Networking and Internet Services Part-2

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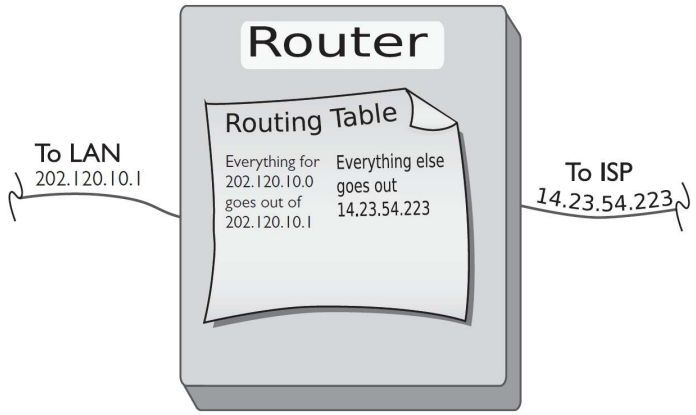
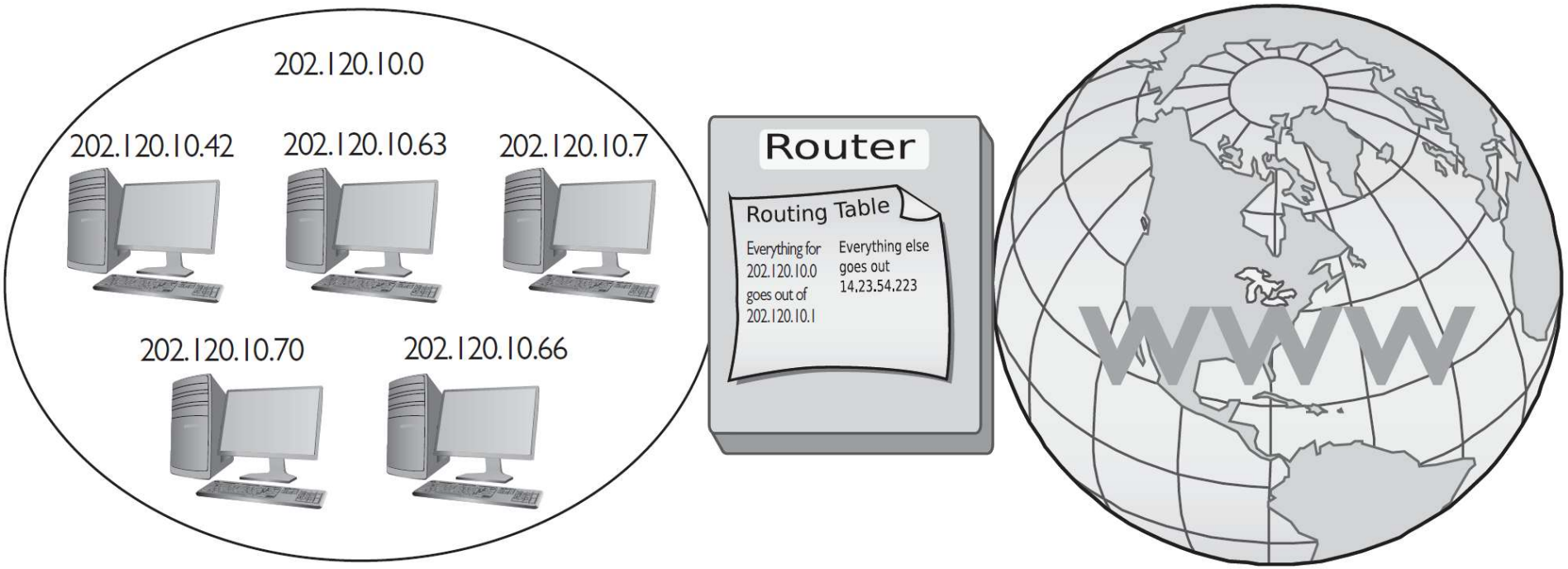
Router

- A.k.a Default gateway
  - When communicating intra-network you MUST use the gateway.
  - Usually an IP address in the start of the range, or 2nd from the end.
  - So, for 192.168.1.x our router will usually be 192.168.1.1 ro 192.168.1.254
- Router uses a routing table to determine what to do with received packets.

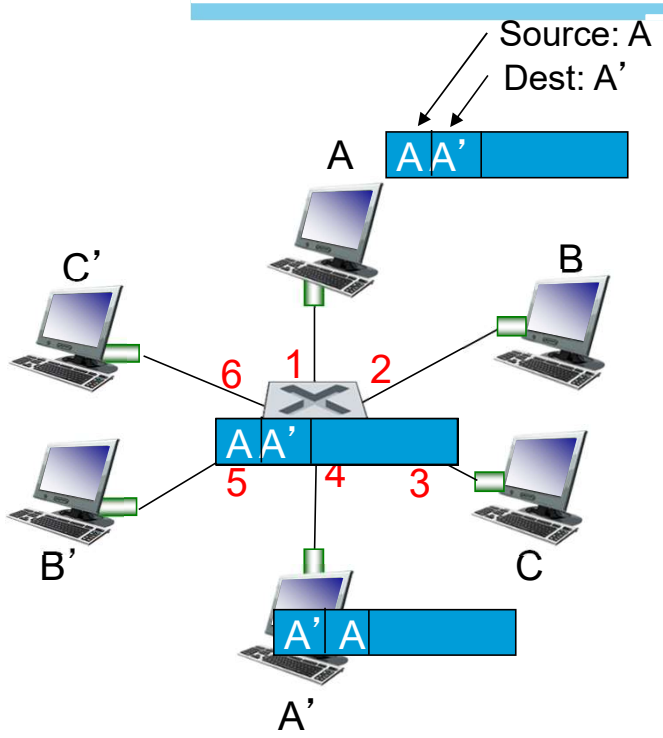


Routing Overview



forwarding: example

- frame destination, A', location unknown: *flood*
- destination A location known: selectively send on just one link



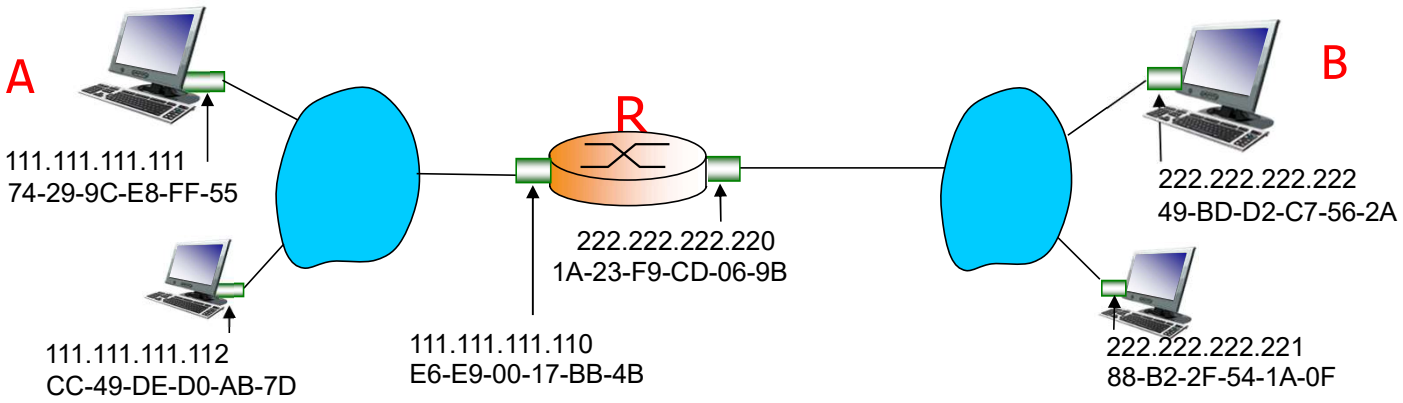
MAC addr	interface	TTL
A	*1*	*60*
A'	*4*	*60*

switch table (initially empty)

Addressing: routing to another LAN

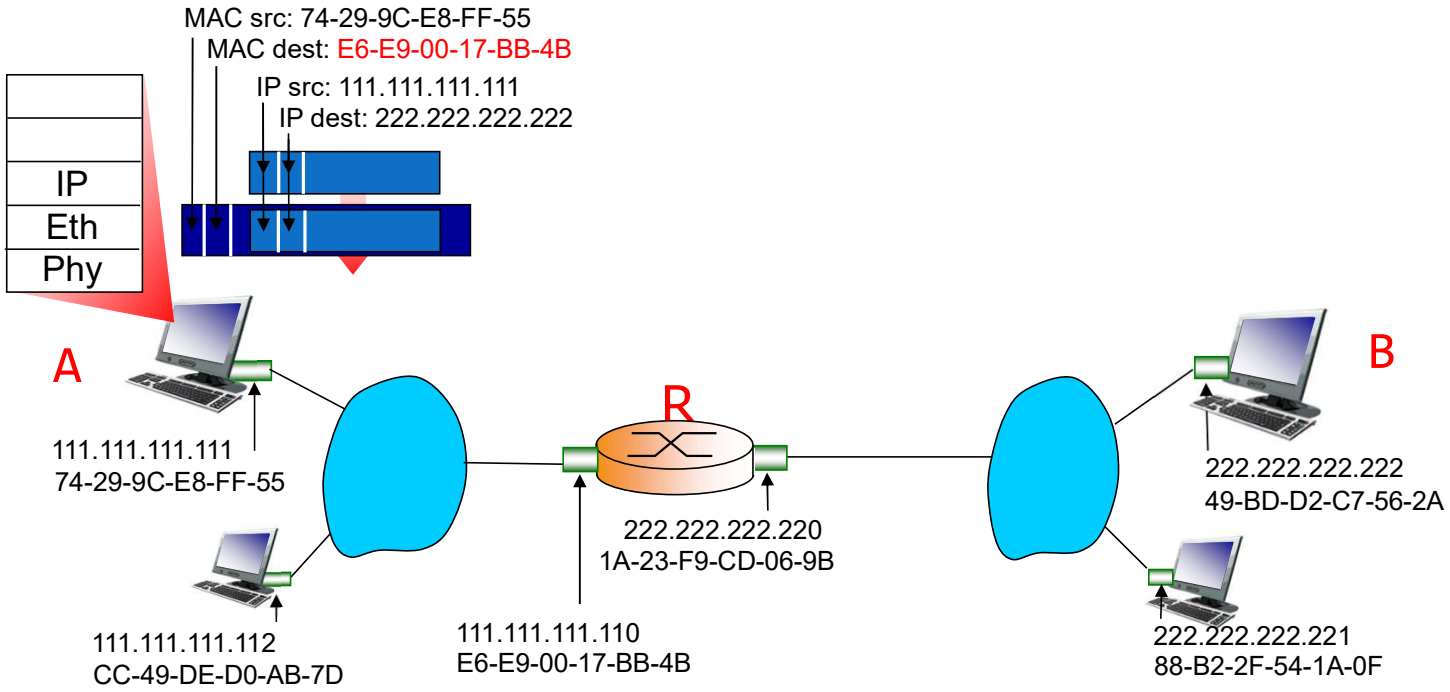
Walkthrough: send datagram from A to B via R

- focus on addressing – the IP (datagram) and MAC layer (frame)
- Assume A knows B's IP address
- Assume A knows the IP address of the first hop router, R (how?)
- Assume A knows R's MAC address (how?)



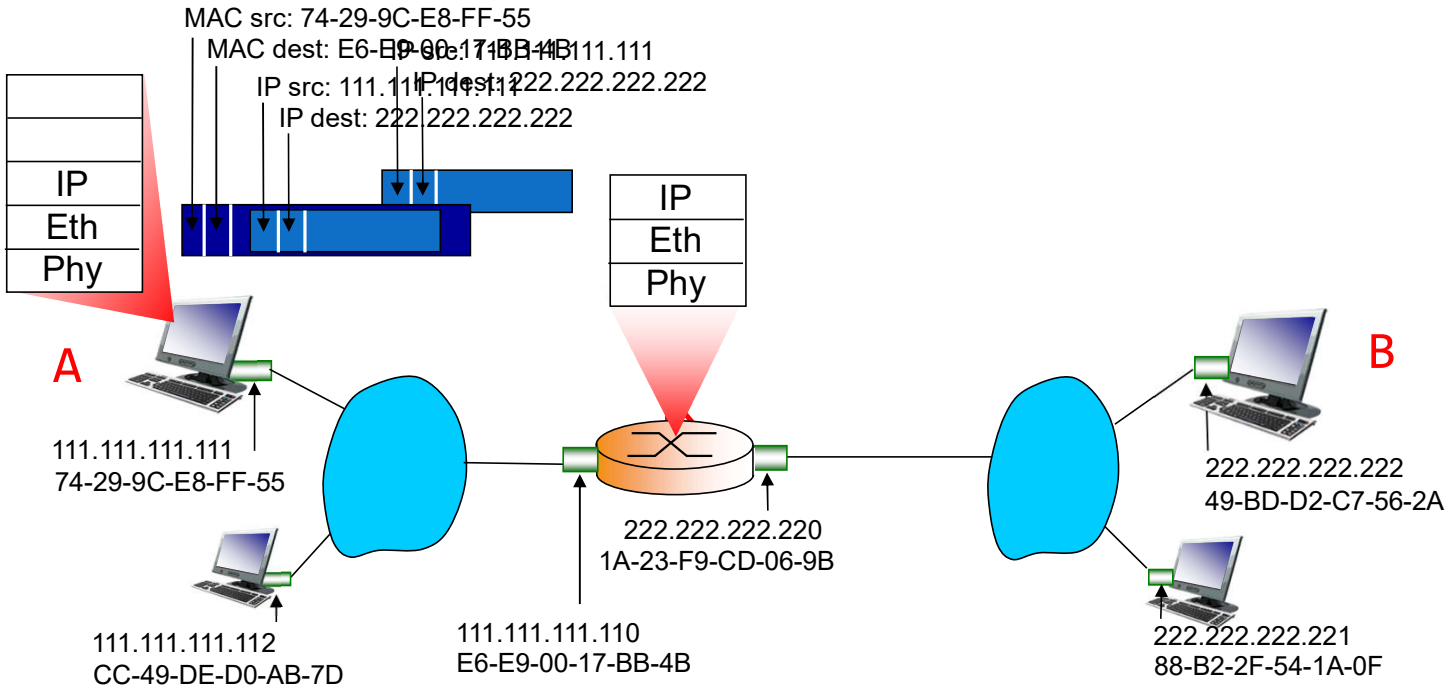
Addressing: routing to another LAN

- A creates IP datagram with IP source A, destination B
- A creates link-layer frame with R's MAC address as destination address, frame contains A-to-B IP datagram



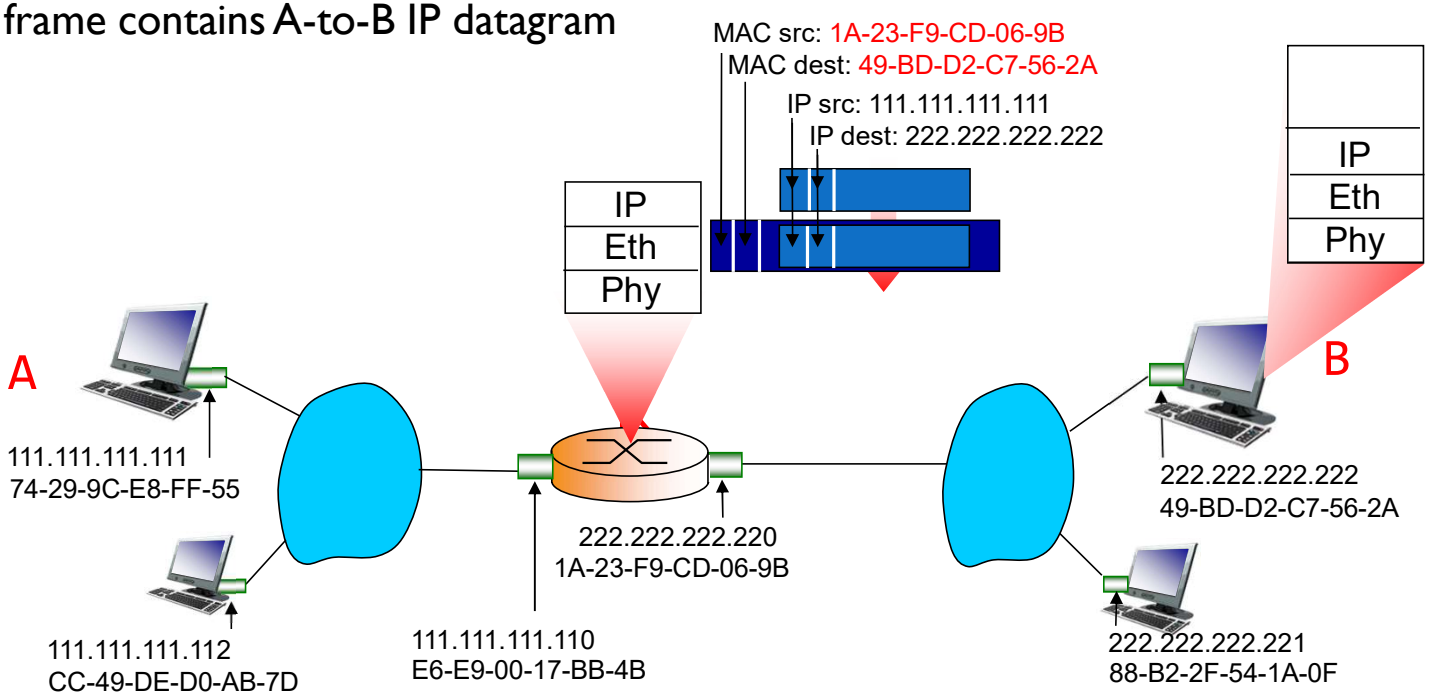
Addressing: routing to another LAN

- frame sent from A to R
- frame received at R, datagram removed, passed up to IP



Addressing: routing to another LAN

- R forwards datagram with IP source A, destination B
- R creates link-layer frame with B's MAC address as destination address, frame contains A-to-B IP datagram



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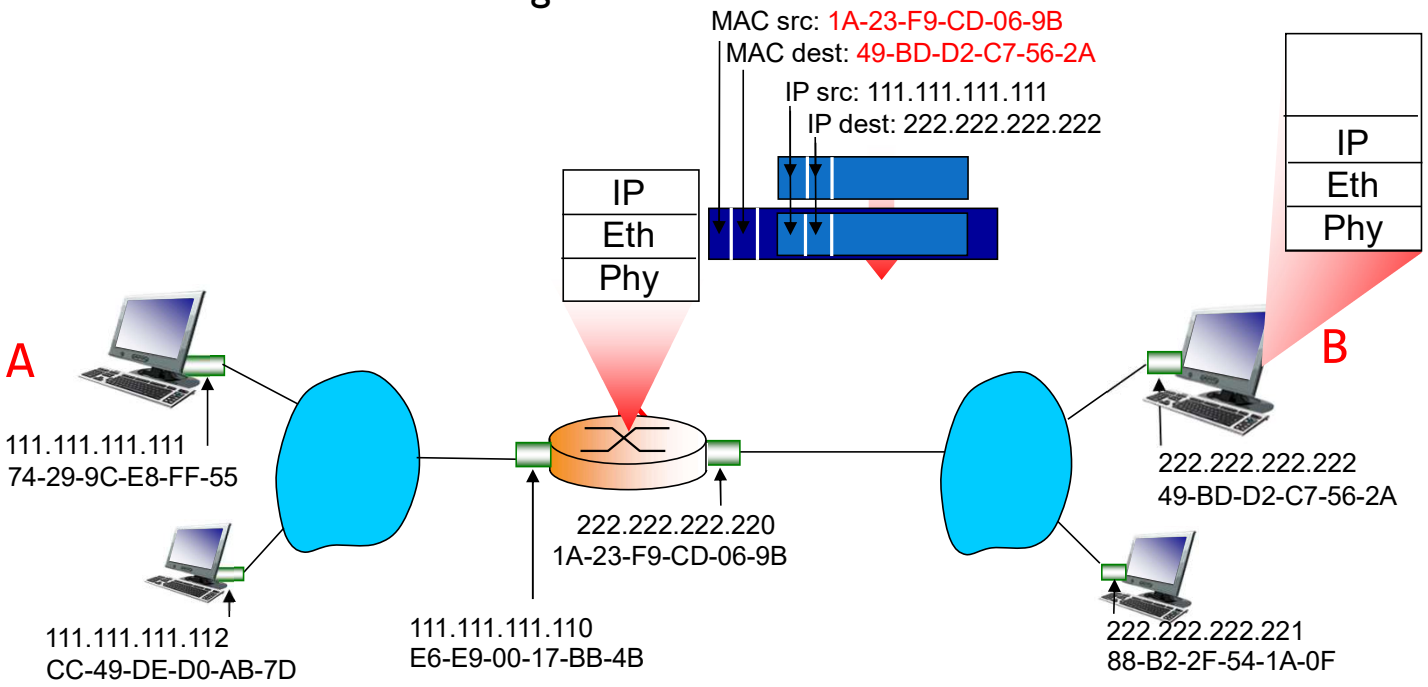
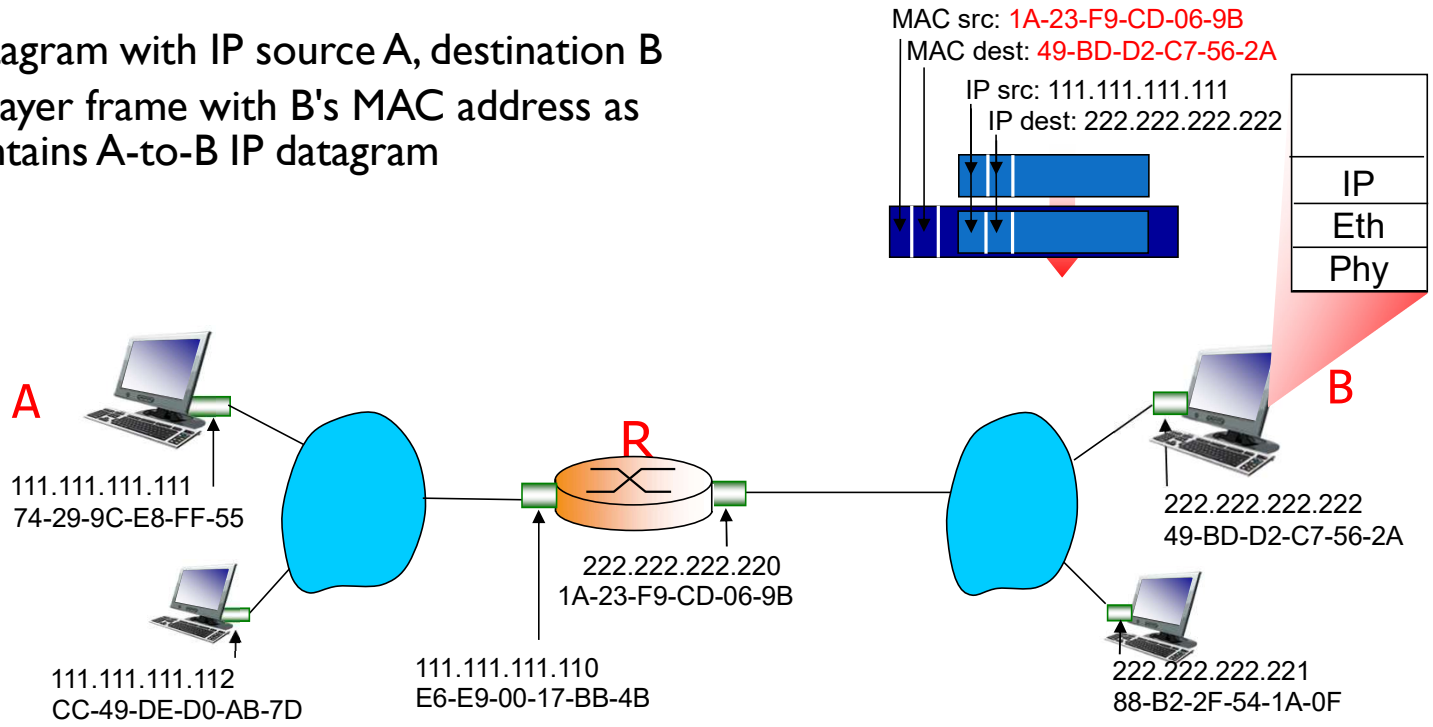


Addressing: routing to another LAN

- R forwards datagram with IP source A, destination B
- R creates link-layer frame with B's MAC address as dest, frame contains A-to-B IP datagram



* Check out the online interactive exercises for more examples: http://gaia.cs.umass.edu/kurose_ross/interactive/

Shorthand for subnet masks

11111111111111111111111100000000 = 255.255.255.0
24 ones, so we can append /24 to ip address.

11111111111111110000000000000000 = 255.255.0.0
/16

11111111000000000000000000000000 = 255.0.0.0
/8

Example

201.23.45.123/24

IS

IP address of 201.23.45.123
with a subnet mask of 255.255.255.0

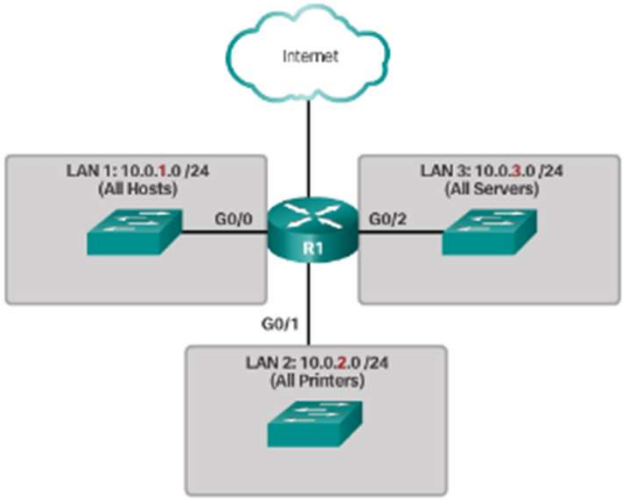
Exercise

- Example: Network 10.0.0.0/8 is a very large network with $2^{24} - 2$ hosts and a subnet mask of 255.0.0.0
- What is the following /xx notation?
- 255.255.254.0?

IP

- A network ID of 202.120.10.0, for example, a network is limited to IP addresses from 202.120.10.1 to 202.120.10.254.
- 202.120.10.255 is the **broadcast** address and is reserved.
- Bigger networks can use more creative network ID like 172.10.0.0 this gives 65534 hosts.
- (256 * 2) – 2 = 65534 (Why -2?)

Reasons for Subnetting



Slides - courtesy of Cisco Systems

IP Classes

The philosophy of IP classes stems from the early design of the Internet Protocol.

IP classes (Class A, B, C, D, and E) were developed as a way to allocate and categorize IP addresses based on network size and use.

The goal was to provide a scalable and organized system for distributing IP addresses during the initial stages of the internet's growth.

IP Classes

1. **Class A**: These were meant for the largest networks. They had a large number of hosts and a small number of networks. The first 8 bits were used for the network portion, while the remaining 24 bits were used for hosts.

2. **Class B**: Intended for medium-sized organizations. They had a balance between the number of networks and hosts. The first 16 bits were for the network portion, and the remaining 16 bits were for hosts.

3. **Class C**: Designed for smaller organizations. They had a large number of networks but fewer hosts within each network. The first 24 bits were for the network portion, and the remaining 8 bits were for hosts.

4. **Class D**: Reserved for multicast addresses.(video conferencing or streaming)

5. **Class E**: Reserved for experimental purposes and isn't used in the public domain.

IP Classes

Origin:

- The classful IP addressing scheme was defined in various RFCs (Request for Comments), primarily by the early architects of the Internet and the Internet Engineering Task Force (IETF).

Evolution of IP Classes

With the growth of the Internet, it became clear that this class-based system wasn't efficient, especially given the rapid exhaustion of address space and the inflexibility of classful allocations. The primary problems were:

Inefficiency: Many Class A and Class B addresses were allocated to organizations that didn't need that many addresses, leading to wastage.

Scarcity: As more and more organizations came online, there were not enough Class B and Class C addresses to go around.

Address IP Classful Issues

1. **Classless Inter-Domain Routing (CIDR)**: Introduced in the mid-1990s, CIDR effectively replaced the classful addressing system. It allows for a more granular allocation of IP addresses by using a variable-length subnet mask. This change helped slow the rapid exhaustion of IPv4 addresses.

2. **Introduction of IPv6**: Recognizing that IPv4 addresses would eventually run out, IPv6 was introduced with a vastly larger address space (128 bits compared to IPv4's 32 bits).

Important network categorization: CLASS

Class	First Value	Netmask	Addresses	
A	1-126	255.0.0.0	1.0.0.0– 126.255.255.255	16,277,214
B	128-191	255.255.0.0	128.0.0.0– 191.255.255.255	65534
C	192-223	255.255.255.0	192.0.0.0– 223.255.255.255	254
	224-239		224.0.0.0– 239.255.255.255	Multicast

IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)
A	1-127**	00000000-01111111	N.H.H.H	255.0.0.0
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0
D	224-239	11100000-11101111	NA (multicast)	
E	240-255	11110000-11111111	NA (experimental)	

** All zeros (0) and all ones (1) are invalid hosts addresses.

Examples of IPV4 addresses

- Class "A" 1-126 (what happened to 127? Stay tuned)
  - 100.0.0.0 /8
- Class "B" 128-191
  - 132.7.0.0/16
- Class "C" 192 - 223
  - 200.3.5.0/24

How many hosts for each class “A”, “B” and “C”?

- Class “A” 1-126 (what happened to 127? Stay tuned)
  - 100.0.0.0 /8
  - Number of hosts* $2^{24} - 2$
- Class “B” 128-191
  - 132.7.0.0/16
  - Number of hosts* $2^{16} - 2$
- Class “C” 192 – 223 200.20.1.3/24
  - 200.3.5.0/24
  - Number of hosts* $2^{8} - 2$
- * Two hosts are reserved for network and broadcast
  ** 0 is used for default routes and 127 is used for loopback

Private network ranges for class “A”, “B” and “C”

- Each class has its own set of private IP addresses
- These addresses can be used locally anywhere, but they are NEVER routed over the Internet.
  - Class “A”
    - 10.0.0.0 /8
  - Class “B”
    - 172.16.0.0 /12
  - Class “C”
    - 192.168.0.0/16

- RFC 1918

Class D – Multicast addresses

- Class D examples: 224 – 239
  - Multicast addresses used for one to many, devices "subscribe" to the group
  - Used in video, collaboration, and for routing protocols
  - 224.0.0.1 – all hosts on the same network segment
  - 224.0.0.2 – all routers
  - 224.0.0.5 – OSPF routing protocol(Open shortest Path First)
  - 224.0.0.6 – OSPF routing protocol
  - 224.0.0.10 – EIGRP (Cisco's routing protocol)
  - 224.0.0.9 – RIP routing protocol

Trick to determine A/B/C/D class looking at binary octets.

- Class A address always begins with a 0 (0xxxxxxx);
- Class B, it begins with a 10 (10*xxxxxx*);
- Class C, with 110 (110*xxxxx*);
- Class D, with 1110 (1110*xxxx*);

Other IP Addresses

- Loopback addresses
  - 127.0.0.0 /8 or 127.0.0.1 to 127.255.255.254
    - Test that your NIC card is working and that the IP stack on the computer is working.
- Link-local addresses or Automatic Private IP Addressing (APIPA) addresses
  - 169.254.0.0 /16 or 169.254.0.1 to 169.254.255.254
    - This is what you get when DHCP fails
- TEST-NET addresses
  - 192.0.2.0/24 or 192.0.2.0 to 192.0.2.255
- Classless Addressing
  - CIDR
  - Allocated IPv4 addresses based on prefix length, not class

Multicast

- Multicast class blocks are used for one-to-many communication, such as in streaming video conferencing.

- There are three types of ways to send a packet: a *broadcast*, which is where every computer on the LAN hears the message; a *unicast*, where one computer sends a message directly to another user; and a *multicast*, where a single computer sends a packet to a group of interested computers.

Class A has how many hosts?

- Netmask = 255.0.0.0
- **24** bits for hosts…
- 11111111 00000000 00000000 00000000
- 2^24 = 16277216 (-2)

Identify each address with its proper class.

Write “A”, “B”, “C”, “D”, “E” or “None” in the provided area.

Sample	Write answer here
3.0.5.0	
129.129.129.129	
235.40.19.64	
192.168.375.0	
190.0.0.0	
200.200.200.0	
255.245.235.225	
192.168.255.0	
10.100.1.1	
127.0.0.1	

Identify each address with its proper class.

Write “A”, “B”, “C”, “D”, “E” or “None” in the provided area.

Sample	Write answer here
3.0.5.0	Class A
129.129.129.129	Class B
235.40.19.64	Class D
192.168.375.0	Invalid
190.0.0.0	Class B
200.200.200.0	Class C
255.245.235.225	Class E
192.168.255.0	Class C
10.100.1.1	Class A
127.0.0.1	Loopback(local)

More IP Address Exercises

Identify the default (or classful) mask from the given IPv4 sample addresses. Write the "/" value and the four dotted decimal value in the provided area.

Sample	/ value	Four dotted decimal value
3.0.5.0	/	
129.129.129.129	/	
190.0.0.0	/	
192.168.255.0	/	
10.100.1.1	/	

Identify the network address and the broadcast address for each of the given samples.

Sample	Network	Broadcast
3.0.5.0/8		
129.129.129.129/16		
190.0.0.0/16		
192.168.255.0/24		
10.100.1.1/8		

More IP Address Exercises

Identify the default (or classful) mask from the given IPv4 sample addresses. Write the "/" value and the four dotted decimal value in the provided area.

Sample	/ value	Four dotted decimal value
3.0.5.0	/8	255.0.0.0
129.129.129.129	/16	255.255.0.0
190.0.0.0	/16	255.255.0.0
192.168.255.0	/24	255.255.255.0
10.100.1.1	/8	255.0.0.0

Identify the network address and the broadcast address for each of the given samples.

Sample	Network	Broadcast
3.0.5.0/8	3.0.0.0	3.255.255.255
129.129.129.129/16	129.129.0.0	129.129.255.255
190.0.0.0/16	190.0.0.0	190.0.255.255
192.168.255.0/24	192.168.255.0	192.168.255.255
10.100.1.1/8	10.0.0.0	10.255.255.255

Try to find answer for these questions
IP Classful Questions

- What class is 135.8.9.2 and what is the classful subnet mask?
- What is the range for a class C network and what is the classful subnet mask?
- What class uses subnet mask 255.255.0.0?
- Give a valid address for a class A network
- How many bits for the hosts can you have in a class B network
- Which classful network has a total of 8 bits for its host portion

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