IPv4 Addressing & Subnetting

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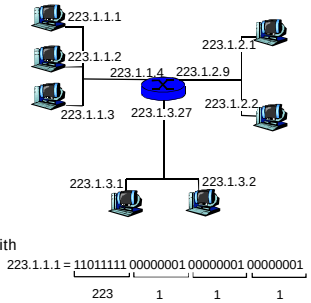
IPv4 Addressing: introduction

- IP address: 32-bit identifier for host, router interface
- Interface: connection between host/router and physical link
  - router's typically have multiple interfaces
  - IP addresses associated with each interface



223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

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Octets

- An IP address is made up of 4 bytes
- The 32-bit IP address is broken up into 4 octets, which are arranged into a dotted-decimal notation scheme.
- An octet is a set of 8 bits
- Example of an IP version 4:

  172.64.126.52

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IP Address Classes

- IP addresses are divided into 5 classes, each of which is designated with the alphabetic letters A to E.
- Class D addresses are used for multicasting.
- Class E addresses are reserved for testing

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IP Address Classes *(Cont.)*

- The 5 IP classes are split up based on the value in the 1st octet:

IP Address Class Assignments	
Class	*First Octet Value*
Class A	0 ~ 127
Class B	128 ~ 191
Class C	192 ~ 223
Class D	224 ~ 239
Class E	240 ~ 255

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IP Address Classes *(Cont.)*

- Using the ranges, you can determine the class of an address from its 1st octet value.
- An address beginning with 120 is a Class A address, 155 is a Class B address & 220 is a Class C address.

IP Address Class Assignments	
Class	*First Octet Value*
Class A	0 ~ 127
Class B	128 ~ 191
Class C	192 ~ 223
Class D	224 ~ 239
Class E	240 ~ 255

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Are You the Host or the Network?

- The 32 bits of the IP address are divided into Network & Host portions, with the octets assigned as a part of one or the other.

Network & Host Representation By IP Address Class				
Class	*Octet1*	*Octet2*	*Octet3*	*Octet4*
Class A	Network	Host	Host	Host
Class B	Network	Network	Host	Host
Class C	Network	Network	Network	Host

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Are You the Host or the Network? *(Cont.)*

- Each network is assigned a network address & every device or interface (such as a router port) on the network is assigned a host address.
- There are only 2 specific rules that govern the value of the address.
  - A host address cannot be designated by all zeros or all ones.
  - These are special addresses that are reserved for special purposes.

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Class A Addresses

- Class A IP addresses use the 1st 8 bits (1st Octet) to designate the Network address.
- The 1st bit of the first octet which is always a 0, is used to indicate the address as a Class A address & the remaining 7 bits are used to designate the Network.
- The other 3 octets contain the Host address.

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Class A Addresses *(Cont.)*

- There are 128 Class A Network Addresses, but because addresses with all zeros aren't used & address 127 is a special purpose address, 126 Class A **Networks** are available.

IP Address Class Assignments	
Class	*First Octet Value*
Class A	0 ~ 127
Class B	128 ~ 191
Class C	192 ~ 223
Class D	224 ~ 239
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Class A Addresses *(Cont.)*

- There are 16,777,214 Host addresses available in a Class A address.
- Rather than remembering this number exactly, you can use the following formula to compute the number of hosts available in any of the class addresses, where "**n**" represents the number of bits in the host portion:

$(2^n - 2)$ = Number of available hosts

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Class A Addresses *(Cont.)*

- For a Class A network, there are:

$2^{24} - 2$ or 16,777,214 hosts.

- You can use the same formula to determine the number of Networks in an address class.
- Eg., a Class A address uses 7 bits to designate the network, so $(2^7 - 2) = 126$ or there can be 126 Class A Networks.

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Class B IP Addresses

- Class B addresses use the 1st 16 bits (two octets) for the Network address.
- The last 2 octets are used for the Host address.
- **The 1st 2 bits of the first octet, which are always 10,** designate the address as a Class B address & 14 bits are used to designate the Network. This leaves 16 bits (two octets) to designate the Hosts.

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Class B IP Addresses *(Cont.)*

- So how many Class B Networks can there be?
- Using our formula, $(2^{14} - 2)$, there can be 16,382 Class B Networks & each Network can have $(2^{16} - 2)$ Hosts, or 65,534 Hosts.

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Class C IP Addresses

- Class C addresses use the 1st 24 bits (three octets) for the Network address & only the last octet for Host addresses.
- **The 1st 3 bits of the first octet of all class C addresses are set to 110,** leaving 21 bits for the Network address, which means:
  - there can be 2,097,150 $(2^{21} - 2)$ Class C Networks,
  - but only 254 $(2^{8} - 2)$ Hosts per Network.

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Class C IP Addresses *(Cont.)*

Characteristics of the IP Address Classes

Class	Address Range	Identify Bits (binary value)	Bits in Network ID	Number of Networks	Bits in Host ID	Number of Hosts/ Network
A	0 ~ 127	1 (0)	7	126	24	16,777,214
B	128~191	2 (10)	14	16,382	16	5,534
C	192~223	3 (110)	21	2,097,150	8	254

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Special Addresses

- A few addresses are set aside for specific purposes.
- Network addresses that are all binary zeros, all binary ones & Network addresses beginning with 127 are special Network addresses.

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Special Addresses *(Cont.)*

Special IP Addresses

Network Address	Host Address	Description	Example
0's	0's	Default Cisco Route	0.0.0.0
0's	Host Address	Local Network Hosts	0.0.0.115
1's	1's	Broadcast to Local Network	255.255.255.255
Network Address	1's	Broadcast to Network Address	192.21.12.255
127	Anything	Loopback Testing	127.0.0.1

Default route:

- In computer networking, the default route is a setting on a computer that defines the packet forwarding rule to use when no specific route can be determined for a given Internet Protocol (IP) destination address.
- All packets for destinations not established in the routing table are sent via the default route.

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Special Addresses *(Cont.)*

- Within each address class is a set of addresses that are set aside for use in local networks sitting behind a firewall or NAT (Network Address Translation) device or Networks not connected to the Internet.

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Special Addresses (Cont.) – Private address space

- A list of these addresses for each IP address class that are available for use in a LAN.
- This is the private address space

Special Local Network Addresses	
IP Class	*Address Range*
Class A	10.0.0.0 ~ 10.255.255.255
Class B	172.16.0.0 ~ 172.31.255.255
Class C	192.168.0.0 ~ 192.168.255.255

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Default Standard Subnet Masks

- There are default standard subnet masks for Class A, B and C addresses:

Default Subnet Masks	
Address Class	*Subnet Mask*
Class A	255.0.0.0
Class B	255.255.0.0
Class C	255.255.255.0

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Subnet Mask

- An IP address has 2 parts:
  - The Network identification.
  - The Host identification.
- Frequently, the network & host portions of the address need to be separately extracted.
- In most cases, if you know the address class, it's easy to separate the 2 portions.
- The subnet masking process was developed to identify & extract the network and host part of the address.

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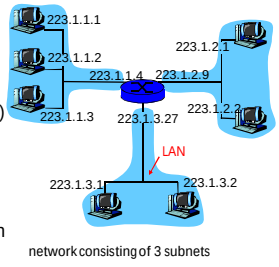
Subnets

- IP address consist of:
  - Subnet/network part (high order bits)
  - host part (low order bits)
- What's a subnet ?
  - device interfaces with same subnet/network part of IP address
  - can physically reach each other without intervening router



network consisting of 3 subnets

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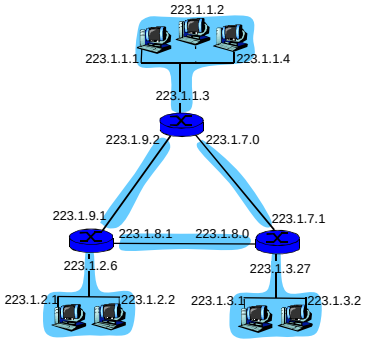
Subnets

- How many?



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Classless Interdomain Routing (CIDR)

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Features of CIDR

- Elimination of classful addressing
- Classless Addressing

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IP addressing: CIDR

- CIDR: Classless InterDomain Routing
  - subnet portion of address can of be arbitrary length
  - address format: a.b.c.d/x, where x is # bits in subnet/network portion of address

200.23.16.0/23

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Example: Class C Addresses

Class C

No. of bits	Subnet Mask	CIDR	#No. of Subnets	No.of Hosts	Nets * Hosts
2	255.255.255.192	/26	2	62	124
3	255.255.255.224	/27	6	30	180
4	255.255.255.240	/28	14	14	196
5	255.255.255.248	/29	30	6	180
6	255.255.255.252	/30	62	2	124

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Example: Class B Addresses

No. of bits	Subnet Mask	CIDR	No. of Subnets	No. of Hosts	Nets * Hosts
2	255.255.192.0	/18	2	16382	32764
3	255.255.224.0	/19	6	8190	49140
4	255.255.240.0	/20	14	4094	57316
5	255.255.248.0	/21	30	2046	61380
6	255.255.252.0	/22	62	1022	63364
7	255.255.254.0	/23	126	510	64260
8	255.255.255.0	/24	254	254	64516
9	255.255.255.128	/25	510	126	64260

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IP addresses: how to get one?

- Q: How does a host get IP address?
- Two options:
  - Given/hard-coded by system admin
  - DHCP: Dynamic Host Configuration Protocol: dynamically get address from as server
    - "plug-and-play"

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IP addresses: how to get one?

- Q: How does network get subnet part of IP addr?
- A: gets allocated portion of its provider ISP's address space

ISP's block	11001000 00010111 00010000	00000000	200.23.16.0/20
Organization 0	11001000 00010111 0001000**0**	00000000	200.23.16.0/23
Organization 1	11001000 00010111 0001001**0**	00000000	200.23.18.0/23
Organization 2	11001000 00010111 0001010**0**	00000000	200.23.20.0/23
...	.....	....	....
Organization 7	11001000 00010111 0001111**0**	00000000	200.23.30.0/23

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IP addressing: the last word...

- Q: How does an ISP get block of addresses?
- A: ICANN: Internet Corporation for Assigned Names and Numbers:
  - allocates addresses
  - manages DNS (Domain Name System). DNS – Converts web address to IP address.
  - assigns domain names, resolves disputes

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