IP Addressing

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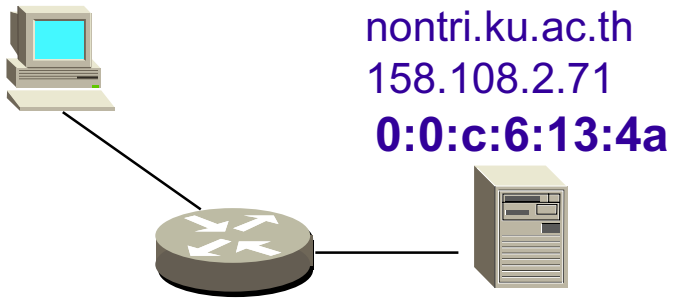
Last updated: July 30, 1999

Three levels of addressing

- **Host names (FQDN)**
  - **nontri.ku.ac.th**
- **Internet (IP) address**
  - **158.108.2.71**
    (32 bit address with “dotted-decimal” notation)
- **station Address - hardware address assigned to interface card, refer to MAC address**
  - **e.g. Ethernet address 0:0:c:6:13:4a**



Converting Host name to MAC

nontri.ku.ac.th

resolve using host file table or Domain Name System (DNS)

158.108.2.71

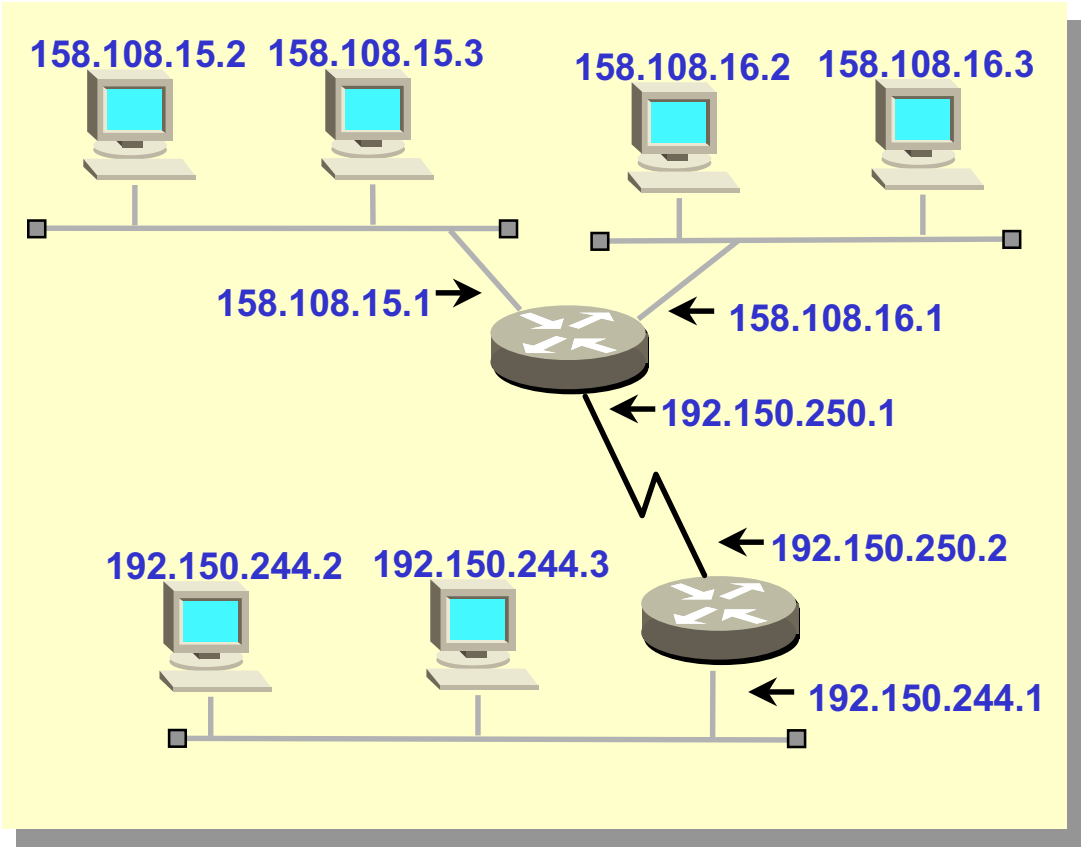
resolve by Address Resolution Protocol(ARP)

0:0:c:6:13:4a

IP Address with router

- **IP address associated with interface (not machine)**

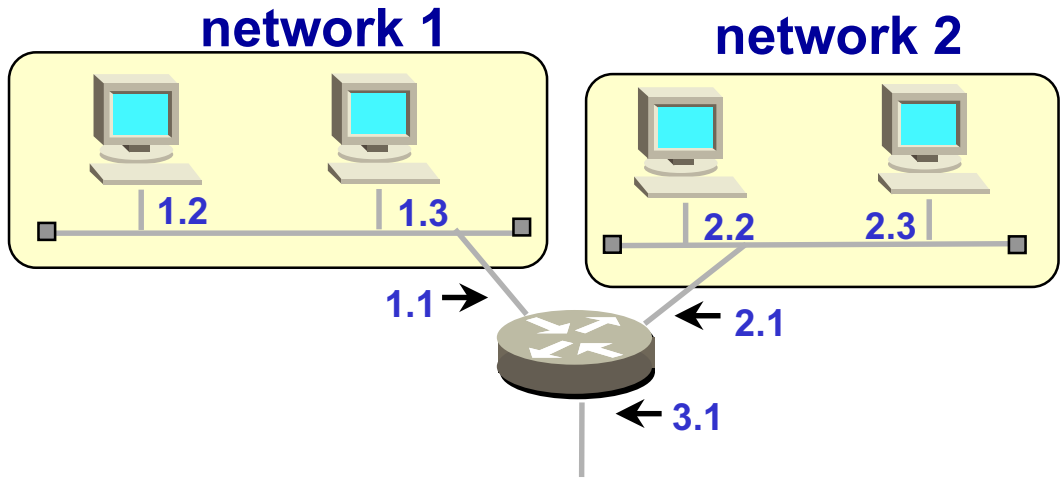
- Each interface has its own IP Address
- Machine with >1 I/f, called multi-homed
- Router is multi-homed machine
- Multi-homed need not to be router



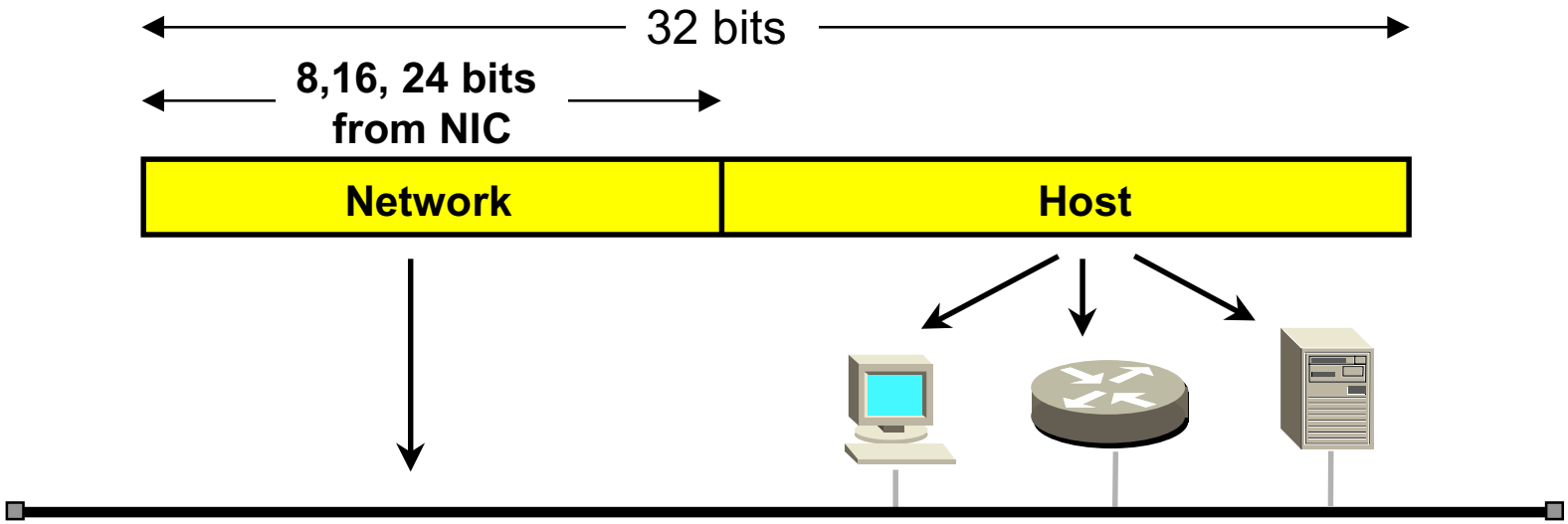
Addressing concept

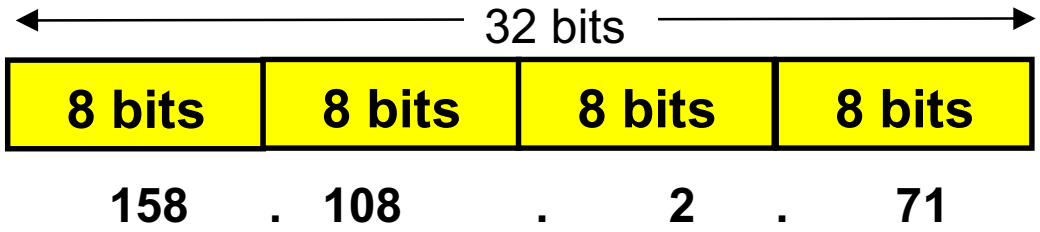
- partitions address into 2 fields
  - network address (path part used for routing)
  - node address (specific device on the net)

network	node
1	1,2,3
2	1,2,3
3	1



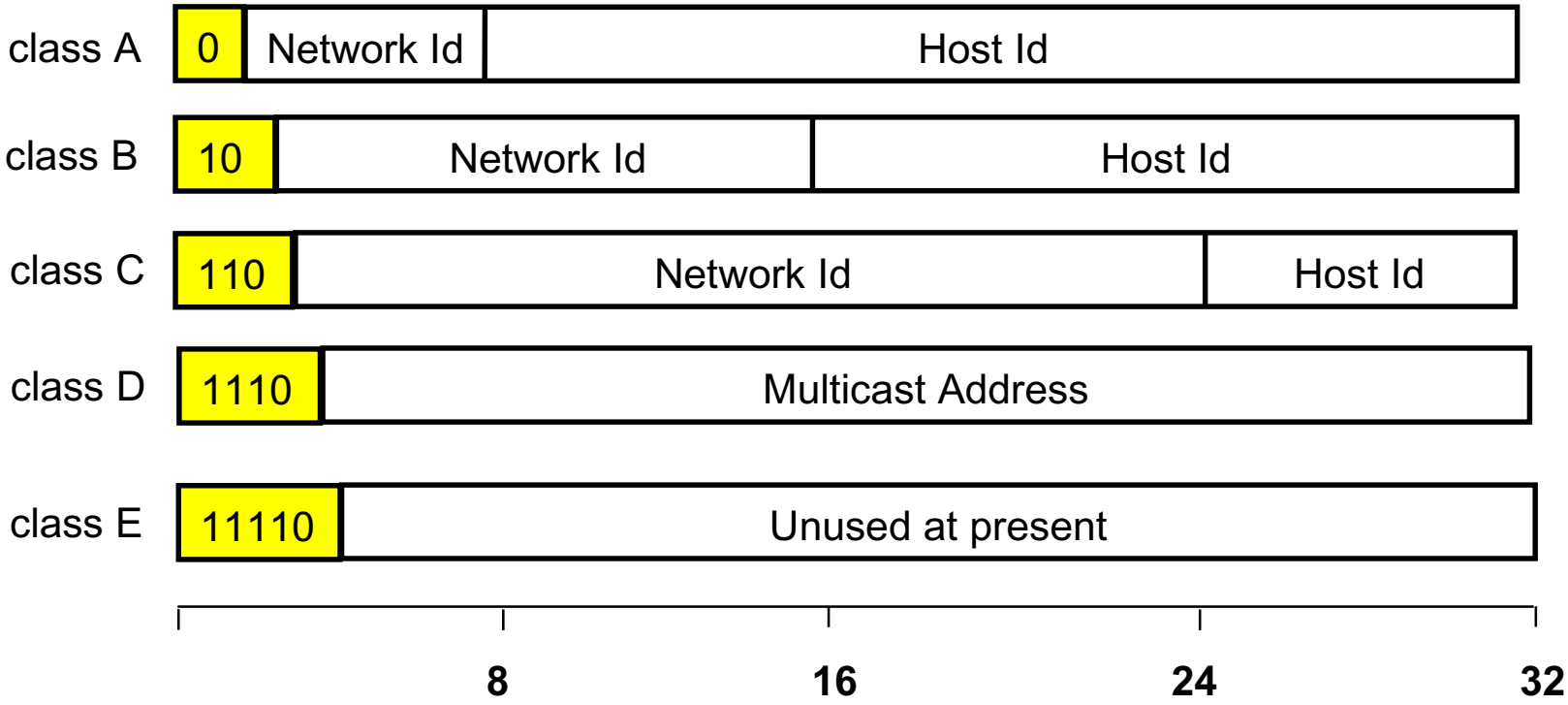
IP Addressing





IP Address Class

- **32 bit address length, contain 2 parts**
  - **network identifier**
  - **host identifier**



IP Address Table

class	initial bits	#bit net	#bit host	range
A	0	7	24	0.0.0.0 127.255.255.255
B	10	14	16	128.0.0.0 191.255.255.255
C	110	21	8	192.0.0.0 223.255.255.255
D	1110	28	-	224.0.0.0 239.255.255.255
E	11110	27	-	240.0.0.0 247.255.255.255

class	address spaces	usable
A	2^24=16677216	166777214
B	2^16=65536	65534
C	2^8 =256	254

Special Addresses

- Host id “all 0s” is reserved to refer to a network number
  - 158.108.0.0, 192.150.251.0
- Host id “all 1s” is reserved to broadcast to all hosts on a specific network (also called net directed broadcast)
  - 158.108.255.255, 192.150.251.255

Special Addresses, cont.

- 0.0.0.0 is reserved and means "this host on this network". Normally use to boot diskless workstation
- 255.255.255.255 is reserved to broadcast to every host on the local network (also called limited broadcast)
- 127.x.x.x means "this node" (local loopback). Messages sent to this address will never leave the local host

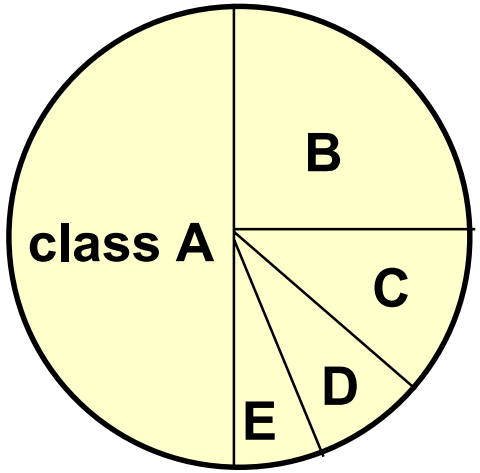
ifconfig

- **See your IP address and subnet mask with Unix's interface configuration command :**

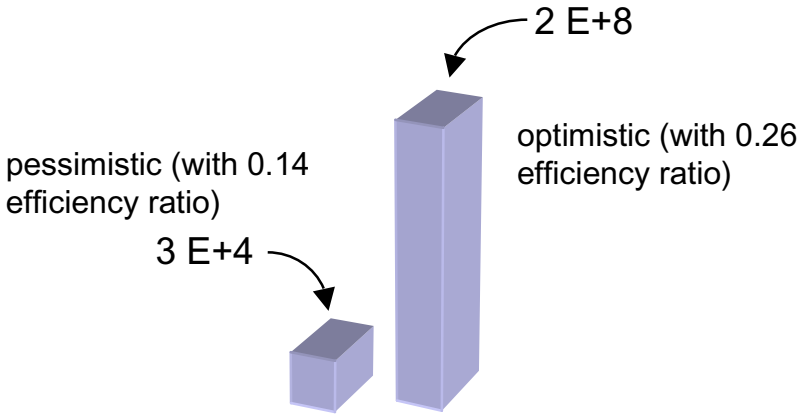
```
# ifconfig -a
lo0: flags=849<UP,LOOPBACK,RUNNING,MULTICAST> mtu 8232
        inet 127.0.0.1 netmask ff000000
le0: flags=863<UP,BROADCAST,NOTRAILERS,RUNNING,MULTICAST> mtu    1500
      inet 158.108.32.3 netmask ffffffc0 broadcast 158.108.32.63
      ether 8:0:20:18:d6:66
```

Problems with Class assignment

- **class A takes 50% range, class B 25%, class C 12.5%**
- **These leads to :**
  - address wasteful (specially in class A)
  - running out of IP address



Population counts in the network with 32 bits address format [RFC1715]



HOW IR assigns IP address (RFC1466)

- class A : no allocations will be made at this time
- class B : allocations will be restricted. To apply:
  - organization presents a subnetting more than 32 subnets
  - organization has more than 4096 hosts
- class C : divided into allocated blocks to distributed regional

192.0.0.0 - 193.255.255.255
194.0.0.0 - 195.255.255.255
196.0.0.0 - 197.255.255.255
198.0.0.0 - 199.255.255.255
200.0.0.0 - 201.255.255.255
202.0.0.0 - 203.255.255.255
204.0.0.0 - 205.255.255.255
206.0.0.0 - 207.255.255.255
208.0.0.0 - 223.255.255.255

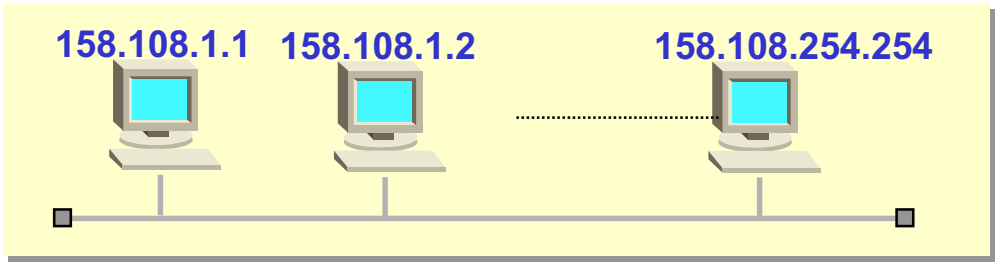
Class C Assignment

- **assignment is based on the subscriber's 24 month projection according to the criteria:**

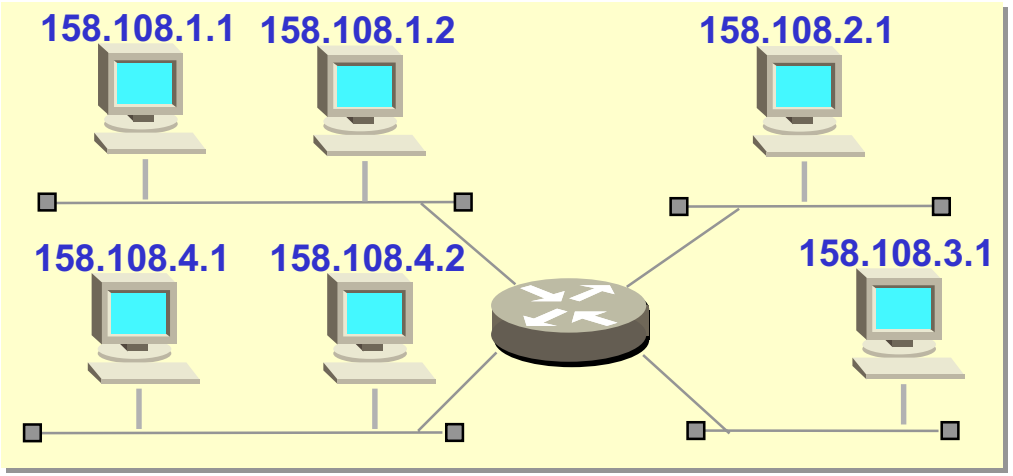
1) requires fewer than 256 addresses 1 class C network
2) requires fewer than 512 addresses 2 contiguous class C networks
3) requires fewer than 1024 addresses 4 contiguous class C networks
4) requires fewer than 2048 addresses 8 contiguous class C networks
5) requires fewer than 4096 addresses 16 contiguous class C networks
6) requires fewer than 8192 addresses 32 contiguous class C networks
7) requires fewer than 16384 addresses 64 contiguous class C networks

Problem with large networks

- Class B “Flat network” more than 60000 hosts
  - How to manage?
  - Performance?



- Class B “subdivided network” to smaller groups with router



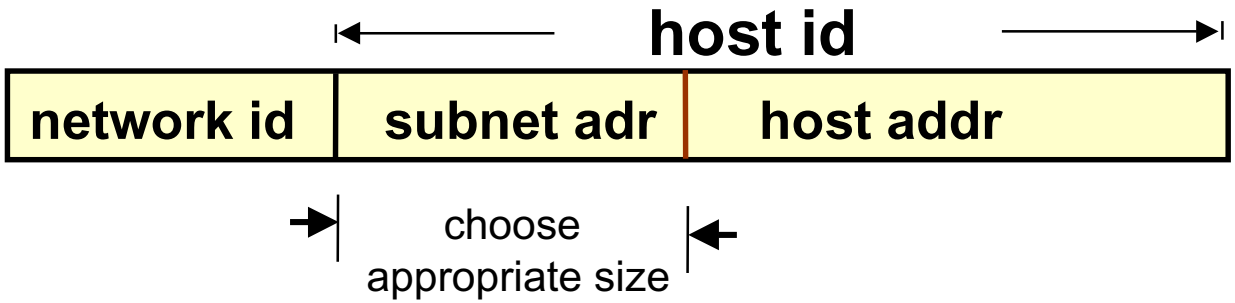
Subnetwork benefits

- Increase the network manager's control over the address space
- Easy to allocate the address space
- Better network performance
- Hide routing structure from remote routers, thus reducing routes in their routing tables

Subdivide on IP network number is an important initial task of network managers

How to assign subnet

- Divide host id into 2 pieces



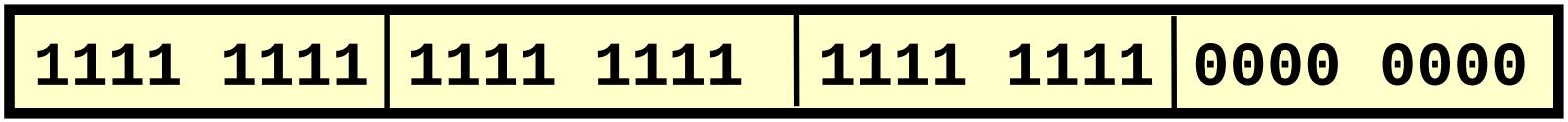
- Class B address such as 158.108 might use its third byte to identify subnet e.g.

  - subnet#1 158.108.1.X
  - subnet#2 158.108.2.X

  x=host addr range from 1-254

Subnet mask

- 32 bit number, tells router to recognize the subnet field, call *subnet mask*
- subnet rule: "The bit covering the network and subnet part of an address are set to 1"
- Example: class B with 24 bit mask

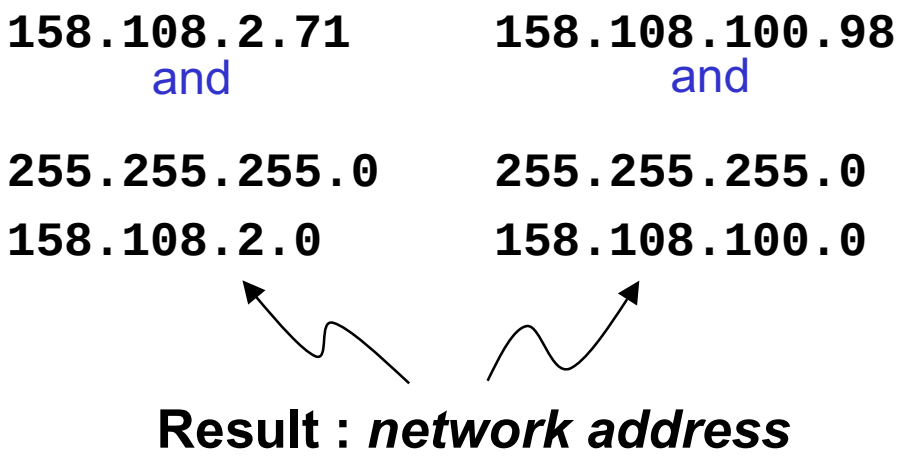


subnet mask= 255.255.255.0

zero bit are used to mask out the host number resulting the network address

Subnet mask, cont

- **Subnet mask 255.255.255.0 for a class B tells:**
  - **network has been partition to 254 subnets**
    - **e.g. 158.108.1.X to 158.108.254.X**
  - **logical "and" between IP addr with mask yields *network address***



Subnet mask bits

- use contiguous subnet mask

128	64	32	16	8	4	2	1		
1	0	0	0	0	0	0	0	=	128
1	1	0	0	0	0	0	0	=	192
1	1	1	0	0	0	0	0	=	224
1	1	1	1	0	0	0	0	=	240
1	1	1	1	1	0	0	0	=	248
1	1	1	1	1	1	0	0	=	252
1	1	1	1	1	1	1	0	=	254
1	1	1	1	1	1	1	1	=	255

Subnet Class B Example

- 255.255.0.0 (0000 0000 0000 0000)
  - 0 subnet with 65534 hosts (default subnet)
- 255.255.192.0 (1100 0000 0000 0000)
  - 2 subnets with 16382 hosts
- 255.255.252.0 (1111 1100 0000 0000)
  - 62 subnets with 1022 hosts
- 255.255.255.0 (1111 1111 0000 0000)
  - 254 subnets with 254 hosts
- 255.255.255.252 (1111 1111 1111 1100)
  - 16382 subnets with 2 hosts

Subnet Class C Example

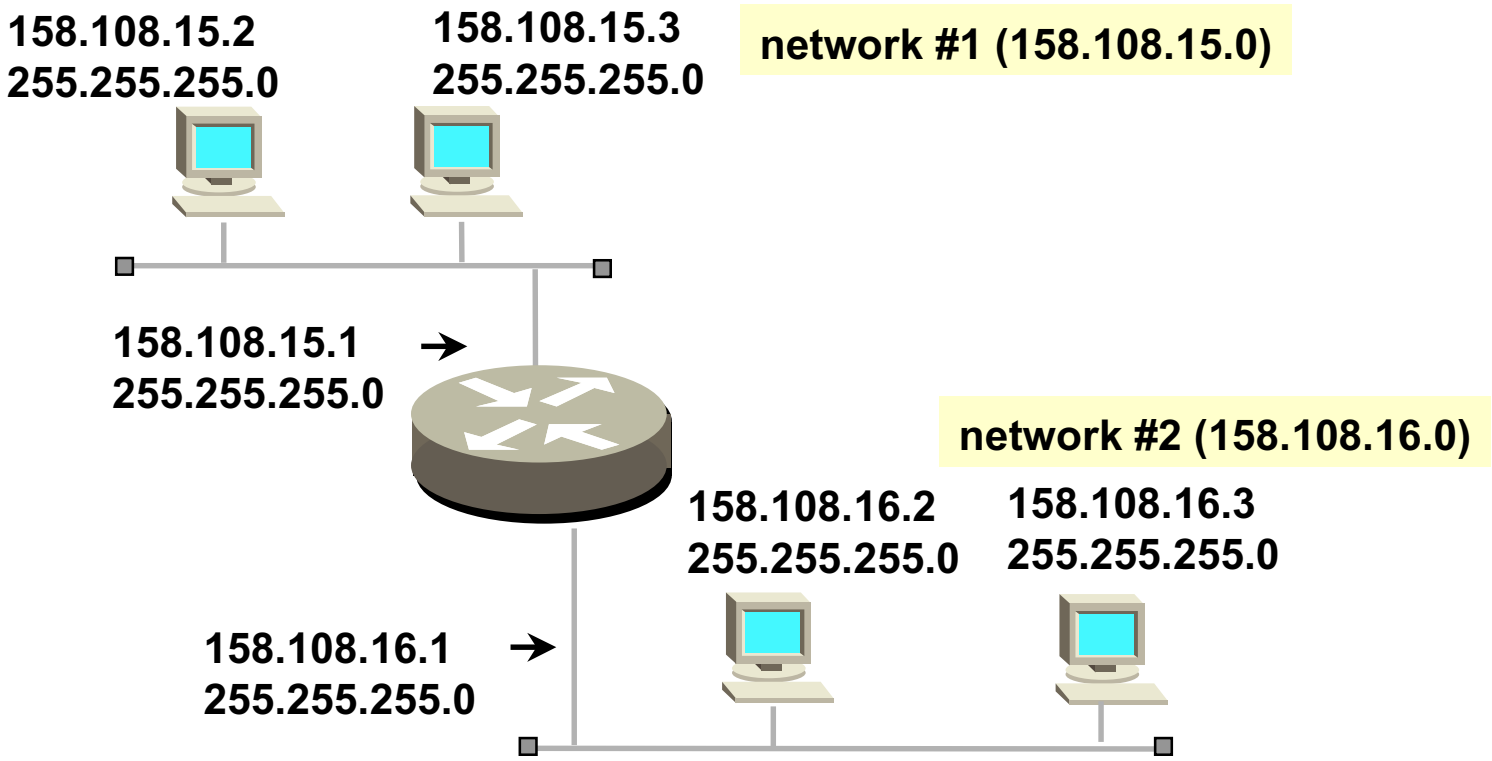
- 255.255.255.0 (0000 0000)
  - 0 subnet with 254 hosts (default subnet)
- 255.255.255.192 (1100 0000)
  - 2 subnets with 62 host
- 255.255.255.224 (1110 0000)
  - 6 subnets with 30 hosts
- 255.255.255.240 (1111 0000)
  - 14 subnets with 14 hosts

Subnet interpretation

IP Address	subnet mask	Interpretation
158.108.2.71	255.255.255.0	host 71 on subnet 158.108.2.0
130.122.34.3	255.255.255.192	host 3 on subnet 130.122.34.0
130.122.34.132	255.255.255.192	host 4 on subnet 130.122.34.128
200.190.155.66	255.255.255.192	host 2 on subnet 200.190.155.64
15.20.15.2	255.255.0.0	host 15.2 on subnet 15.20.0.0

Class B Subnet with router

- router is used to separate network



Subnet routing

- **Traffic is routed to a host by looking "bit-wise and" results**

```
if dest ip addr & subnet mask == my ip addr & subnet mask
      send pkt on local network   %dest ip addr is on the same subnet
else
    send pkt to router            %dest ip addr is on diff subnet
```

Subnet Exercise (1)

- Given IP address 161.200, find out the following to yield not more than 256 hosts per subnet
  - net mask= ??
  - start net id =??
  - end net id=??
  - #of subnet =??

Subnet Exercise (2)

- Given IP address 192.150.251, find out the following to yield not more than 32 hosts per subnet
  - net mask= ??
  - start net id =??
  - end net id=??
  - #of subnet =??

Type of Subnetting

- **Static Subnetting - all subnets in the subnetted network use the same subnet mask**
  - **pros: simply to implement, easy to maintain**
  - **cons: wasted address space (consider a network of 4 hosts with 255.255.255.0 wastes 250 IP)**

- **Variable Length Subnetting - the subnets may use different subnet masks**
  - **pros: utilize address spaces**
  - **cons: required well-management**

*V*ariable *L*ength *S*ubnet *M*ask

- General Idea of VLSM
  - A small subnet with only a few hosts needs a subnet mask that accommodate only few hosts
  - A subnet with many hosts need a subnet mask to accommodate the large number of hosts
- Network manager's responsibility to design an appropriate VLSM

VLSM - sample case

- three different VLSM of 158.108.0.0