VM TCP/IP Routing - Part 1

Session V22

Alan Altmark
IBM Corporation

IBM Systems

Disclaimer

This presentation provides in-depth information on configuration of the routing components of VM TCP/IP.

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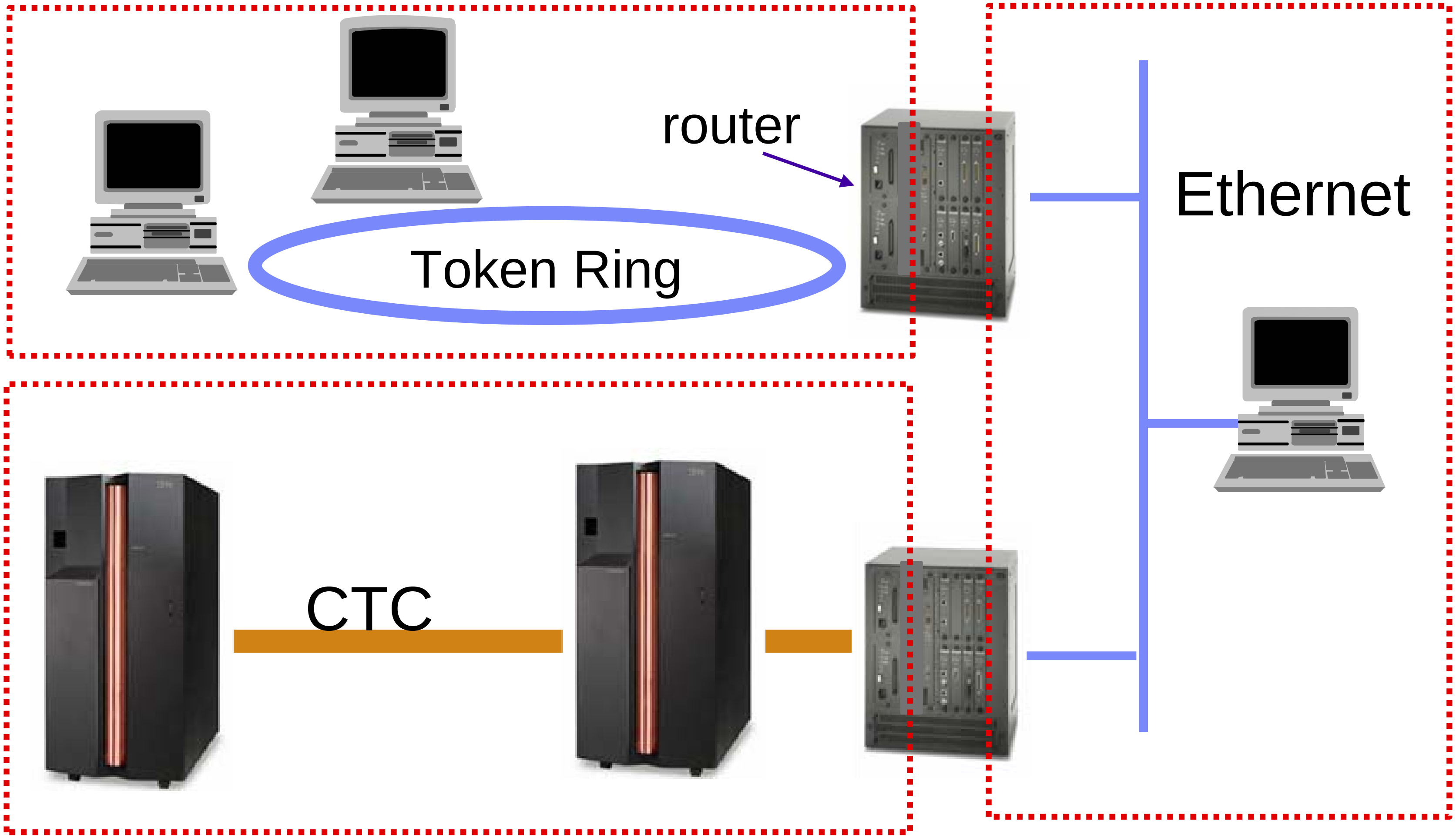
Agenda

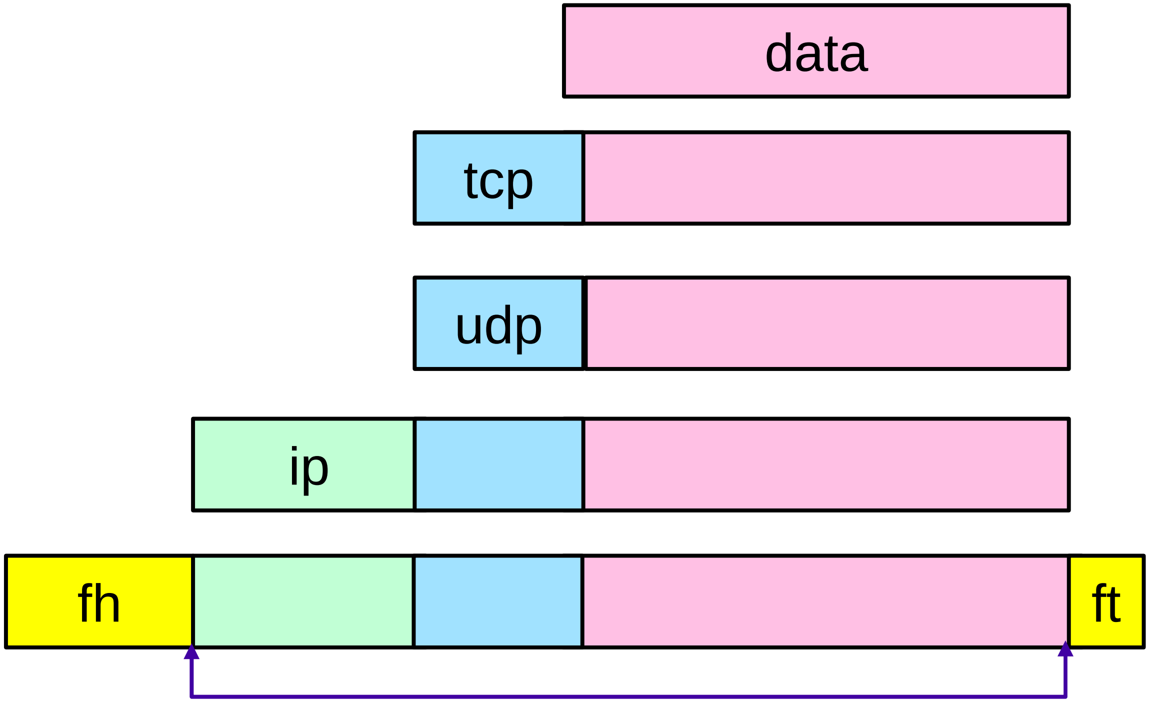
- Link-level communications
  - MAC frames
  - ARP
  - Proxy ARP
- IP Addressing
  - Classes
  - Subnets
- Routing basics

Terminology: LAN Segment



More Terminology

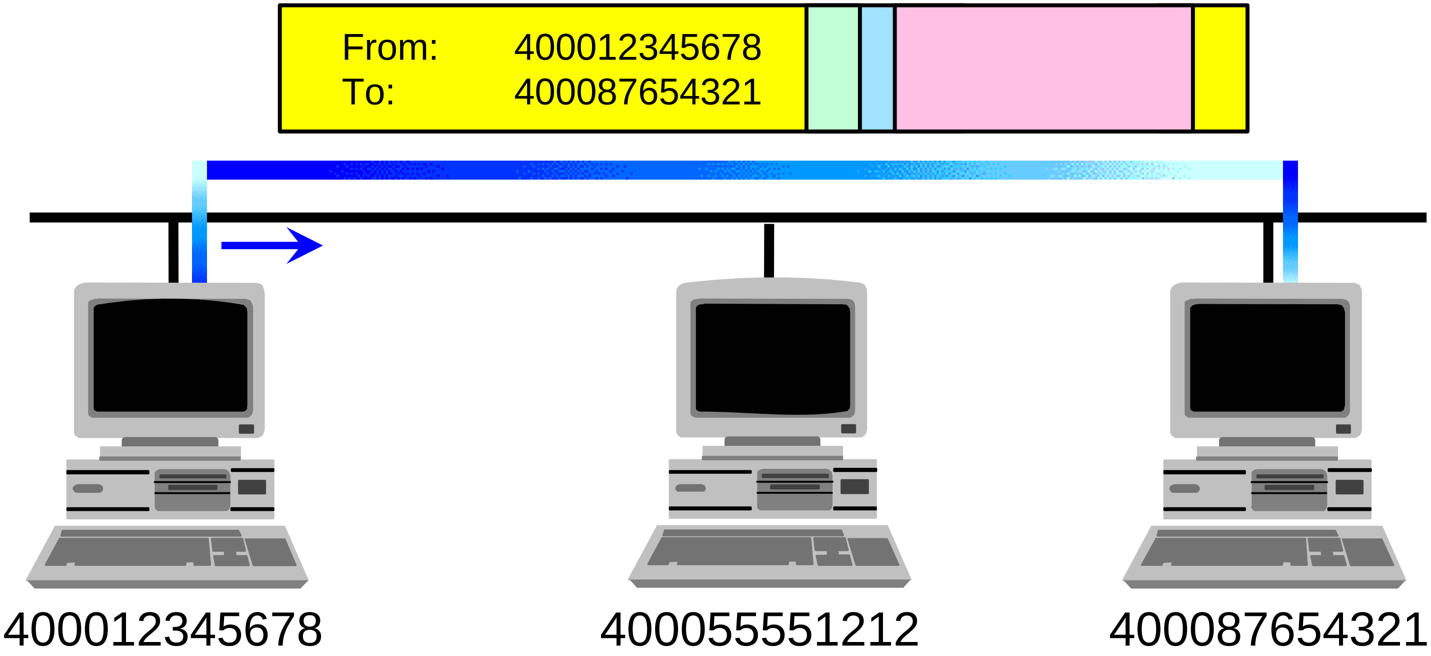
- Application data
- TCP Segment
- UDP Datagram
- IP Packet
- Link Frame
- MTU



Maximum **T**ransmission **U**nit

Link Level Communication - Unicast

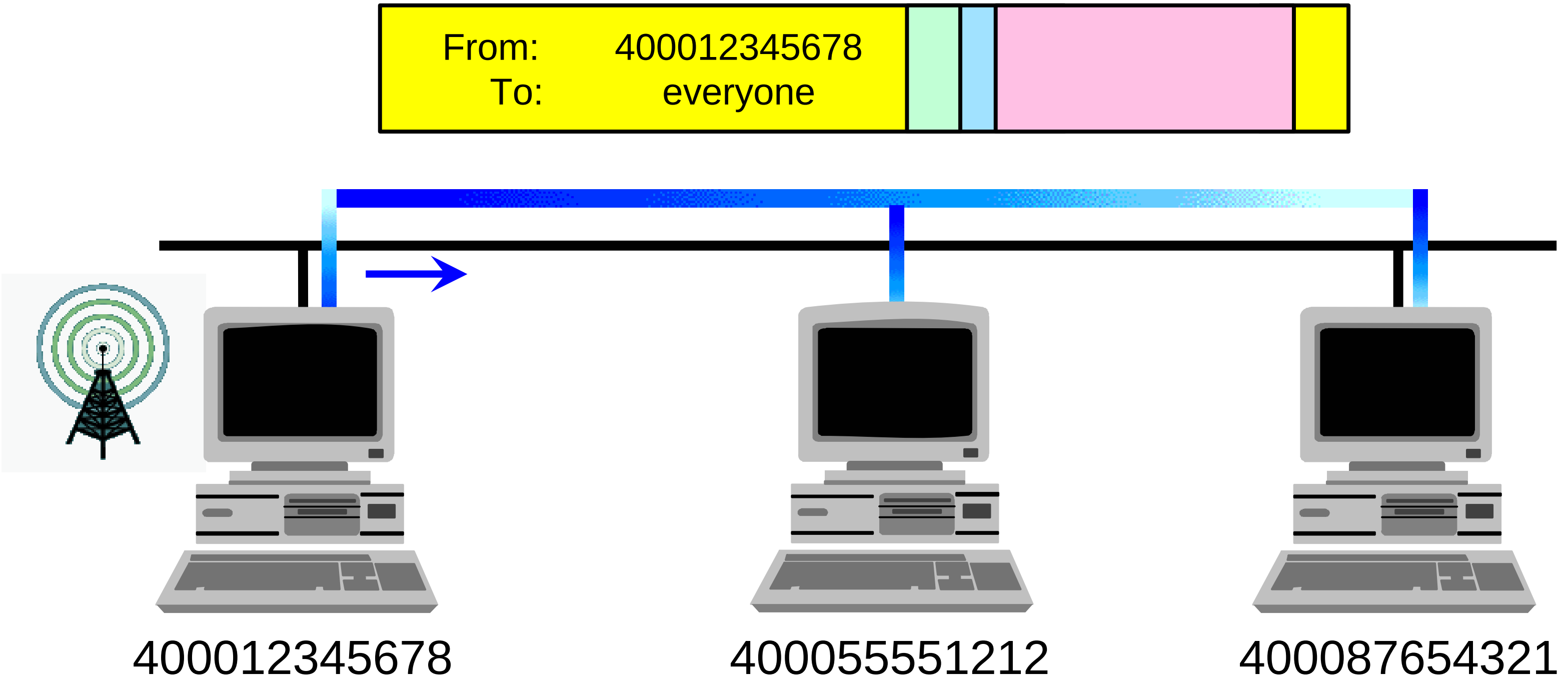
- Frames transmitted using Medium Access Control points and addresses



- Only addressed station picks up frame

Link Level Communication - Broadcast

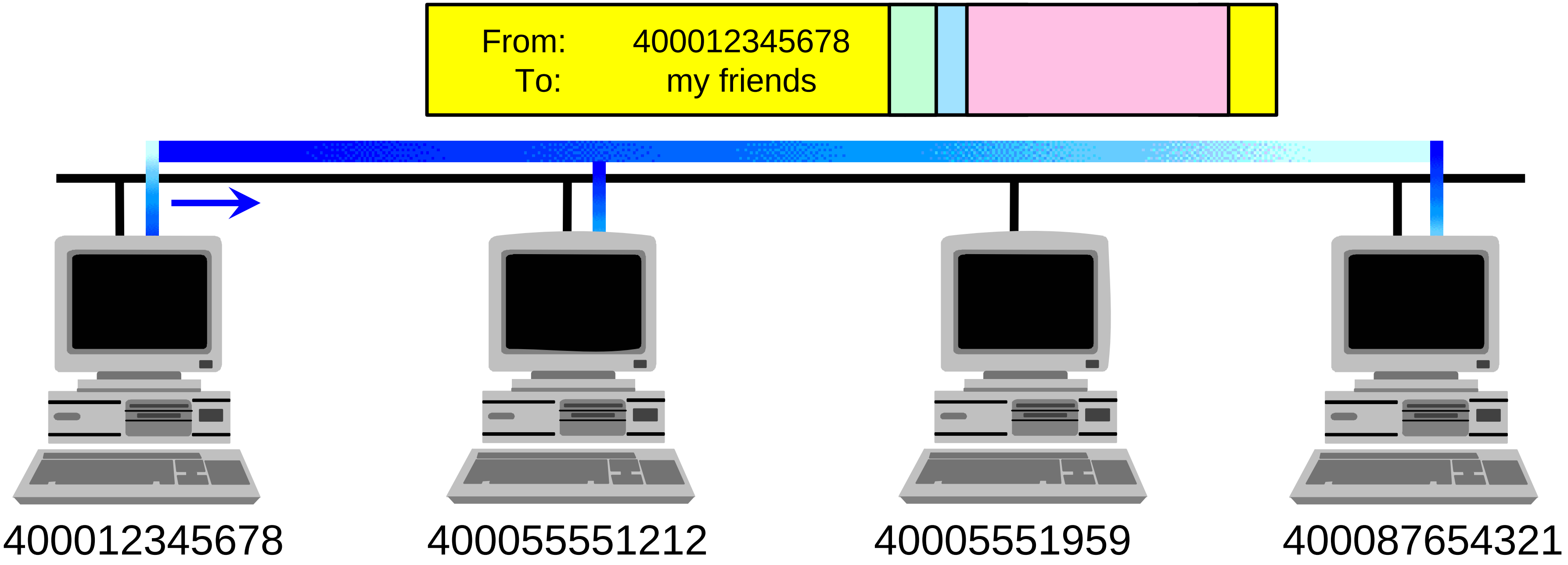
- Station can broadcast by using special format frame



- All stations will pick up frame

Link Level Communication - Multicast

- Station can reach all listening machines on LAN using a special multicast MAC address



- All stations registered for the multicast MAC address will pick up the frame

Converting a MAC address to an IP address

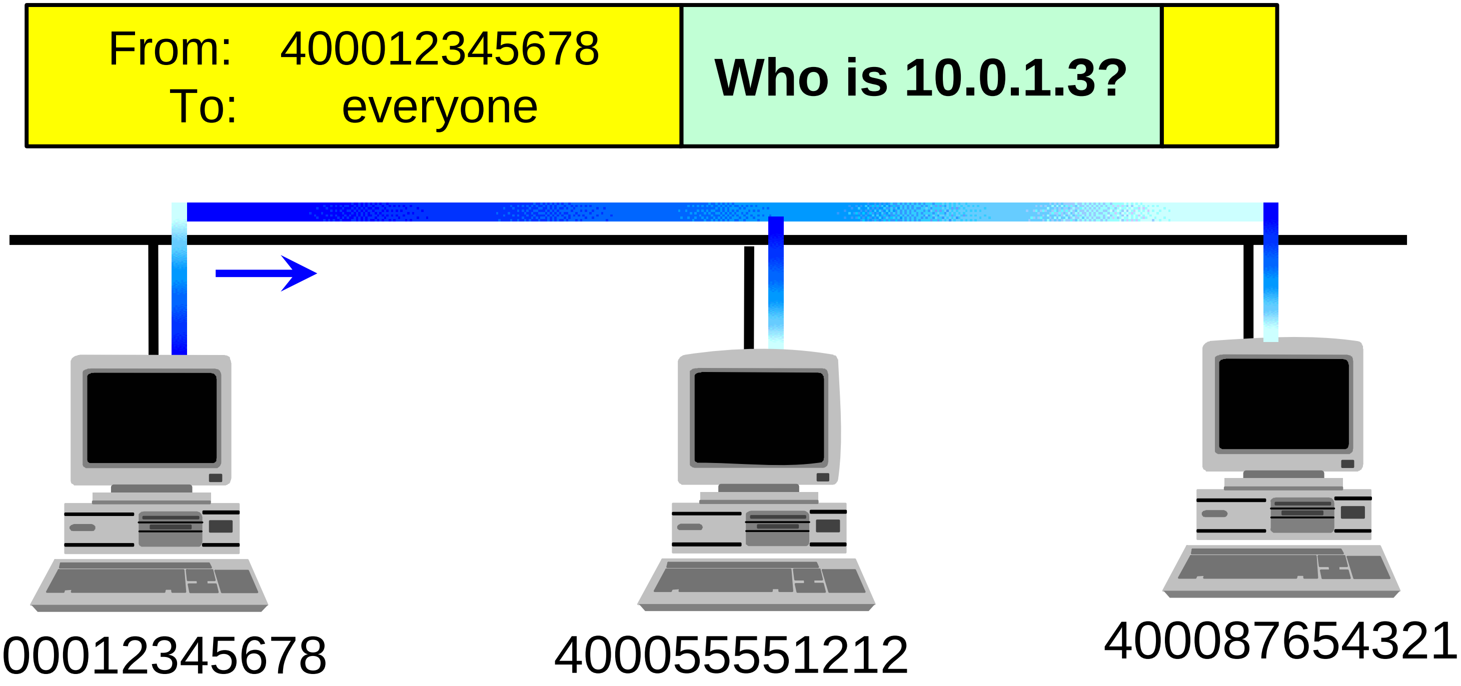
- IP hosts are managed and addressed using an IP address
- IP addresses are logical addresses, not physical

- So, how does TCP/IP convert an IP address to a physical MAC address?

- Answer: **Address Resolution Protocol (ARP)**

ARP Request

- Host broadcasts lookup on local LAN segment
  - Payload contains requested IP address

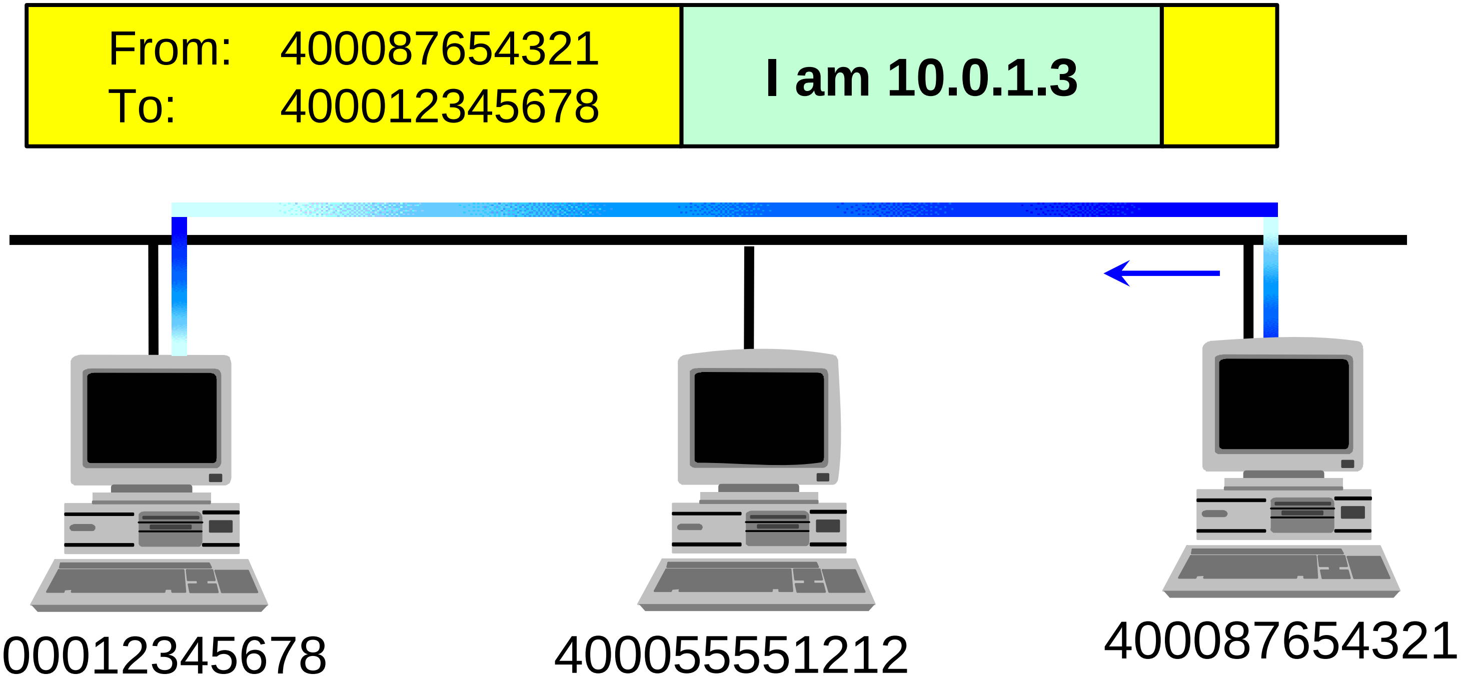


From: 400012345678
To: everyone

Who is 10.0.1.3?

ARP Response

- Owner of IP address responds with unicast response
  - What happens if two hosts have the same IP address?



From: 400087654321
To: 400012345678

I am 10.0.1.3

400012345678

400055551212

400087654321

ARP Cache

- Hosts maintain a cache of ARP responses to avoid ARP before sending each frame

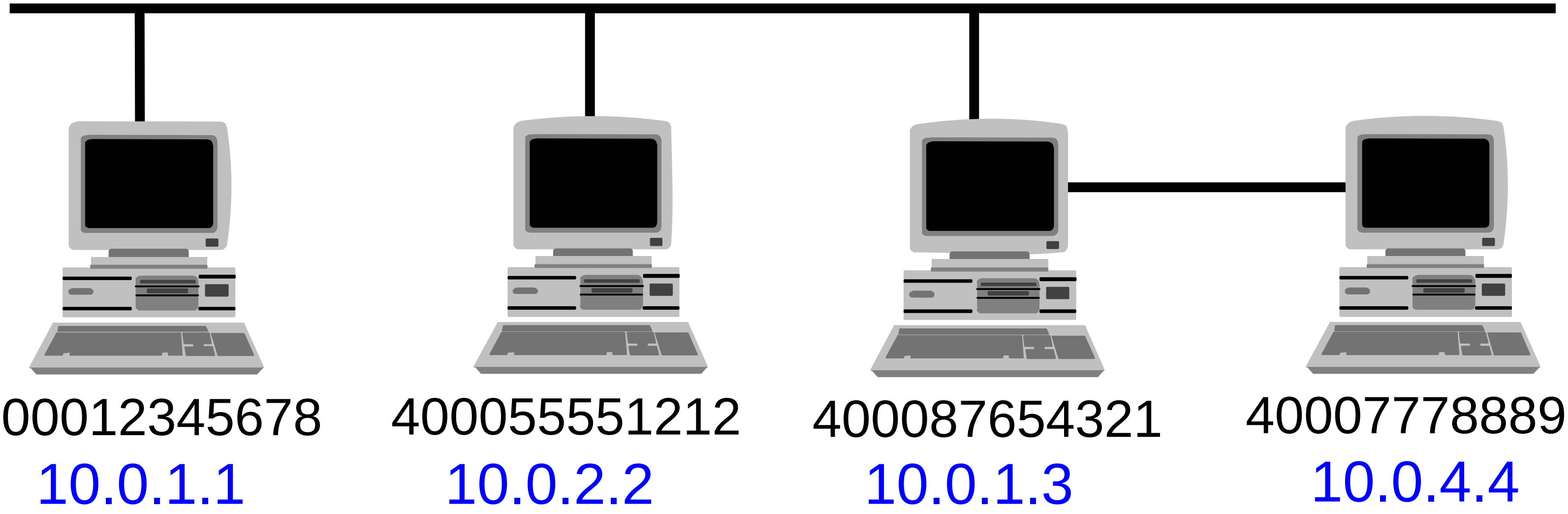
- ARP cache entries expire so that hosts can discover MAC address changes
  - New adapter
  - Different box with same IP address
    e.g. hot standby

Sample cache contents

10.0.1.1	400012345678	Timestamp
10.0.1.2	400055551212	Timestamp
10.0.1.3	400087654321	Timestamp

Proxy ARP: Bending the Rules

- In the following network configuration
  - Are 10.0.1.1 and 10.0.4.4 in the same subnet?
  - What would happen if 10.0.1.1 ARPs for 10.0.4.4?

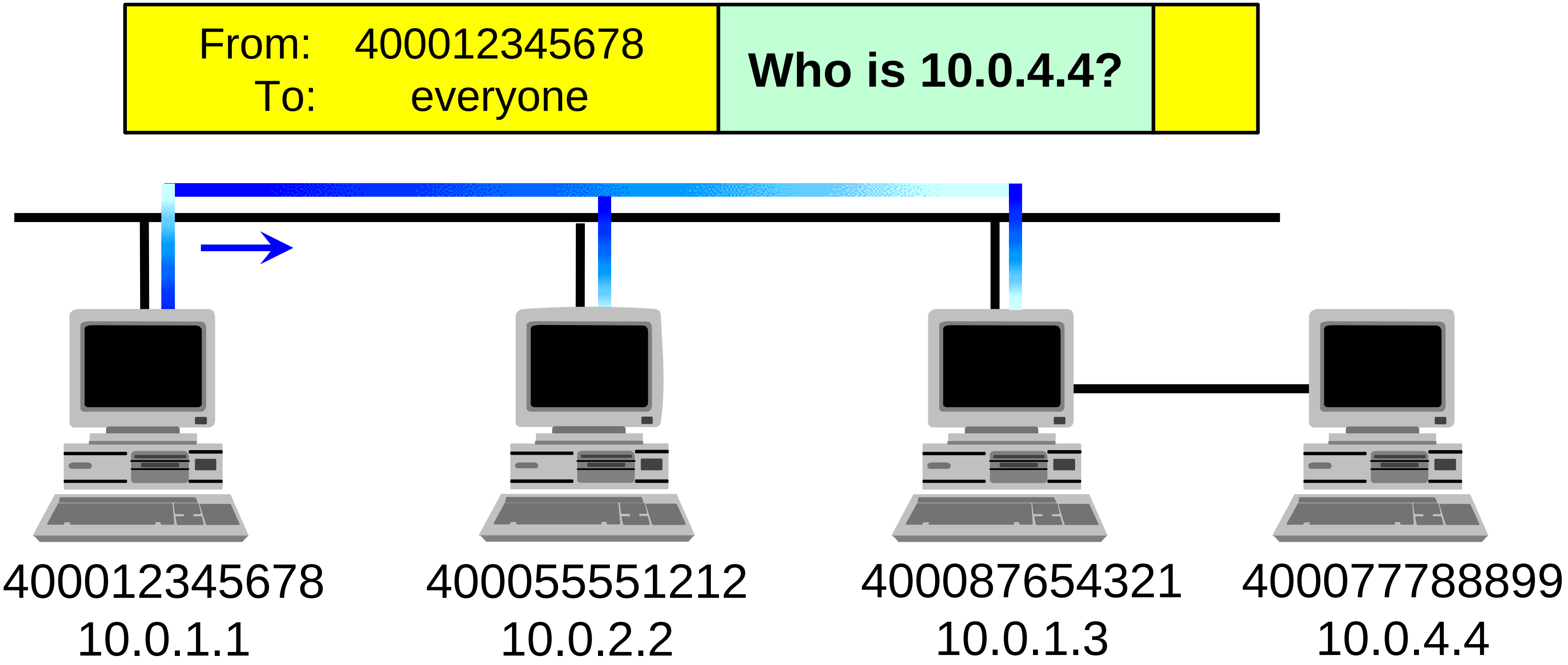


Subnet mask = 255.255.0.0

Surprise!

ARP Request

- 10.0.1.1 *assumes* that 10.0.4.4 is on the LAN because it is in the same subnet, so it ARPs



From: 400012345678
To: everyone

Who is 10.0.4.4?

400012345678
10.0.1.1

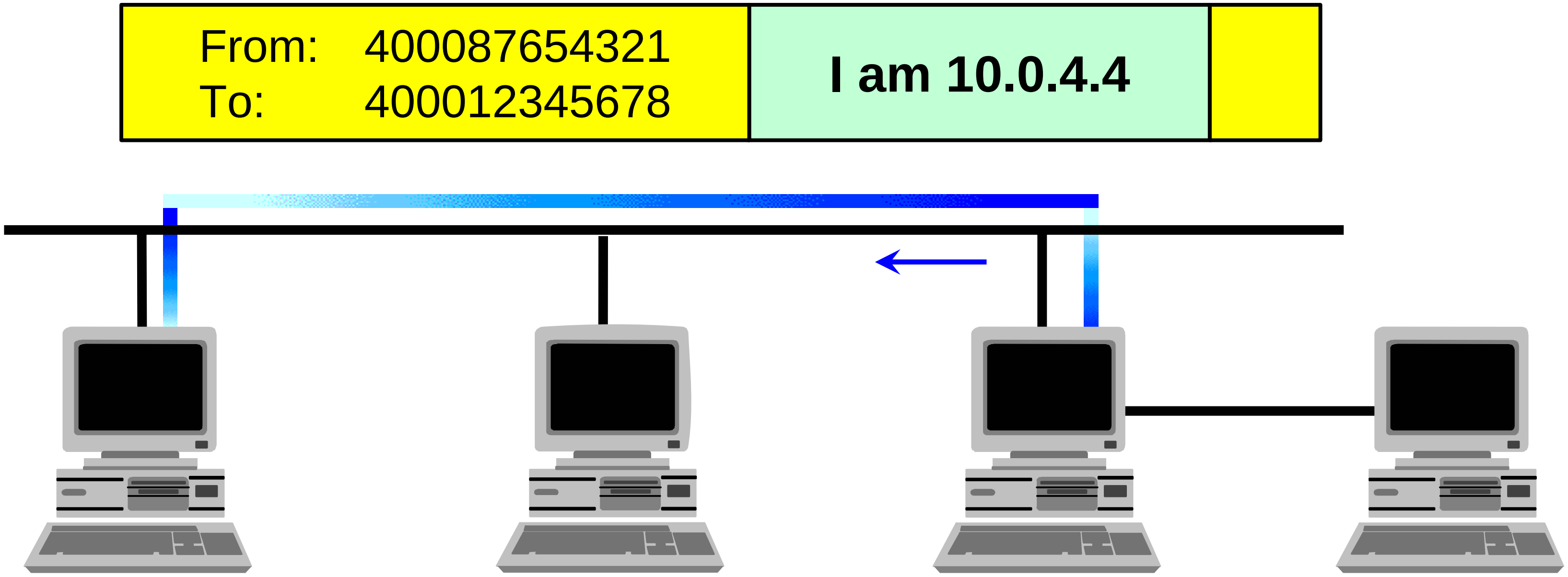
400055551212
10.0.2.2

400087654321
10.0.1.3

400077788899
10.0.4.4

Proxy ARP Response

- 10.0.1.3 pretends it is 10.0.4.4
  - “hidden router”



From: 400087654321
To: 400012345678

I am 10.0.4.4

400012345678
10.0.1.1

400055551212
10.0.2.2

400087654321
10.0.1.3

400077788899
10.0.4.4

Proxy ARP Configuration

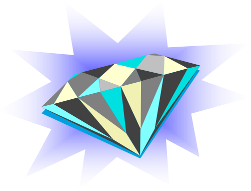
-
  ```
  AssortedParms
                 ProxyARP
  EndAssortedParms
  ```

- z/VM will respond on behalf of another host
  - Not controllable on a per-interface basis
  - HOST route entry required
  - Host must be same subnet as interface ARP arrives on

- Broadcast and multicast packets will not be forwarded

Local vs. Remote Hosts

- **Local** hosts are on same LAN segment and can be reached via ARP or proxy ARP
- **Remote** hosts must be reached through a local gateway or router
  - Each host has a default gateway defined to it
- Proxy ARP blurs the line
  - may provide SHORT-TERM alternative
  - does not solve all problems

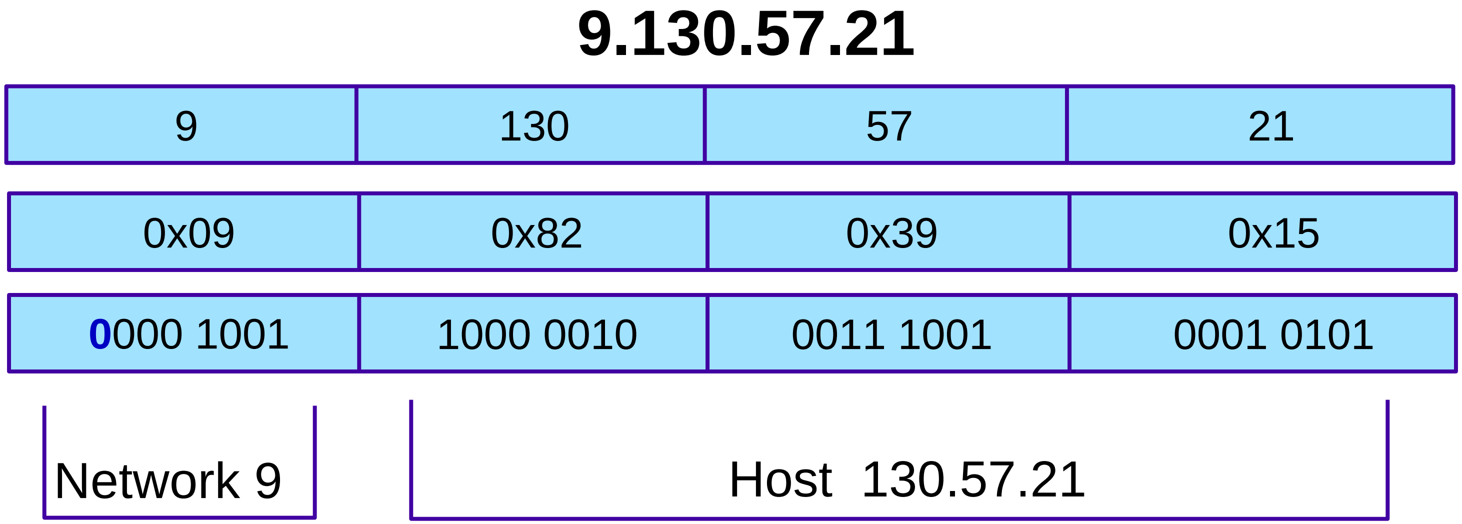


IPv4 Addressing

- 32-bit address, 4 *octets*
  - High-order bits identify *network*
  - Low-order bits identify *host* within network
  - Expressed as a.b.c.d
- Special values for network and host
  - All ones = "everyone"
  - All zeros = "me", "this", or "default"
- Address space divided into classes
  - For convenience only
  - Some defaults are based on class

IPv4 Addressing: Class A

- Networks: 0 to 127
  Total: 128 networks



9.130.57.21

9	130	57	21
0x09	0x82	0x39	0x15
0000 1001	1000 0010	0011 1001	0001 0101

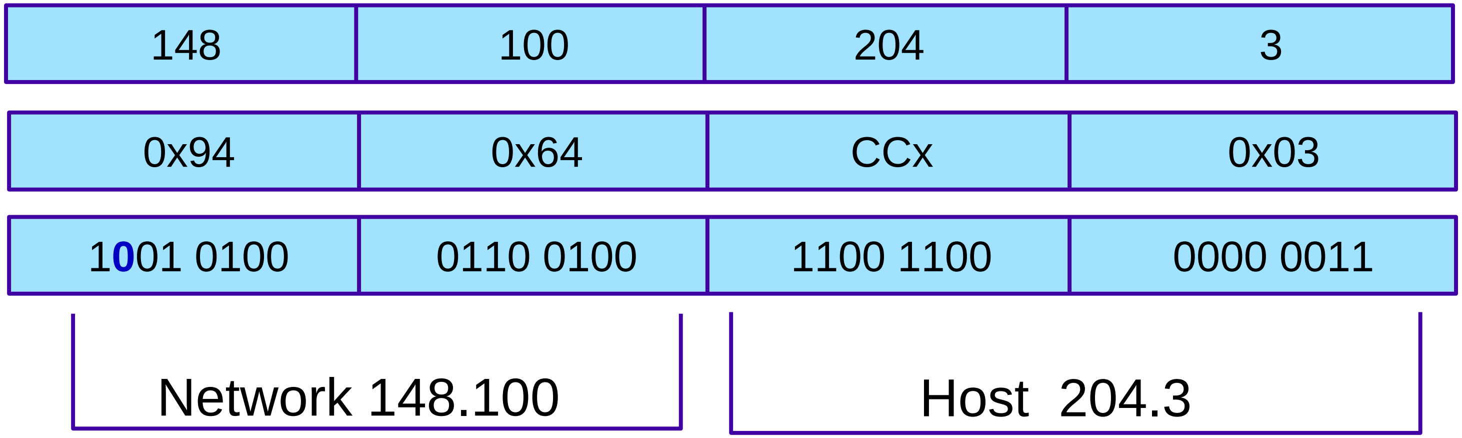
Network 9

Host 130.57.21

IPv4 Addressing: Class B

- Networks: 128.0 to 191.255
  Total: 16 384 networks

148.100.204.3



148	100	204	3
0x94	0x64	CCx	0x03
1001 0100	0110 0100	1100 1100	0000 0011

Network 148.100

Host 204.3

IPv4 Addressing: Class C

- Networks: 192.0.0 to 223.255.255
  Total: 2 097 152 networks

200.14.64.191

200	14	64	191
0xC8	0x0E	0x40	0xBF
11**0**0 1000	0000 1110	0100 0000	1011 1111

Network 200.14.64

Host 191

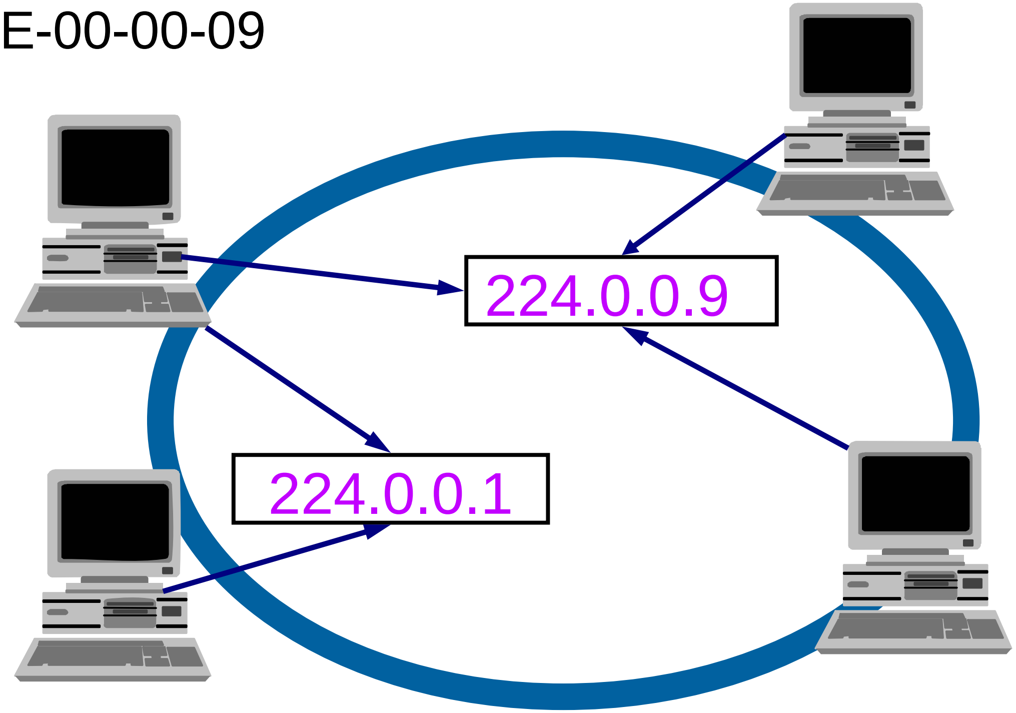
IPv4 Addressing: Class D Multicast

- 224.0.0.0 to 239.255.255.255
- provides 28-bit multicast group id
  - low-order 23 bits used in ethernet address 01-00-5E-00-00-00
  - E.g. 224.0.0.9 = 01-00-5E-00-00-09

- Hardware facility

- Limited broadcast reduces unnecessary processing by uninterested parties

- Used by RIPv2 and OSPF routers, and IPv6

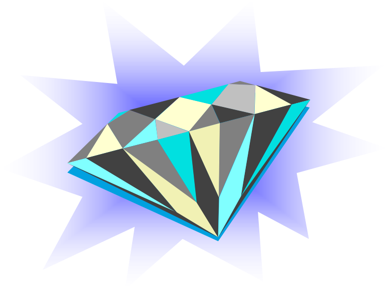


Subnetting

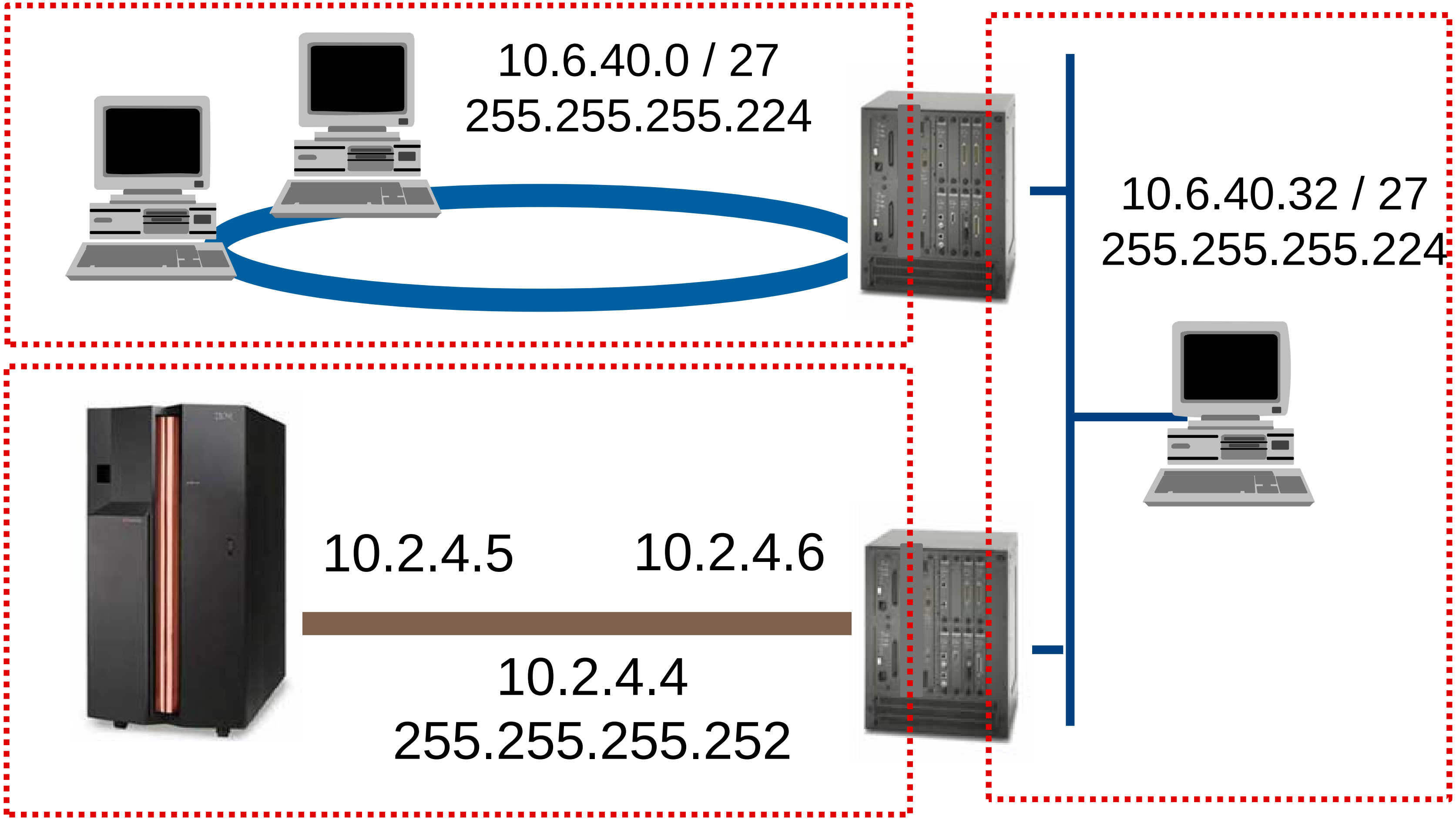
- Class A and B networks provide for 16M and 64K hosts, respectively
- LAN segments do not contain anywhere near that many hosts
- Divide host id portion of address into manageable groups called *subnets*
- In general, classes are used for convenience
  - CIDR - Classless Internet Domain Routing
  - Everything uses subnet masks

Subnetting

- Hosts that are members of the same subnet are considered to be in the same LAN segment
- Point-to-point is a "LAN segment" with exactly two hosts
- Multiple subnets may share same LAN segment
  - a.k.a "multinet"



Subnet = LAN Segment



Subnetting

- The subnet mask defines which bits of the host id are used for the subnet number

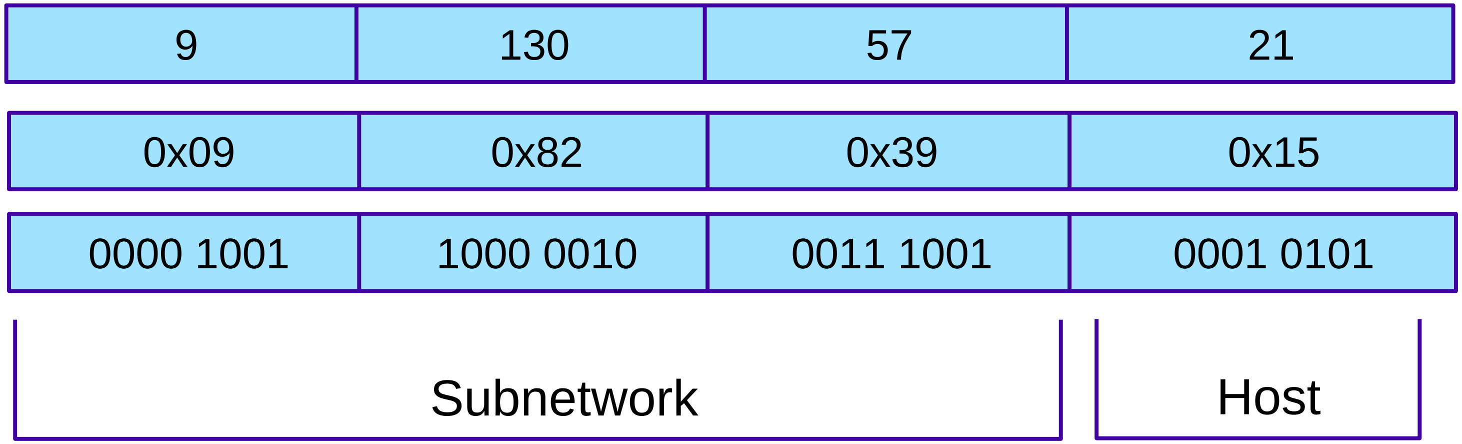
- Subnet number = bitand(address, mask)

  Perform logical AND of destination address and subnet mask to get subnet number

  bitand(9.130.3.157, 255.255.255.240) = 9.130.3.144

IPv4 Subnet Addressing

Subnet mask = 255.255.255.0 (/24)
IP address = 9.130.57.21

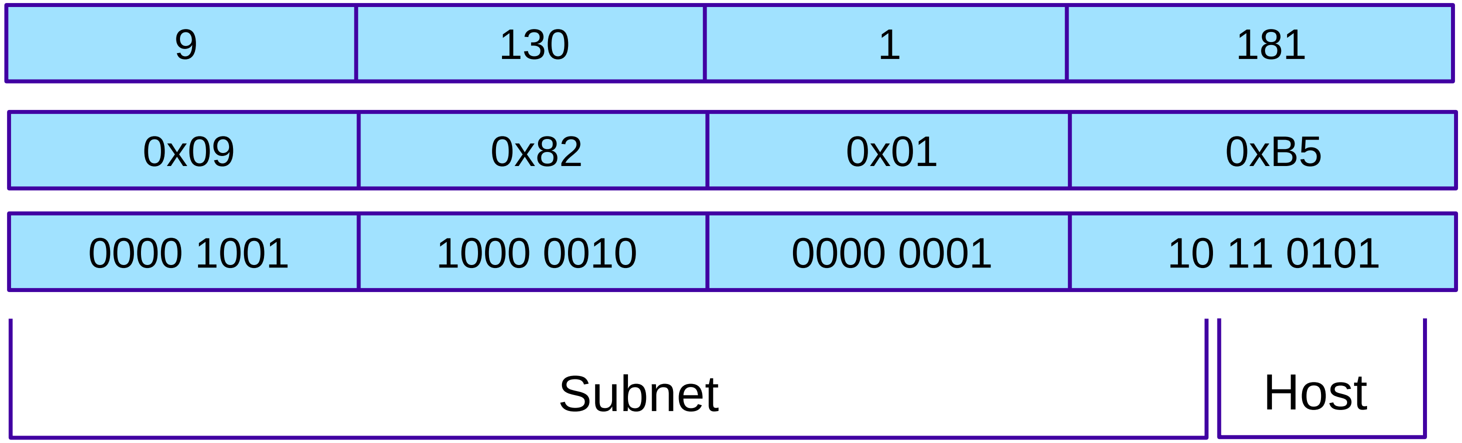


9	130	57	21
0x09	0x82	0x39	0x15
0000 1001	1000 0010	0011 1001	0001 0101

Subnet = 9.130.57.0

IPv4 Subnet Addressing

Subnet mask = 255.255.255.192 (/26)
IP address = 9.130.1.181



9	130	1	181
0x09	0x82	0x01	0xB5
0000 1001	1000 0010	0000 0001	10 11 0101

Subnet value = 9.130.1.128
(How was this determined?)

IPv4 Subnet Addressing

Subnet mask = 255.255.255.192 (/26)
IP address = 9.130.1.181

	0000 1001	1000 0010	0000 0001	1011 0101
&	1111 1111	1111 1111	1111 1111	1100 0000
=	0000 1001	1000 0010	0000 0001	1000 0000
=	9	130	1	128

Subnet = 9.130.1.128
Host = 53 (0x35)

0011 0101

Remaining bits are host number
(cannot be all 1's or all 0's!)

IPv4 Addressing Quick Reference

Class	First octet	Network
A	0-127	a.0.0.0
B	128-191	a.b.0.0
C	192-223	a.b.c.0
D	224-239	n/a

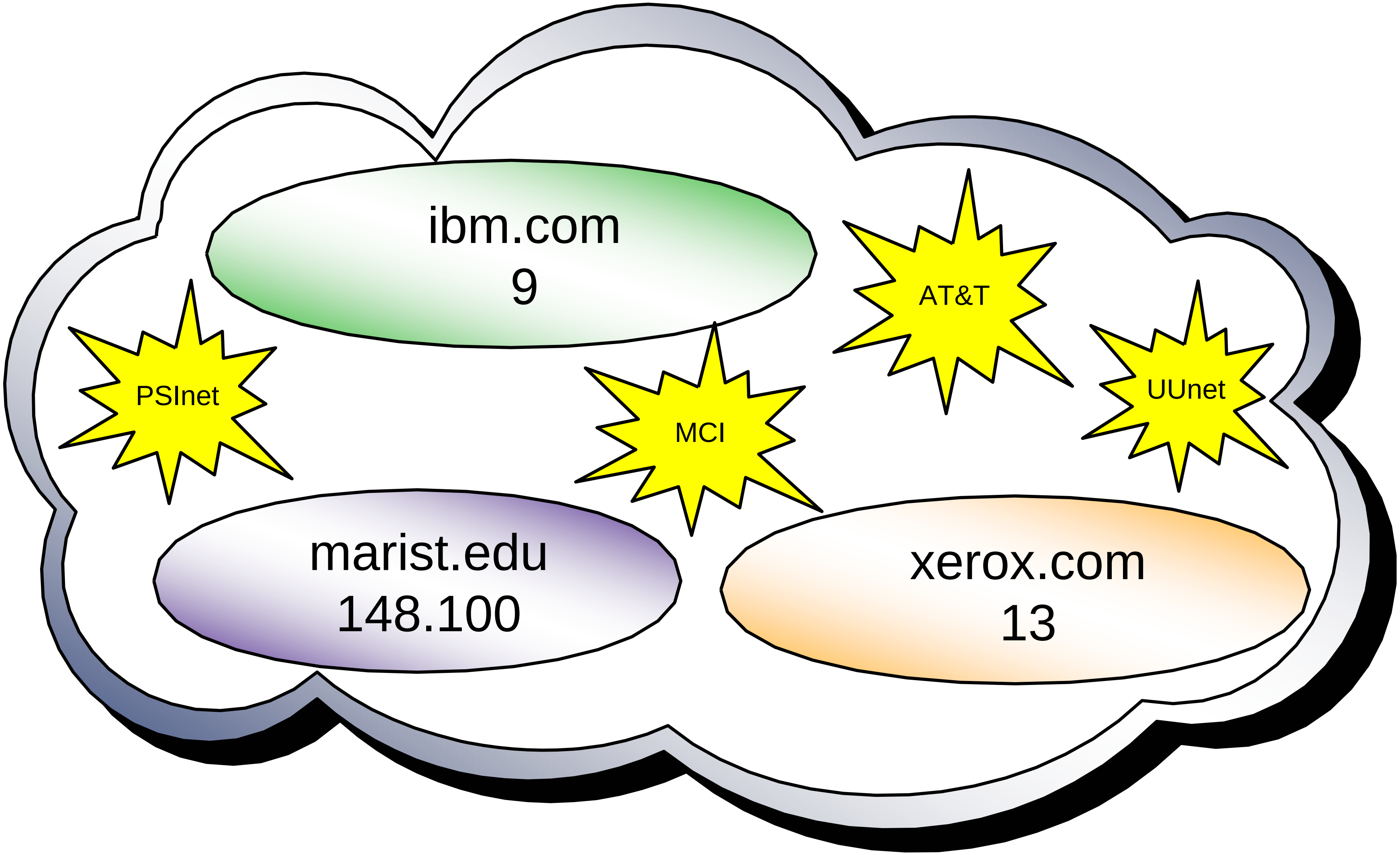
Mask size	Last octet	binary	subnetwork	# hosts
/25	128	1000 0000	**2:** 0 128	126
/26	192	1100 0000	**4:** 0 64 128 192	62
/27	224	1110 0000	**8:** 0 32 64 96 128 160 192 224	30
/28	240	1111 0000	**16:** 0 16 32 48 64 80 96 112 128 144 160 176 192 208 224 240	14
/29	248	1111 1000	**32:** 0 8 16 24 32 40 48 56 64 72 80 88 96 104 112 120 128 136 144 152 160 168 176 184 192 200 208 216 224 232 240 248	6
/30	252	1111 1100	**64:** 0 4 8 16 20 24 28 32 36 ...	2

Special IPv4 Addresses

net ID	**subnet ID**	**host ID**	**Source**	**Destination**	**Description**
0		0	yes	no	this host on this net
0		*hostid*	yes	no	specific host on this net
127		*any*	yes	yes	Loopback
-1		-1	no	yes	local media broadcast
netid		-1	no	yes	network-directed broadcast
netid	*subnetid*	-1	no	yes	subnet-directed broadcast
netid	-1	-1	no	ok	all-subnets-directed broadcast

Local broadcasts are not bridged or routed to other LAN segments

Networks on the Internet



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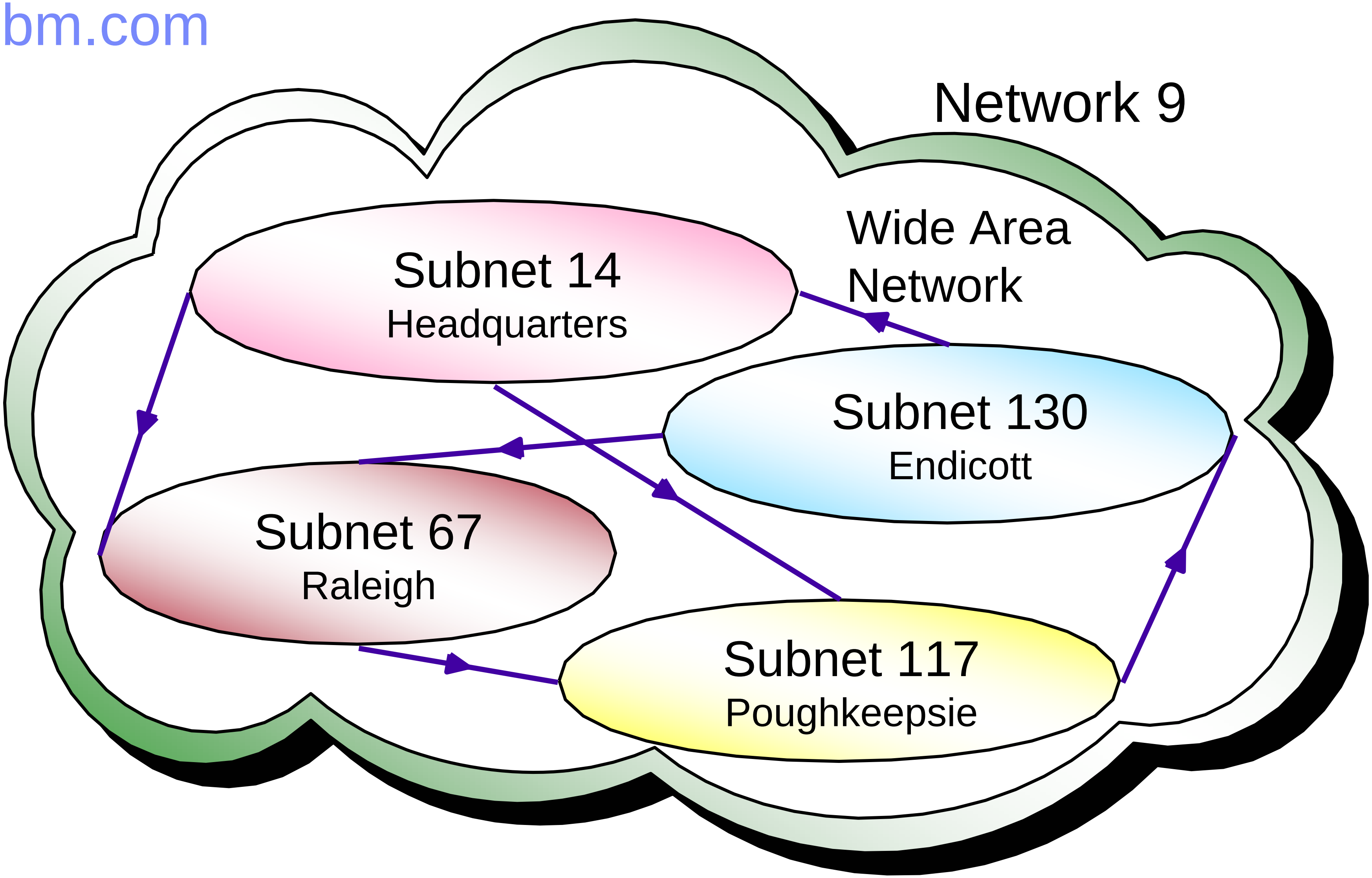
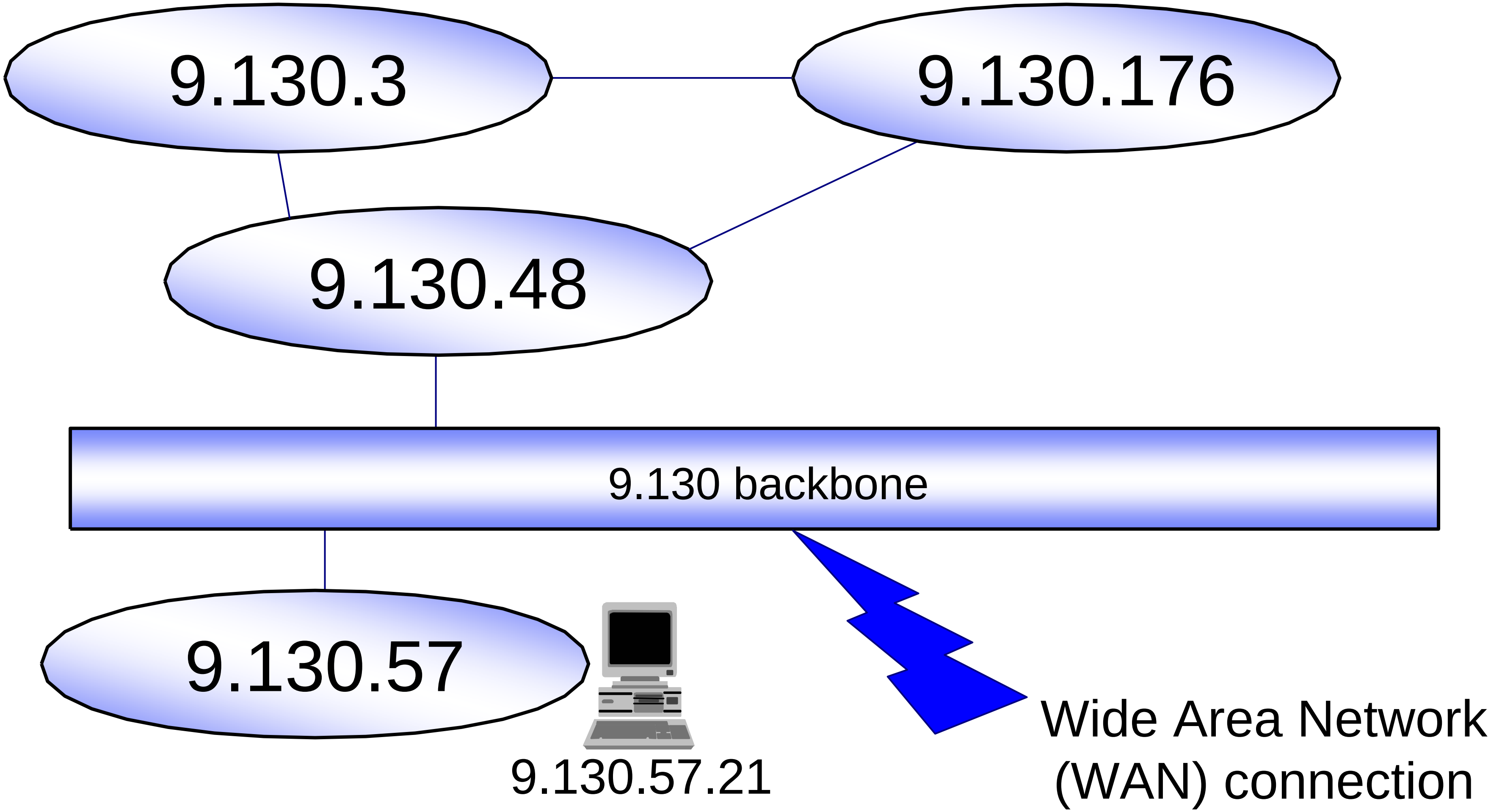

Network 9
Wide Area Network
Subnet 14
Headquarters
Subnet 130
Endicott
Subnet 67
Raleigh
Subnet 117
Poughkeepsie

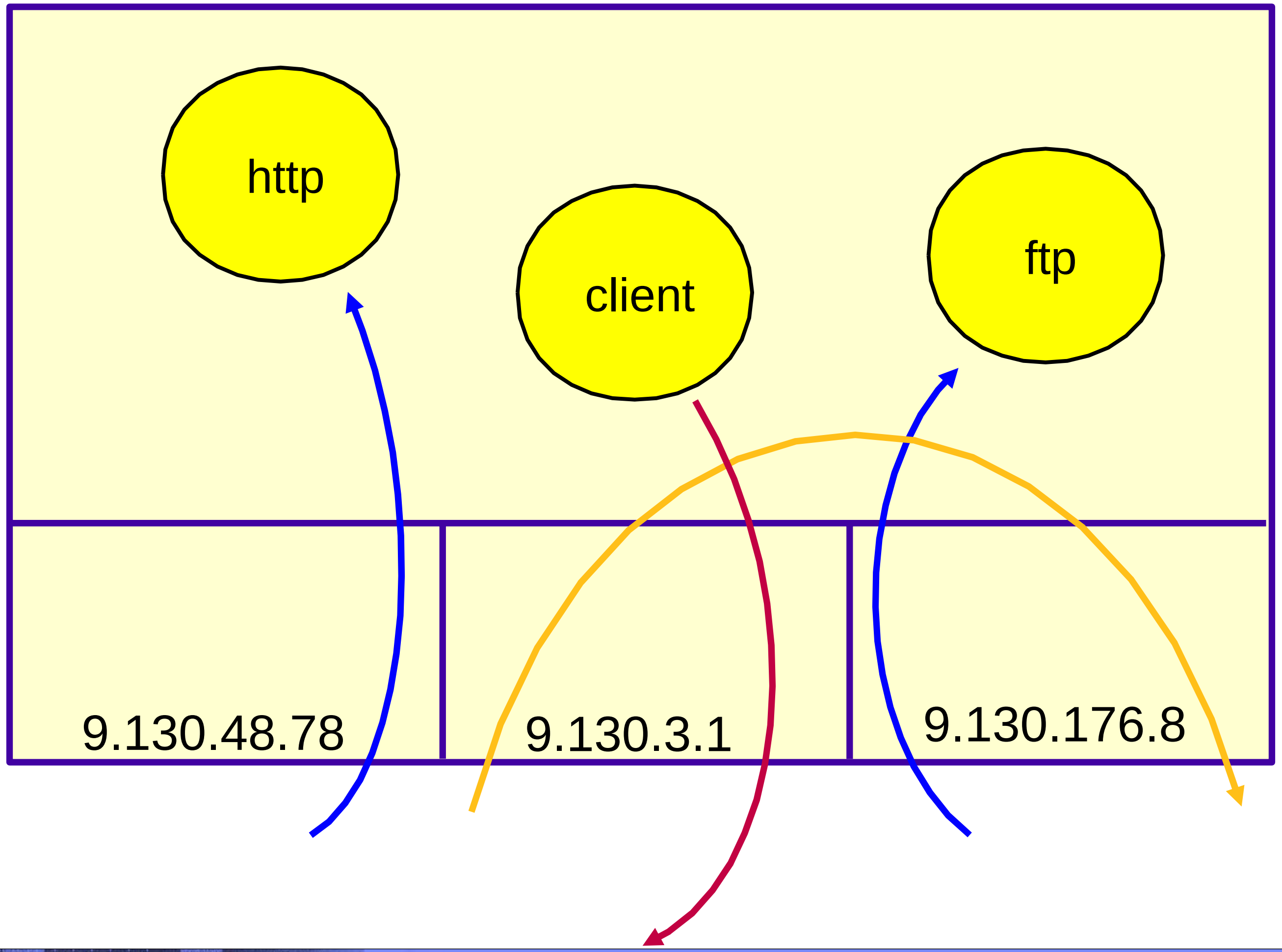
endicott.ibm.com



IP Packet Routing

- Occurs whenever an IP packet is received or sent by a host
  - Sometimes trivial - Only one possible route
  - Sometimes complex - Multi-homed host
- Like a game of "Hot Potato"
  - If not mine, make it someone else's problem ASAP!
  - Logic:
    - If it's for me, kick it upstairs
    - If it's for a host on a network to which I'm connected, send it (point to point) or ARP (LAN)
    - If for some other network, forward to someone else
    - Otherwise, drop it

Multi-homed Host



Routing

- The magic is in selecting the right host in order to reach some other network
- Failing to follow IP addressing rules regarding subnets and LANs result in "host unreachable" or timeouts.
- Describing the local network topology to your system involves learning arcane specification rules
- You will be considered wise and learned!

The Adventure Continues…

- Stay tuned for Routing - Part 2
  Don't touch that dial!

- We'll get into VM TCP/IP host configuration specifics
  - Static routing
  - Dynamic routing
  - VIPA - Virtual IP Addressing
  - Virtual Switching

Read More About It…

z/VM TCP/IP Planning and Customization	SC24-6019
TCP/IP Illustrated, Vol. 1 Addison Wesley	W. Richard Stevens ISBN 0-201-63346-9
Internetworking with TCP/IP Prentice Hall	Douglas P. Comer ISBN 0-13-216987-8

Contact Information

By e-mail:	Alan_Altmark@us.ibm.com
In person:	USA 607.429.3323
On the Web:	http://ibm.com/vm/devpages/altmarka
Mailing lists:	IBMTCP-L@vm.marist.edu VMESA-L@listserv.uark.edu LINUX-390@vm.marist.edu http://ibm.com/vm/techinfo/listserv.html