Lecture 2-1
IP Addressing & Subnetting

IP Addressing
Subnetting

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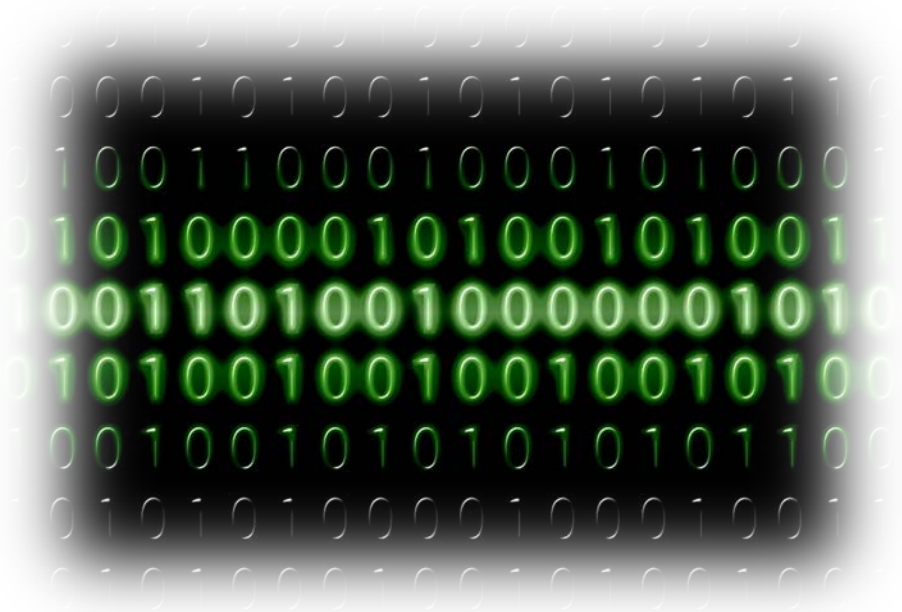
IP Addressing



Addressing

- Domain names: “radford.edu”
- IP Addresses: iii.jjj.kkk.lll, dotted decimal
  - Example: Radford University has a computer (somewhere) with IP address 137.45.192.36
- MAC (Hardware) Address
  - Hexadecimal digits separated by colons or dash.
  - Example: 00-06-6B-FF-0A-B4
- Specific .vs. Broadcast (FF-FF-FF-FF-FF-FF) Addresses

IP Addresses

- An IP Packet can be sent to
  - A single workstation (unicast)
    - Efficient for data between pairs of addresses
  - A specific list of workstations (multicast)
    - Efficient for specific groups, but must specify all individual workstations IP addresses
  - All stations on a network (broadcast)
    - Efficient for large (unknown) group – use special broadcast IP address.
- IP addresses have a special broadcast address
- Class .vs. Classless Addressing.
- Internet Assigned Numbers Authority (IANA)

Special IP Addresses

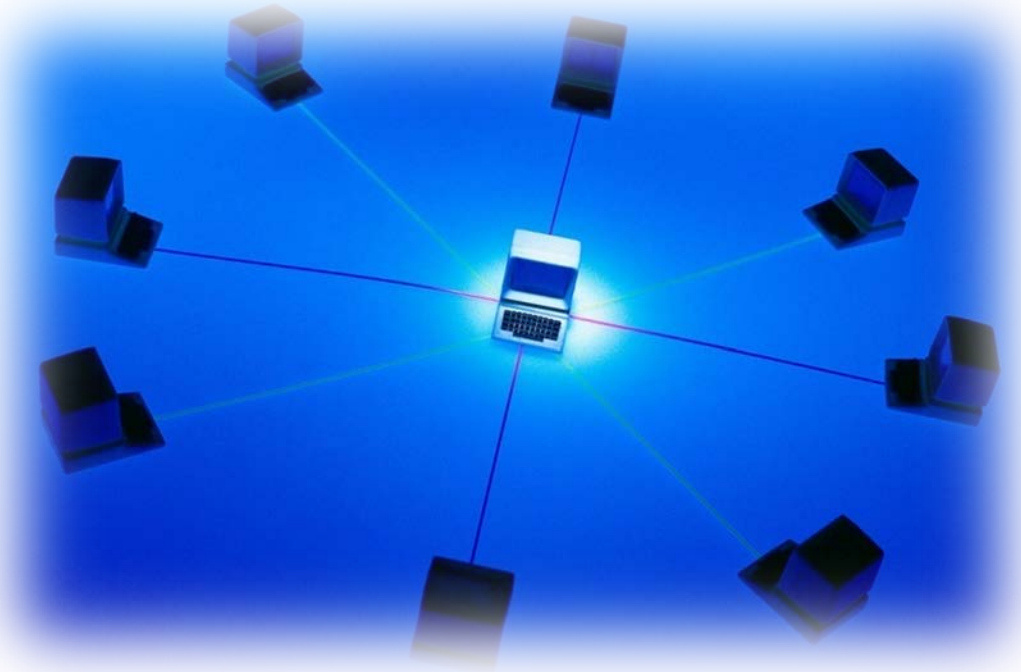
- THIS computer - all 0's--both prefix and suffix
  - 0.0.0.0
- THIS network broadcast - all 1's prefix and suffix
  - 255.255.255.255
- remote net broadcast - net prefix all 1's suffix
  - Ex: 137.45.192.255
- *Network* address - net prefix all 0's suffix
  - 137.45.192.0
- loopback - 127.x.x.x but usually 127.0.0.1
- Everything else is a *Host* IP Address like 137.45.192.96

IP Address Ranges, Or "Classes"

From:	To:	Description
1.x.x.x	126.x.x.x	Class A license
127.x.x.x	127.x.x.x	Loop back
128.x.x.x	191.x.x.x	Class B license (172.16 thru 31. 0. 0 reserved for private addresses)
192.x.x.x	223.x.x.x	Class C license (192. 168. x. 0 reserved for private addresses)
224.0.0.0	224.0.0.255	Multicast: Reserved Link Local Addresses
224.0.1.0	238.255.255.255	Multicast: Globally Scoped Addresses
239.0.0.0	239.255.255.255	Multicast: Limited Scope Addresses
240.x.x.x	255.255.255.254	Experimental
255.255.255.255		Broadcast

IP Format

137.45.104.172



Dotted Decimal vs Binary

137.45.104.172

10001001001011010110100010101100

Conversion Between Decimal & Binary

128	X	1	=	128
64	X	0	=	0
32	X	0	=	0
16	X	0	=	0
8	X	1	=	8
4	X	0	=	0
2	X	0	=	0
1	X	1	=	1
				137

Conversion Between Decimal & Binary

128	1	128	0	0	0	0	1	128
64	0	0	0	0	1	64	0	0
32	0	0	1	32	1	32	1	32
16	0	0	0	0	0	0	0	0
8	1	8	1	8	1	8	1	8
4	0	0	1	4	0	0	1	4
2	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0
		137		45		104		172

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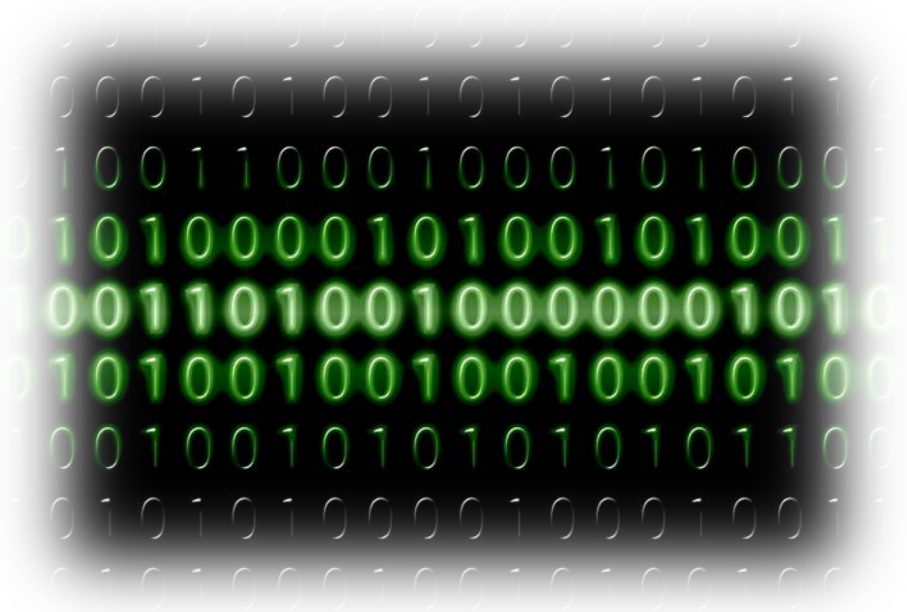
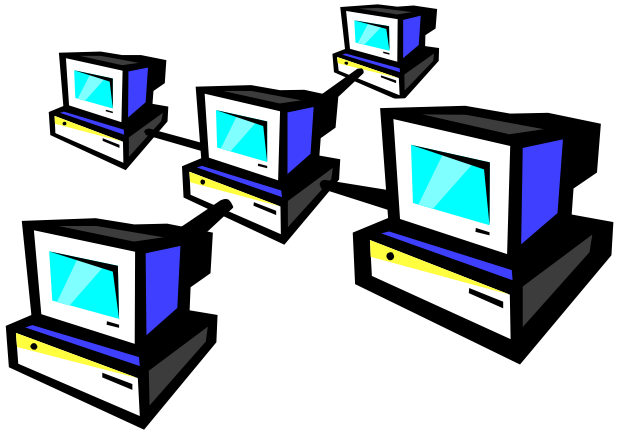


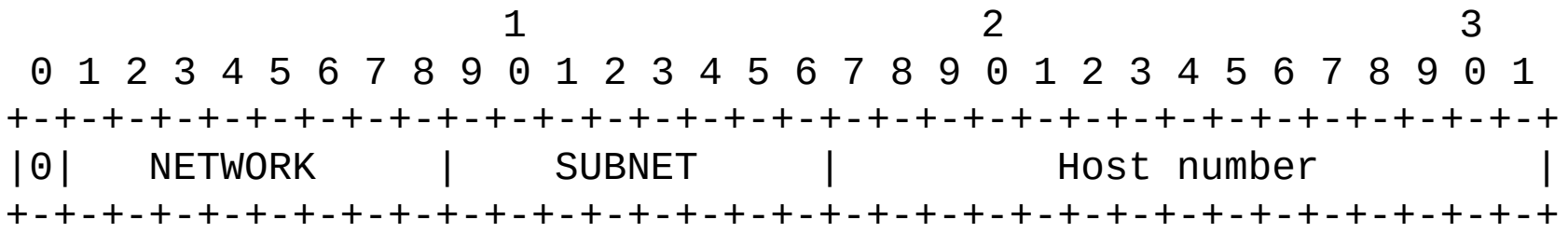
Why Subnets?

- In class A, B, or C networks, there are too many IP addresses to fit on one segment.
  - Thus, need routers and subnets to isolate parts.



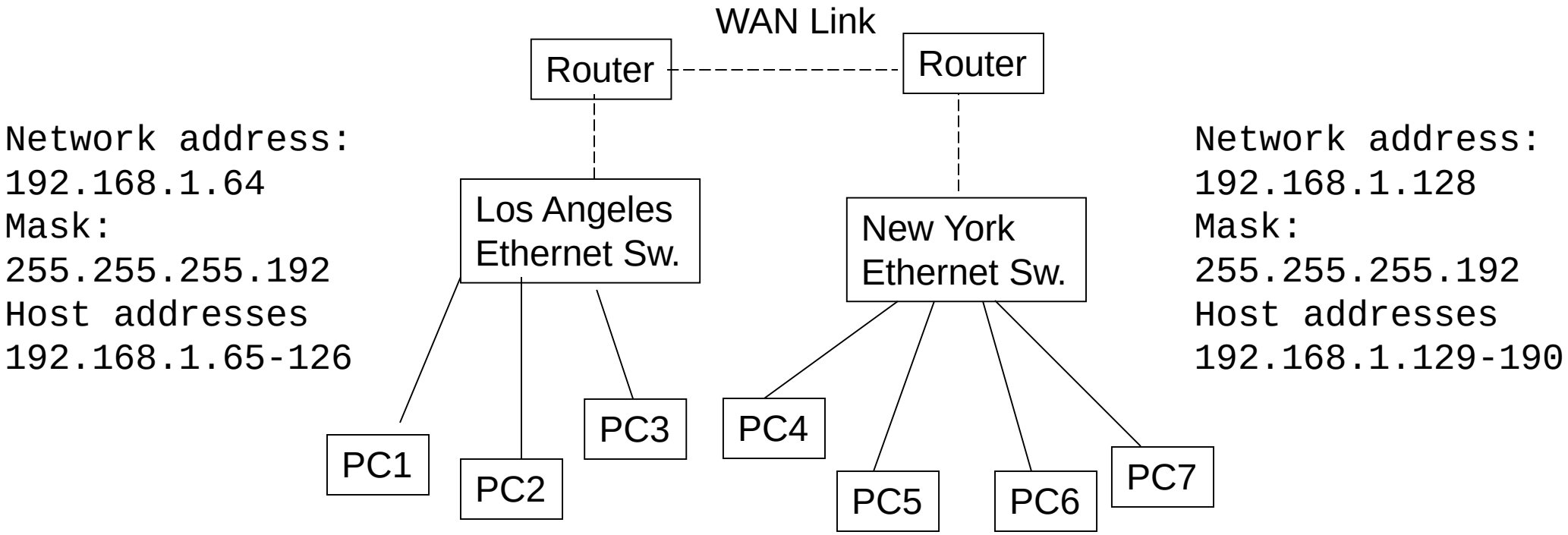
Subnets: A new interpretation

- IP Addresses had a new subnet field inserted between network & local fields
  - IP address := <network-number><subnet-number><host-number>
- Ex: A Class A Network with 8-bit subnet field



Class C subnet example

- See www.minasi.com -- newsletters, etc.
- Look at IP Subnetting Tutorial http://www.ralphb.net/IPSubnet/index.html



Sample Question

[Q1] Given: Class C IP Address 196.72.84.0

5 subnets

[Q2] Given: Class B IP Address 132.84.0.0

12 subnets

Subnet Mask for Class C

137.45.104.172

255.255.255.0

“Anding” a Binary Subnet Mask

10001001**00101101**01101000**10101100**

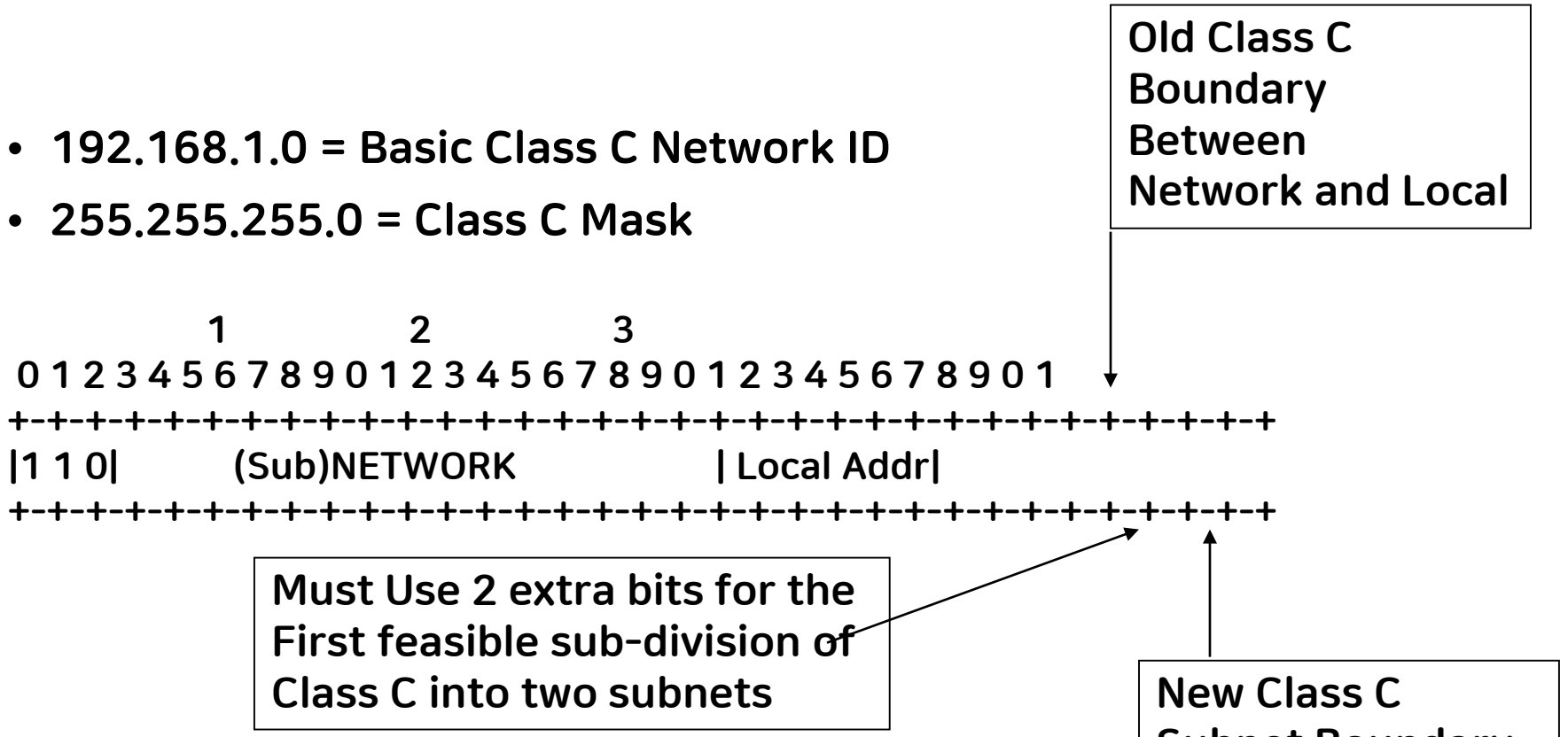
11111111**11111111**11111111**00000000**

10001001**00101101**01101000**00000000**

subnet ID = (137.45.104.0)

Subnet example

- 192.168.1.0 = Basic Class C Network ID
- 255.255.255.0 = Class C Mask



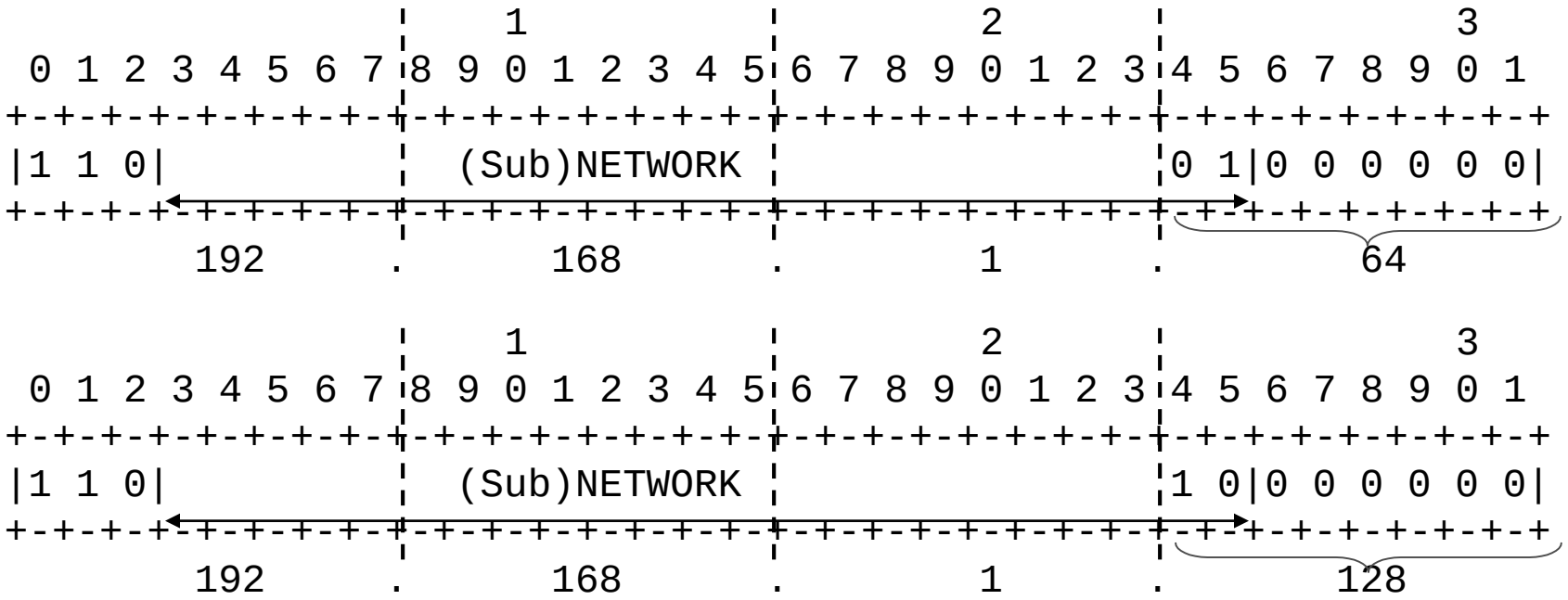
- 192.168.1.64, 192.168.1.128 New sub-Network IDs
- 255.255.255.192 = New Subnet Mask

SubNetwork IDs, Host Ranges & Broadcast Addresses

- Using extra two bits in Network ID
  - 00 – Can't use because this is the part of the original Class C's Network ID
  - 01 – Available 01000000 = 64
  - 10 – Available 10000000 = 128
  - 11 – Can't use because this is part of the original Class C's broadcast address
- Hence
  - 192.168.1.64 is the first sub-Network ID
  - 192.168.1.128 is the second

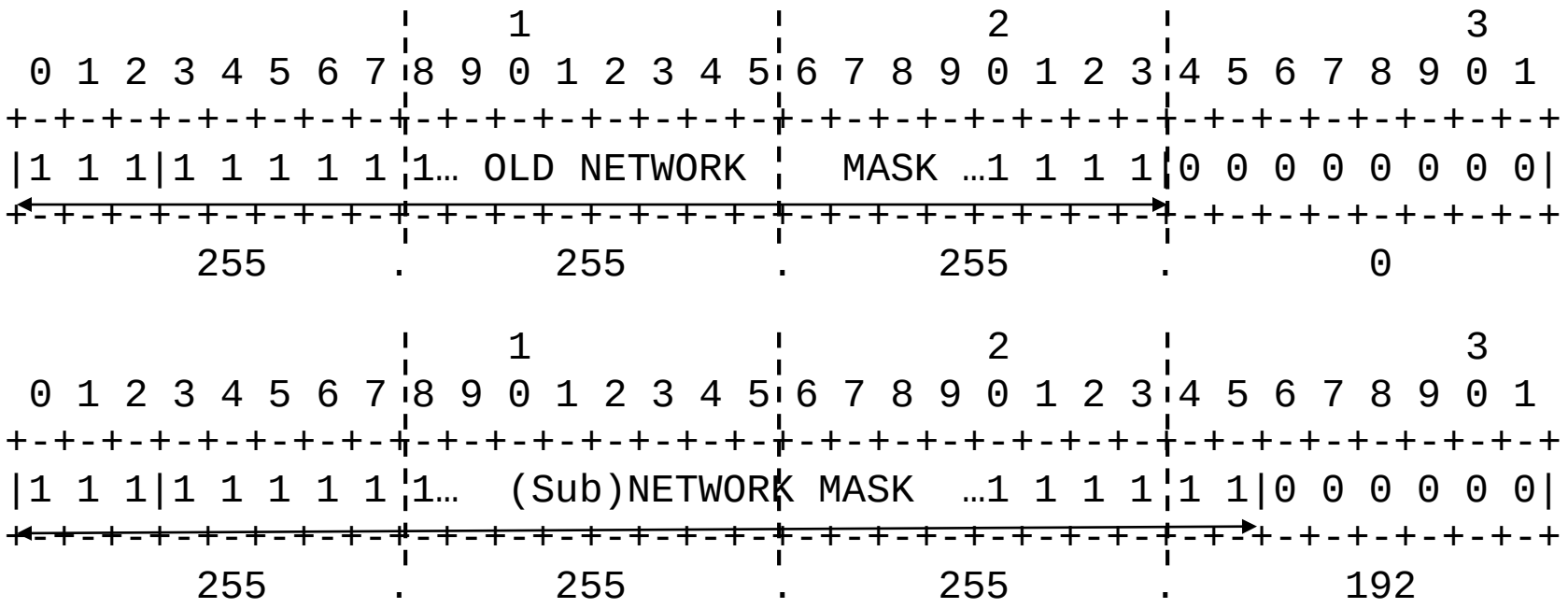
Binary for the subnetwork IDs

- Byte boundaries shown by dashed lines
- Subnet IDs = Local address field of all zeroes (6 bits)
- 01 or 10 to get bottom byte (8 bits)
- Result = 64 or 128 when translated to decimal



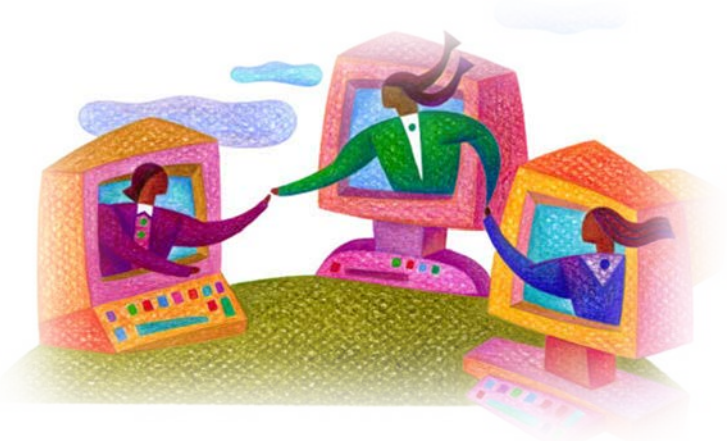
Binary for Masks (Old .vs. New)

- A Mask is a device for indicating how long the (sub)network field is
- All 1's covering the entire network id portion



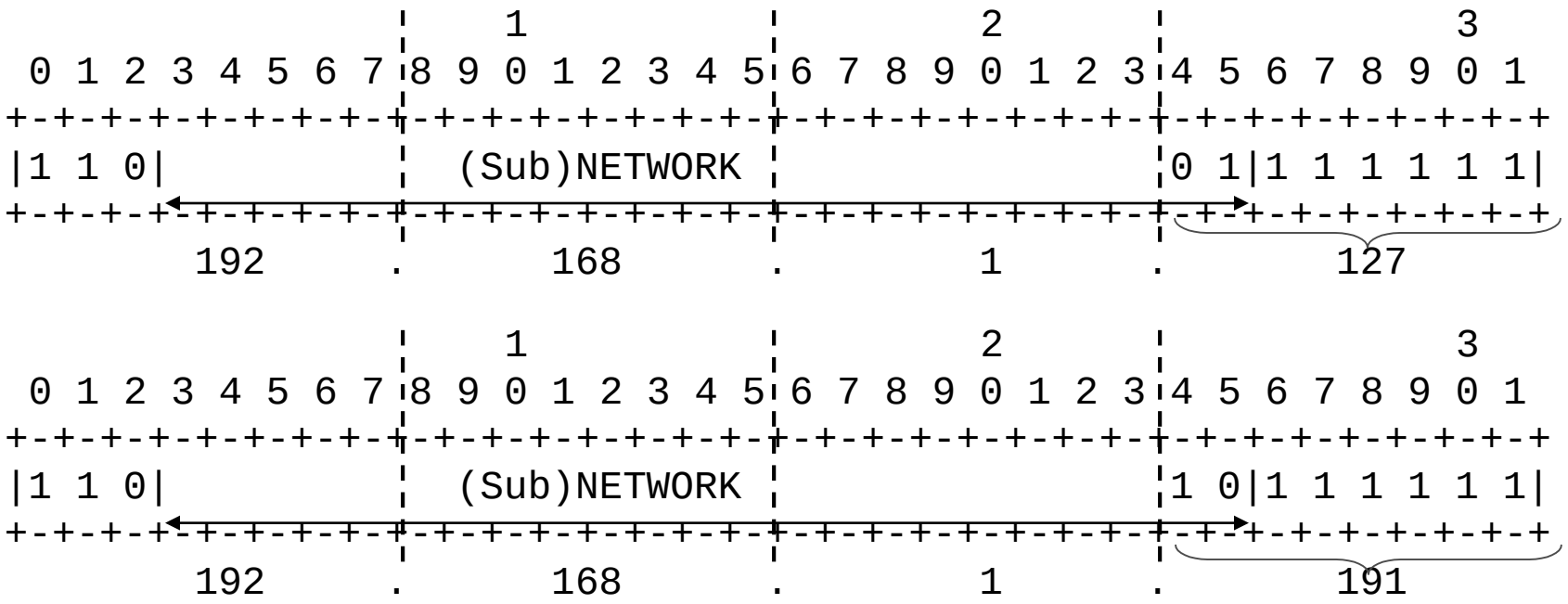
Host Ranges

- Network Mask is 255.255.255.192
- 192.168.1.64 has 62 host addresses
  - First available host address = 192.168.1.65
  - Last available host address = 192.168.1.126
  - Broadcast address = 192.168.1.127
- 192.168.1.128 has 62 host addresses
  - First available host address = 192.168.1.129
  - Last available host address = 192.168.1.190
  - Broadcast address = 192.168.1.191



Binary for Broadcast addresses

- Broadcast addresses have all 1's in the host field
- Remember, we always translate 8 bit octets to decimal!



Recap: Network Classes

- IANA (Internet Assigned Numbers Authority)
- Class A
  - IP address := <8bits>.<24bits>
  - 16 Million hosts in a class A network domain
- Class B
  - IP address = <16bits>.<16bits>
  - 65534 hosts in a class B network domain
- Class C
  - IP address = <24bits>.<8bits>
  - 256 hosts in a class C network domain

➔ Waste of Address Range~!

Note on Classful vs. Classless

- Note that, in classful subnetting, we lose quite a few blocks of addresses.
- RFC 1519 (Classless Inter-Domain Routing = CIDR) was introduced in 1993 to deal with rapid depletion of IP address space due to “Classful Fragmentation”
- Problem:
  - Given the entire internet was “classful” in 1993, how to transition to classless methods?
  - What exactly is the impact to internet protocols (in all the millions of devices and hosts) of such a change?

Impact of CIDR

- We needed new routing protocols (haven't introduced those yet)
- We need new ways of handling masks
- The bottom line is:
  - There is a way to use all those un-used addresses (all zeroes, all ones) that we discarded in classful subnetting.
  - (Ex) 192.211.1.8 /24

Routable and Nonroutable Addresses

- Nonroutable Address [RFC 1918]
  - Internet Router ignore the following addresses.
    - 10.0.0.0 – 10.255.255.255
    - 172.16.0.0 – 172.31.255.255
    - 192.168.0.0 – 192.168.255.255
  - Millions of networks can exist with the same nonroutable address.
  - “Intranet” : Internal Internet
  - NAT (Network Address Translation) router
  - Side benefit : “Security”

VLSM (Variable Length Subnet Masking)

- Can support variable length of subnet id in a single domain
- How?
  - Decide the necessary number of bits for a host id first
  - Then, get the number of bits for a subnet id

VLSM: Sample Question

- [Given] IP Addr 192.3.4.0/24
  - AtlantaHQ: 58 hosts
  - PerthHQ: 26 hosts
  - SydneyHQ: 10 hosts
  - CorpusHQ:10 hosts
  - WAN1: 2 IP addresses
  - WAN2: 2 IP addresses
  - WAN3: 2 IP addresses

➔Give a subnet address, an address range, a broadcast address, and a network prefix

Reference: Cisco Network Fundamental course

H/W (e.g., Ethernet) Addresses

- A Hardware (H/W) address of all 1's signifies the broadcast address at the link layer of Ethernet
- Ethernet NICs can also be configured (through software) with several *Multicast* addresses
- All Ethernet NICs will accept a packet with either
  - Individual HW address of NIC
  - The broadcast address
  - Any of the configured multicast addresses
- Finally, Ethernet NICs can be put into *promiscuous* mode –
  - Accept all packets regardless of H/W address
  - Useful for monitoring, "sniffing", debugging