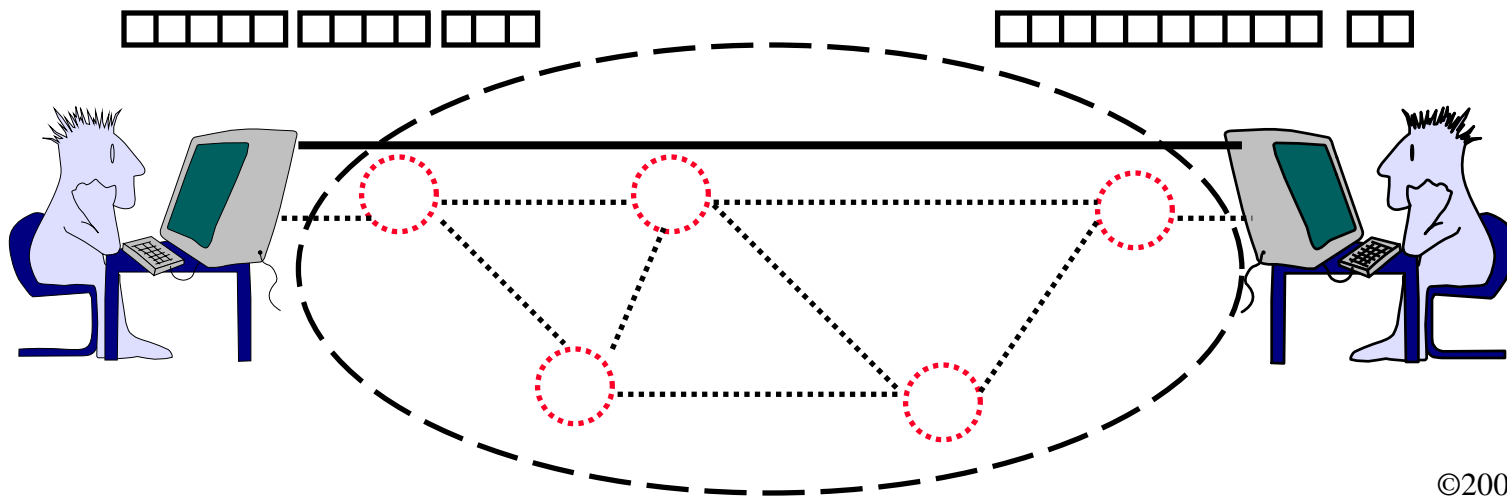
- ❑ Inter-autonomous system protocol [RFC 1267]
- ❑ Used since 1989 but not extensively until recently
- ❑ Advertises all transit ASs on the path to a destination address
- ❑ A router may receive multiple paths to a destination
⇒ Can choose the best path

BGP Operations

- ❑ BGP systems initially exchange entire routing tables. Afterwards, only updates are exchanged.
- ❑ BGP messages have the following information:
 - ❑ Origin of path information: RIP, OSPF, ...
 - ❑ AS_Path: List of ASs on the path to reach the dest
 - ❑ Next_Hop: IP address of the border router to be used as the next hop to reach the dest
 - ❑ Unreachable: If a previously advertised route has become unreachable
- ❑ BGP speakers generate update messages to all peers when it selects a new route or some route becomes unreachable.

TCP: Key Features

- ❑ Point-to-point communication: **Two** end-points
- ❑ **Connection** oriented. Full duplex communication.
- ❑ **Reliable** transfer: Data is delivered in order
Lost packets are retransmitted.
- ❑ **Stream** interface: Continuous sequence of octets

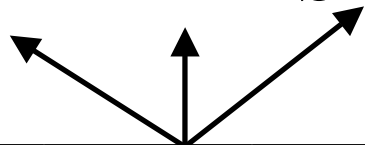


Transport Control Protocol (TCP)

- Key Services:
 - Send: Please send when convenient
 - Data stream push: Please send it all now, if possible.
 - Urgent data signaling: Destination TCP! please give this urgent data to the user
(Urgent data is delivered in sequence. Push at the should be explicit if needed.)
 - Note: Push has no effect on delivery.
Urgent requests quick delivery

TCP Header Format

FTP HTTP SMTP



Source Port	Dest Port	Seq No	Ack No	Data Offset	Resvd	Control	Window
-------------	-----------	--------	--------	-------------	-------	---------	--------

16 16 32 32 4 6 6 16

Check-sum	Urgent	Options	Pad	Data
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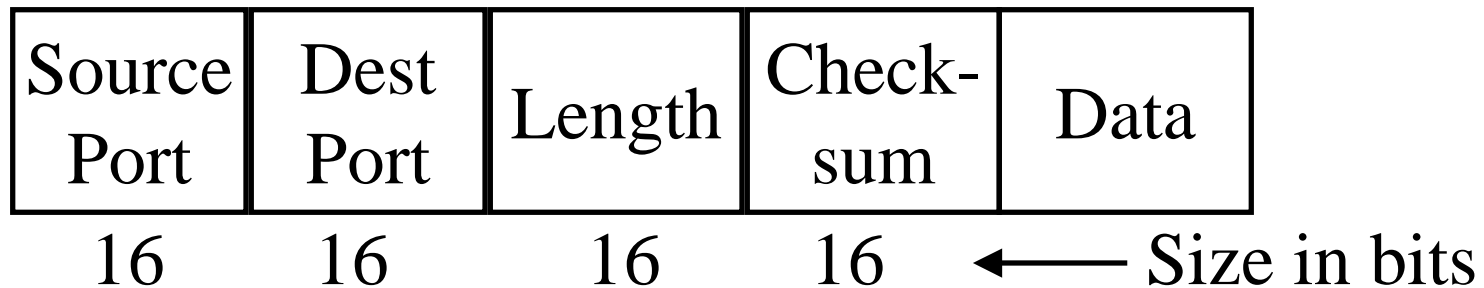
16 16 x y ← Size in bits

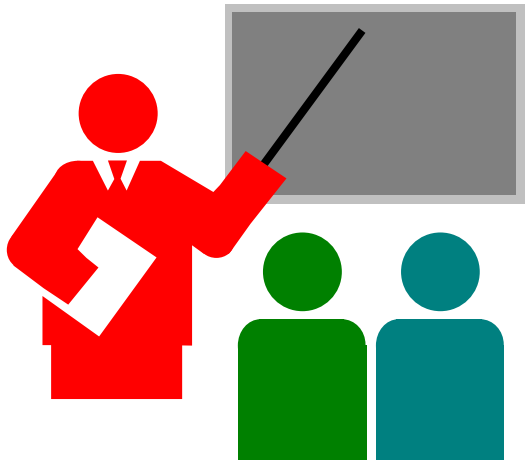
TCP Header

- ❑ Source Port (16 bits): Identifies source user process
20 = FTP, 23 = Telnet, 53 = DNS, 80 = HTTP, ...
- ❑ Destination Port (16 bits)
- ❑ Sequence Number (32 bits): Sequence number of the first byte in the segment.
- ❑ Ack number (32 bits): Next byte expected
- ❑ Data offset (4 bits): # of 32-bit words in the header
- ❑ Reserved (6 bits)
- ❑ Window (16 bits): Will accept [Ack] to [Ack]+[window]

User Datagram Protocol (UDP)

- ❑ **Connectionless** end-to-end service
- ❑ **Unreliable**: No flow control.
No error recovery (No acks. No retransmissions.)
- ❑ Used by network management and Audio/Video.
- ❑ Provides port addressing
- ❑ Error detection (Checksum) optional.





Summary

- ❑ IP is the forwarding protocol between networks
- ❑ IPv4 uses 32-bit addresses
- ❑ DNS: Maps names to addresses
- ❑ OSPF uses link-state advertisements
- ❑ BGP is used between autonomous systems
- ❑ TCP provides reliable full-duplex connections.
- ❑ UDP is connectionless and simple. No flow/error control.

Homework 2

True or False?

T F

- A sample IP address is 10.0.110.357
- Two computers cannot have the same IP address
- Two computers cannot have the same complete DNS name
- IANA assigns all names used inside a company.
- Each DNS server database stores all computer names in the world.
- Routing tables used by IP are prepared using routing protocols like OSPF, BGP.
- RIP is used in small networks
- OSPF area border routers connect to other autonomous systems.
- OSPF Hellos are flooded through out the area.
- BGP is used between autonomous systems
- TCP delivers all packets to the destination exactly as received at the source.
- TCP port numbers are related to applications using them.
- UDP is unreliable transport protocol.

Marks = Correct Answers _____ - Incorrect Answers _____ = _____