Computer Networking – Part 4

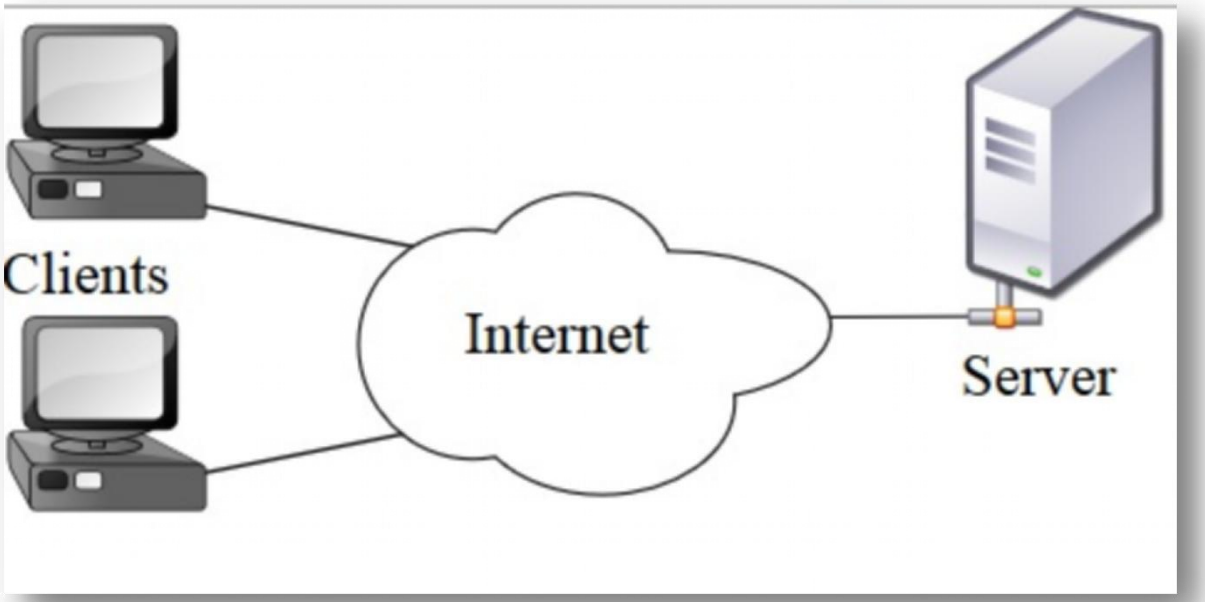
Contents

- Client Server Configuration
- Format of IP Addresses
- Traditional Class Networks
- Network Masks
- Subnetting
- CIDR
- Special IP Addresses

Client Server Configuration

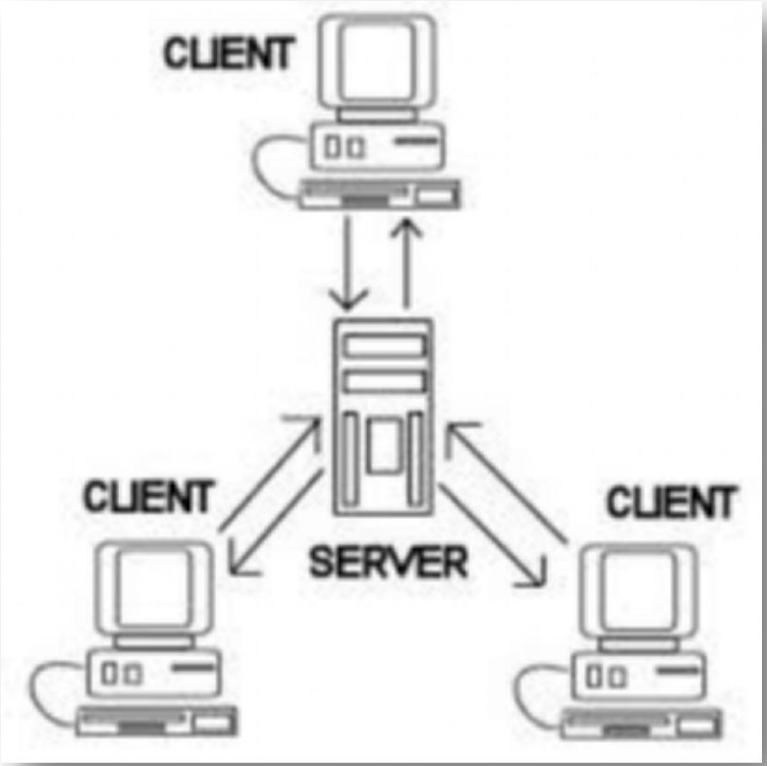
What is Client Server Configuration?

- Client-server is a computing architecture which separates a client from a server
- It is almost always implemented over a computer network
- The most basic type of client-server architecture employs only two types of nodes: **clients** and **servers**



What is Client Server Configuration?

- This type of architecture is sometimes referred to as two-tier
- It allows devices to share files and resources.
- **Server** - provides the service
- **Client** - is considered as the customer requesting the service



Web Servers

- A Web server is a program that, using the client/server model and the World Wide Web's Hypertext Transfer Protocol (HTTP), serves the files that form Web pages to Web users (whose computers contain HTTP clients that forward their requests).

Mail Servers

- A mail server (also known as a mail transfer agent or MTA, a mail transport agent, a mail router or an Internet mailer) is an application that receives incoming e-mail from local users (people within the same domain) and remote senders and forwards outgoing e-mail for delivery.

Proxy Servers

- In computer networks, a proxy server is a server (a computer system or an application) that acts as an intermediary for requests from clients seeking resources from other servers.

Application Servers

- An application server can be either a software framework that provides a generalized approach to creating an application-server implementation, regard to what the application functions are, or the server portion of a specific implementation instance

DNS Servers

- Domain Name Server, and is the system used to translate word-based addresses of systems (such as WWW.EXAMPLE.COM) to the numerical IP (Internet Protocol) address of the computer or system that should be located at that address.

DHCP – Dynamic Host Control Protocol

- DHCP allows a computer to join an IP-based network without having a pre-configured IP address. DHCP is a protocol that assigns unique IP addresses to devices, then releases and renews these addresses as devices leave and re-join the network
- Internet service providers usually use DHCP to help customers join their networks with minimum setup effort required

Leased Lines

- A leased line is a service contract between a provider and a customer, whereby the provider agrees to deliver a symmetric telecommunications line connecting two or more locations in exchange for a monthly rent (hence the term lease).

ISPs - (Internet Service Providers)

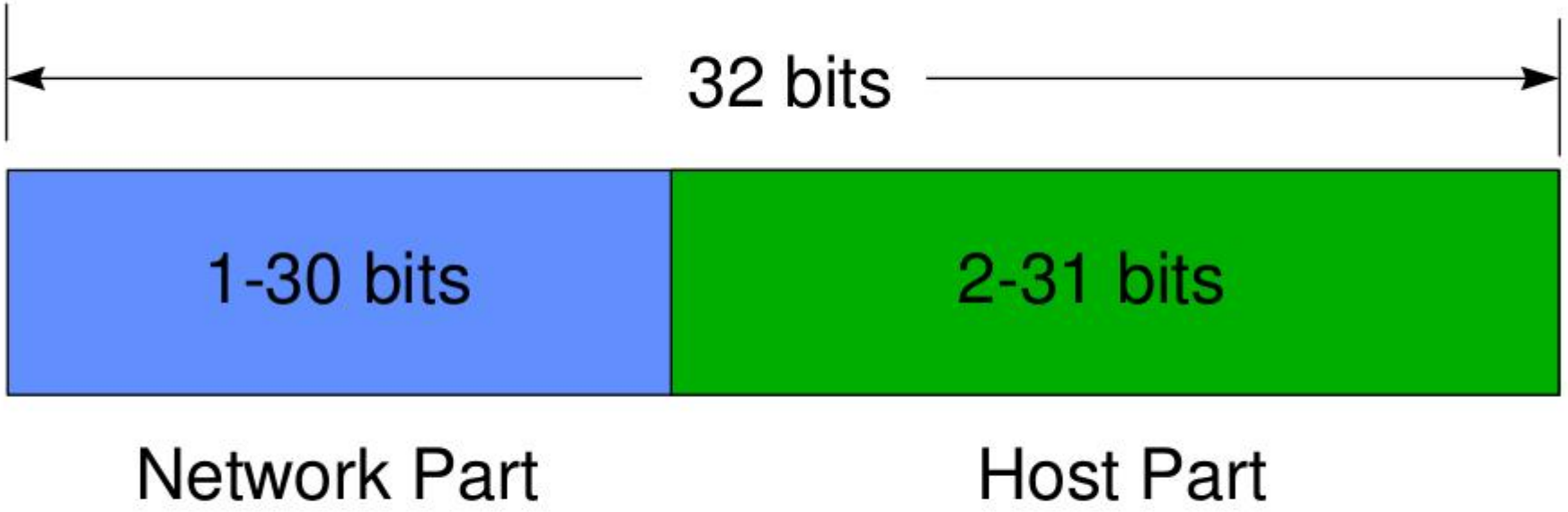
- An Internet service provider (ISP) is an organization that provides services for accessing, using, or participating in the Internet.

IP Addresses

IP Addresses

- All IP interfaces have IP addresses
- Each IP interface must have its own unique IP address
- Internally, this is represented as a 32-bit number of 0's and 1's
- IP addresses consist of two parts
  - ✓ network identification
  - ✓ host identification

Breaking it up into network number and host is key



We care because that's how we do routing

- IP routing is based on a simple "next hop" model.
  - ✓ Is the destination address ON my network or NOT?
    - ❖ If it is ON my network, send it directly
    - ❖ If it is NOT on my network, send it via a router
- To match network numbers, you must know what part is network and what part is host

Representing IP Addresses

- There are several ways the IP address can be represented
  - 32 bit number of 0's and 1's
    - ✓ 10100001 00101100 11000000 00000001
  - four decimal numbers separated by dots
    - ✓ 161.44.192.1
  - hexadecimal representation
    - ✓ 9D.2C.BC.01

Traditional Class Networks

Traditional Network Class Addresses

- The first dotted quad value identifies the network class and how much of the IP address is the network identifier
  - ✓ Class A Networks (first number between 1-127)
  - ✓ Class B Networks (first number between 128-191)
  - ✓ Class C Networks (first number between 192-223)
- There are also some special IP addresses which are defined in a different way
  - ✓ Class D Networks (first number between 224-239) for IP multicast
  - ✓ Class E Networks (first number between 240-255) for Landmark routing

Assigning Network Numbers

- Network numbers imply some space for hosts
  - Network numbers are assigned by your Internet Service Provider, who got them from the InterNIC (Network Information Center)
- Network numbers are written as a full 32-bit quantity (and an implied network mask)
- Networks end with some number of contiguous zero-bits on the right
- These zero-bits are where customers can use one bits for host addresses

Assigning Network Numbers

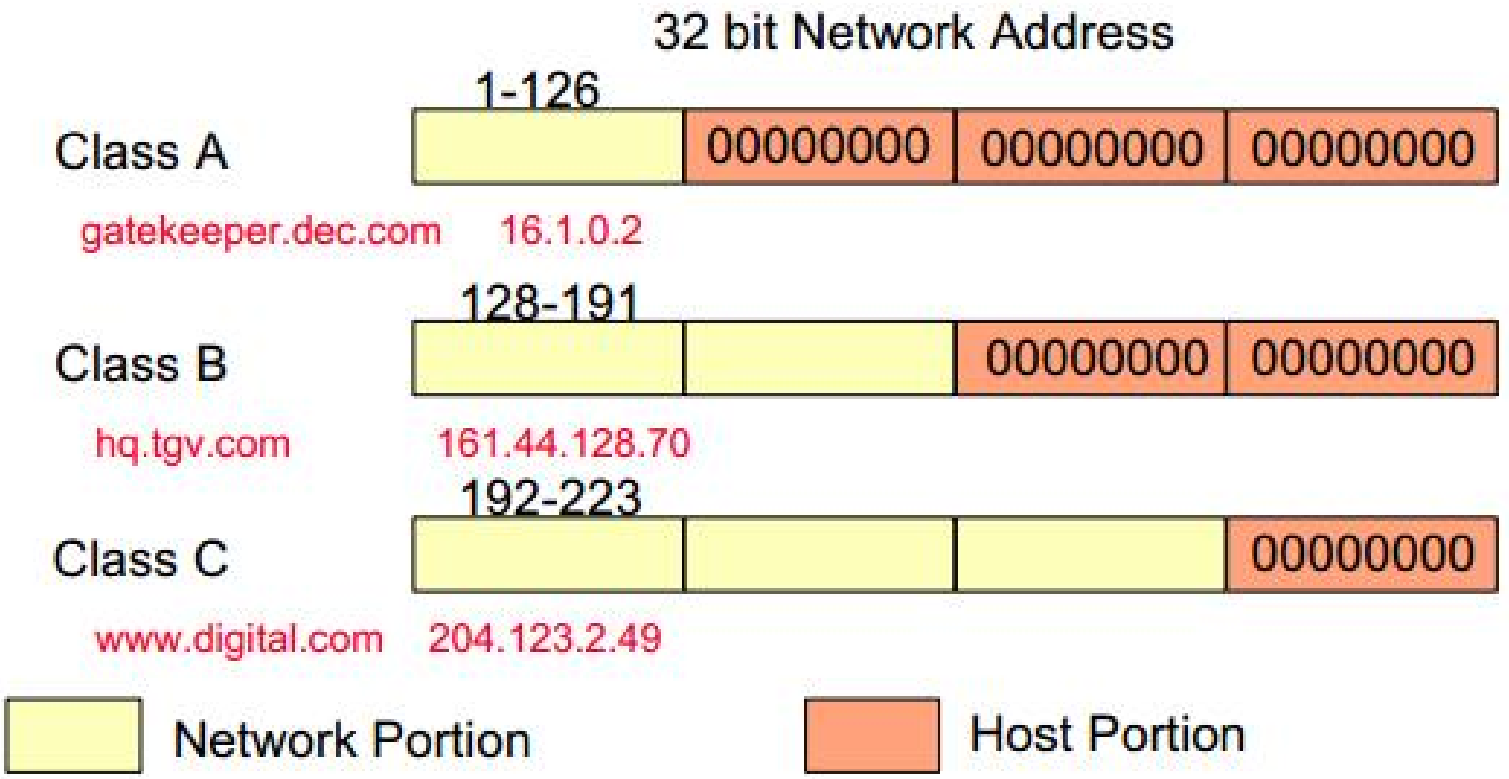
- For “local” use, although your provider may reserve some of them
- 10.0.0.0 - 10.255.255.255 (10/8)
- 172.16.0.0 - 172.31.255.255 (172.16/12)
- 192.168.0.0 - 192.168.255.255 (192.168/16)
- (see also RFC 1918 and RFC 1627)

Network Masks

Network Mask

- Identifies how many bits of the IP address the host may use
- The mask contains a 1 bit for every bit in the “network portion” of the address
- The mask contains a 0 bit for every bit in the “host portion” of the address
- Every host on a network must have the same network mask
- May also be called the Subnet Mask

Default Network Masks

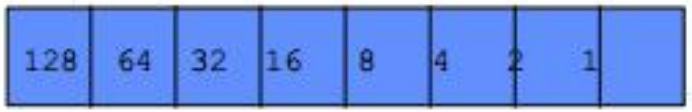


Network Masks are now shown with slash notation

- Class A network number
  - ✓ 8 bits of network, 24 bits of host
  - ✓ 10.0.0.0/8
- Class B network number
  - ✓ 16 bits of network, 16 bits of host
  - ✓ 128.196.0.0/16
- Class C network number
  - ✓ 24 bits of network, 8 bits of host
  - ✓ 192.245.12.0/24

Translating between the two is easy

255.255.0.0	/16
255.255.128.0	/17
255.255.192.0	/18
255.255.224.0	/19
255.255.240.0	/20
255.255.248.0	/21
255.255.252.0	/22
255.255.254.0	/23
255.255.255.0	/24
255.255.255.128	/25
255.255.255.192	/26
255.255.255.224	/27
255.255.255.240	/28
255.255.255.248	/29
255.255.255.252	/30



10000000 = 128 = 128

11000000 = 192 = 128+64

11100000 = 224 = 128+64+32

11110000 = 240 = 128+64+32+16

11111000 = 248 = 128+64+32+16+8

11111100 = 252 = 128+64+32+16+8+4

11111110 = 254 = 128+64+32+16+8+4+2

11111111 = 255 = 128+64+32+16+8+4+2+1

Simple Network Example

- Network address 192.195.240.0
- Network mask 255.255.255.0 or /24
- Host numbers
  - ✓ 192.195.240.1 - 192.195.240.254
- First 24 bits identify the network
- Last 8 bits are for the host EXCEPT:
  - ✓ Can't use all 0's (.0, assigned network)
  - ✓ Can't use all 1's (.255, broadcast address)

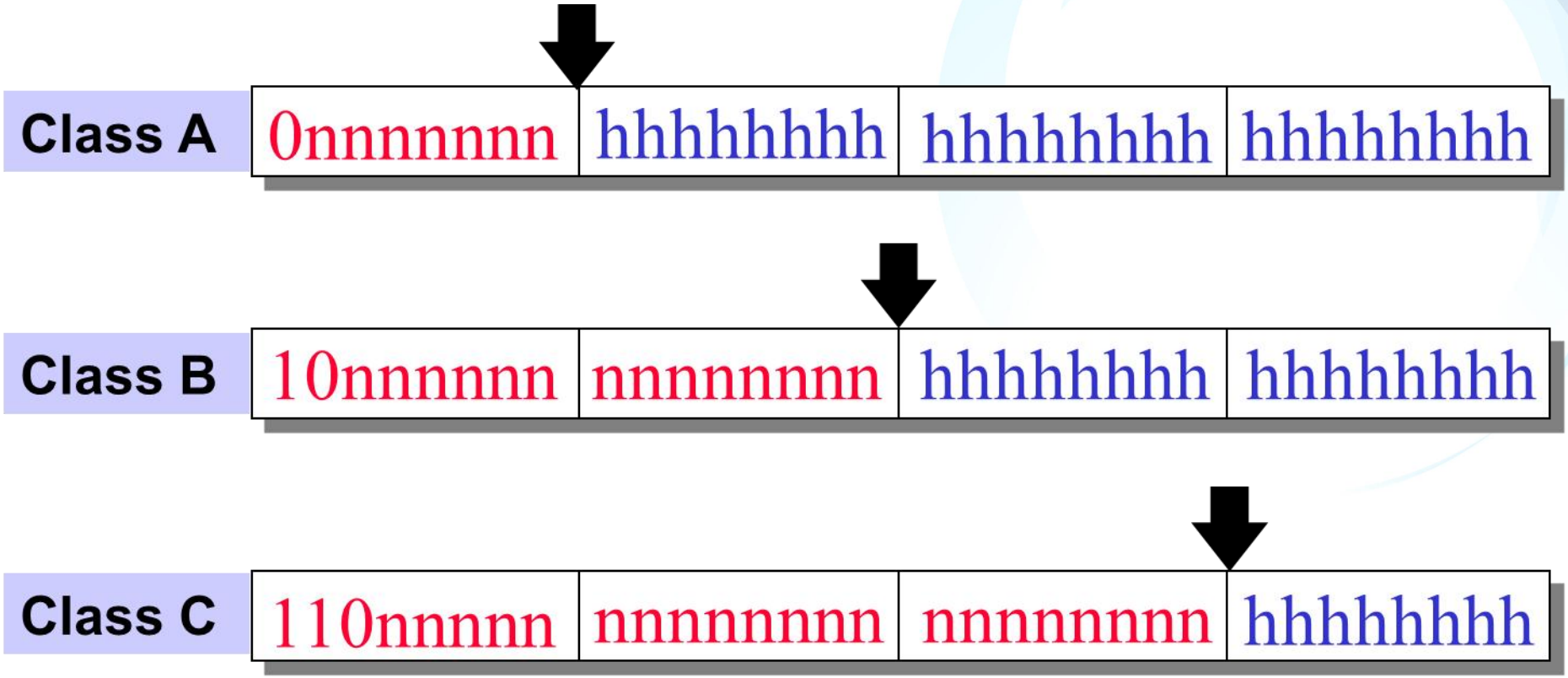
Two addresses in every network are special

- Host part all ones (usually “255-ish”)
  - ✓ This is defined as the broadcast address, and means “all systems on the current network”
- Host part all zeros (usually “0-ish”)
  - ✓ This is defined as the network number and cannot be used
- Example:
  - ✓ 192.245.12.0/24 is a network with 8 bits
  - ✓ 192.245.12.255 is the broadcast address
  - ✓ 192.245.12.0 is the network number
  - ✓ 192.245.12.1 through 192.245.12.254 are hosts

Network Mask Usage

- Host address: 192.195.240.4
- Network Mask: 255.255.255.0 (/24)
  - ✓ Logical AND yields network 192.195.240.0
- Destination host: 192.195.241.4
  - ✓ Logical AND yields network 192.195.241.0
- Since the network 24 bits of the local host and destination host are unequal, the destination host is not on local net

Summary of Classful Addressing Scheme



n = network address bit

h = host identifier bit

Summary cont..

Class	Networks	Hosts	Share of IP address space
A	127	16,777,214	1/2
B	16,384	65,534	1/4
C	2,097,152	254	1/8

Problems with Classful IP Addresses

- By the early 1990s, the original classfull address scheme had a number of problems
  - ✓ Flat address space. Routing tables on the backbone Internet need to have an entry for each network address. By the 1993, the size of the routing tables started to outgrow the capacity of routers (C networks).
- Other problems:
  - ✓ Too few network addresses for large networks
    Class A and Class B addresses were gone
- Limited flexibility for network addresses:
  - ✓ Class A and B addresses are overkill (>64,000 addresses)
  - ✓ Class C address is insufficient (requires 40 Class C addresses)

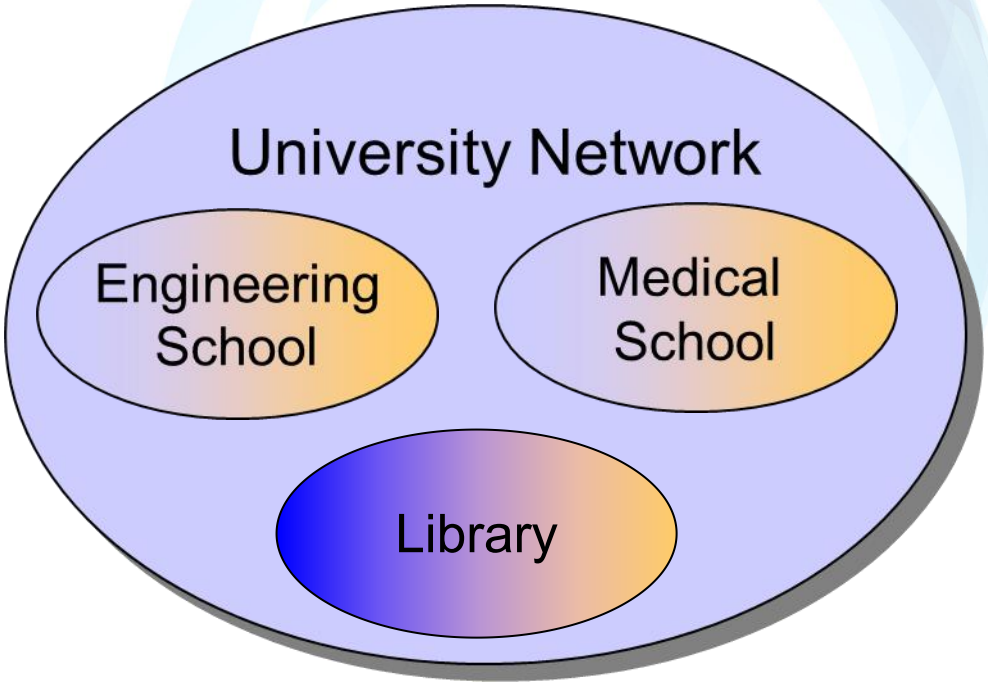
Subnets

Subnets

- The idea is to share the same IP network number among multiple subnets
- Subnets of a network should reside in the same general locale (e.g., college campus, corporate location, …)
- Routers on an IP network know their local subnets
- Remote routers need to know only the network address

Subnettings

- **Problem**: Organizations have multiple networks which are independently managed
  - **Solution 1**: Allocate a separate network address for each network
    - Difficult to manage
    - From the outside of the organization, each network must be addressable.
  - **Solution 2**: Add another level of hierarchy to the IP addressing structure

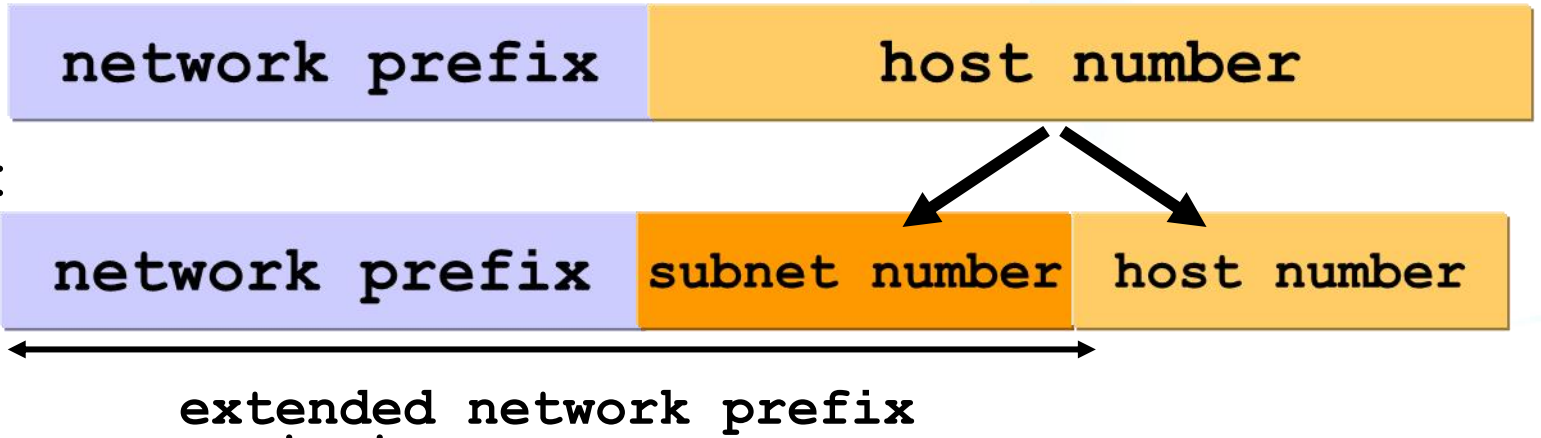


- **Solution 2**: Add another level of hierarchy to the IP addressing structure

→ **Subnetting**

Basic Idea of Subnetting

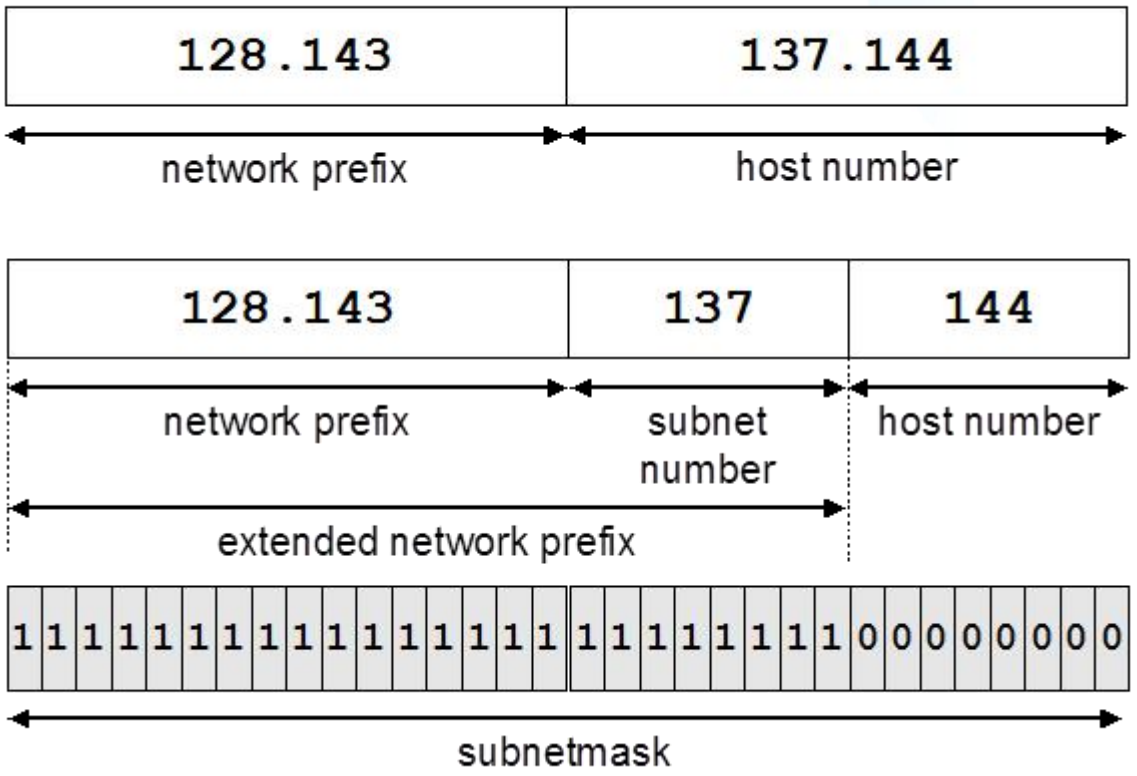
- Split the host number portion of an IP address into a subnet number and a (smaller) host number.
- Result is a 3-layer hierarchy



- organization
- Internally, subnets are treated as separate networks
- Subnet structure is not visible outside the organization

Subnetmask

- Routers and hosts use an extended network prefix (subnetmask) to identify the start of the host numbers.



Advantages of Subnetting

- With subnetting, IP addresses use a 3-layer hierarchy:
  - ✓ Network
  - ✓ Subnet
  - ✓ Host
- Reduces router complexity. Since external routers do not know about subnetting, the complexity of routing tables at external routers is reduced.
- Note: Length of the subnet mask need not be identical at all subnetworks

Advantages of Subnetting Cont.

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Advantages of Subnetting Cont.

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  - ✓ Host
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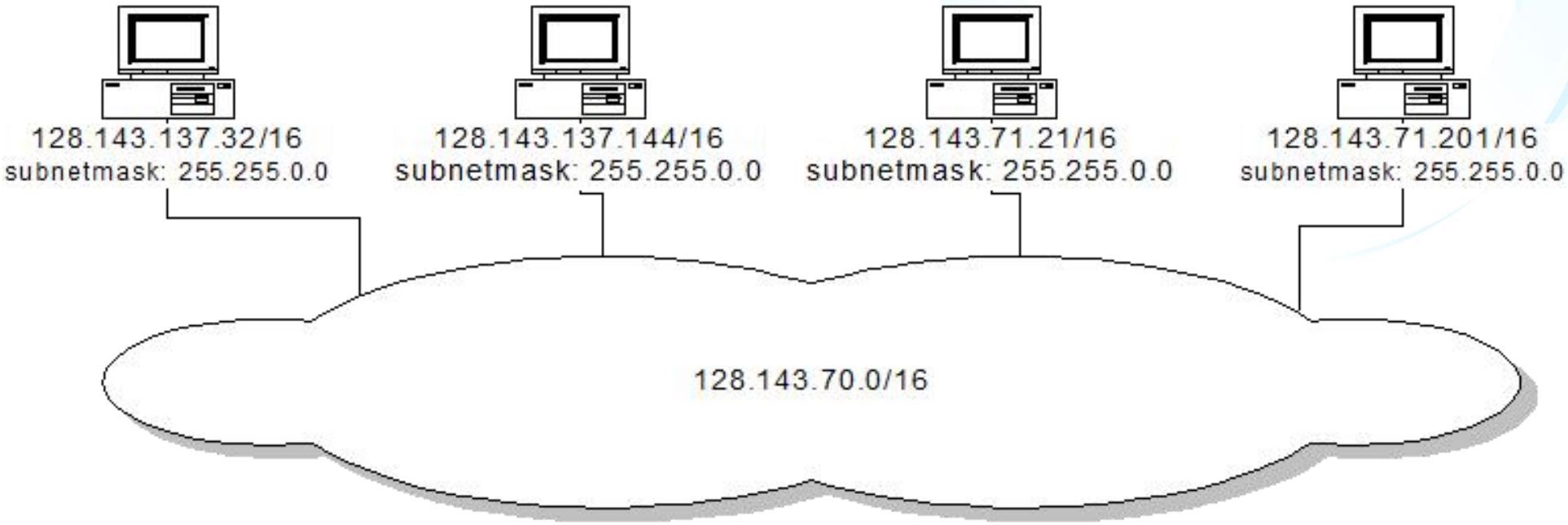
- Note: Length of the subnet mask need not be identical at all subnetworks

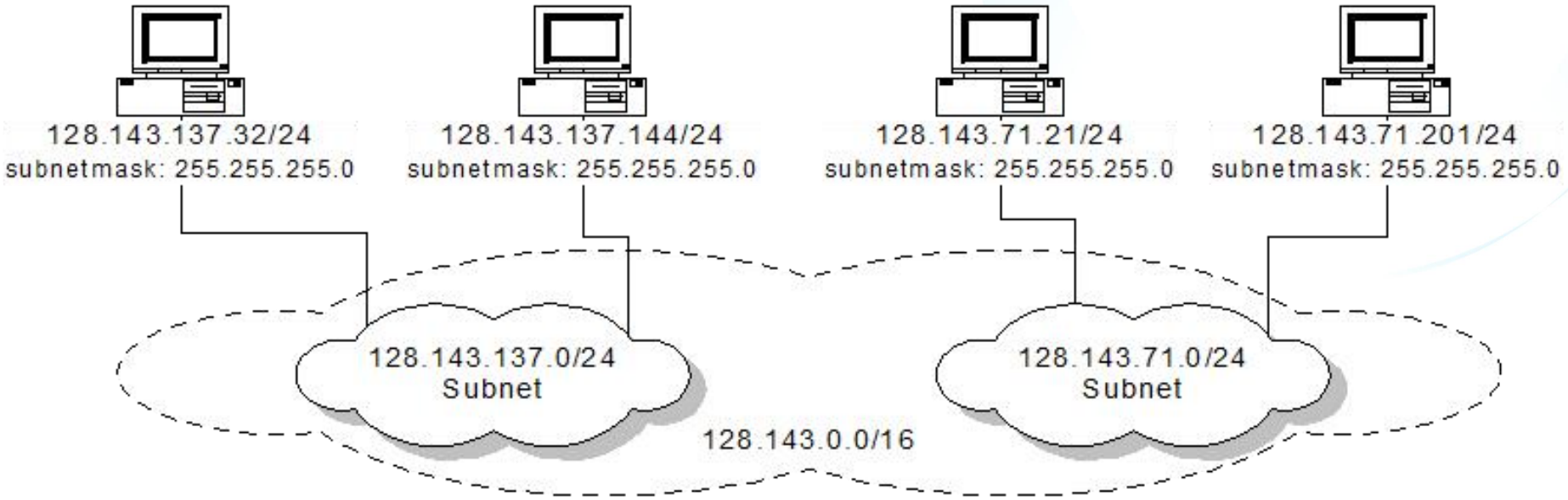
No Subnetting

- All hosts think that the other hosts are on the same network



With Subnetting

- Hosts with same extended network prefix belong to the same network



Variable Length Subnet Masks

- With only a single subnet mask across a network prefix, an organization was locked into a fixed number of fixed size subnets
- When a network is assigned more than one subnet mask, it is considered a network with “variable length subnet masks” since extended-network-prefixes have different lengths
- VLSM permits slicing and dicing subnets into different sizes and therefore numbers of hosts in subnets under a single Network ID, thereby minimizing, if not eliminating, wasted addresses

CIDR

CIDR - Classless Interdomain Routing

- IP backbone routers have one routing table entry for each network address:
  - ✓ With subnetting, a backbone router only needs to know one entry for each Class A, B, or C networks
  - ✓ This is acceptable for Class A and Class B networks
    - 27 = 128 Class A networks
    - 214 = 16,384 Class B networks
  - ✓ But this is not acceptable for Class C networks
    - 221 = 2,097,152 Class C networks
- In 1993, the size of the routing tables started to outgrow the capacity of routers
- Consequence: The Class-based assignment of IP addresses had to be abandoned

CIDR - Classless Interdomain Routing

- Goals:
  - ✓ New interpretation of the IP address space
  - ✓ Restructure IP address assignments to increase efficiency
  - ✓ Permits route aggregation to minimize route table entries
- CIDR (Classless Interdomain routing)
  - ✓ abandons the notion of classes
  - ✓ Key Concept: The length of the network prefix in the IP addresses is kept arbitrary
  - ✓ Consequence: Size of the network prefix must be provided with an IP address

CIDR Notation

- CIDR notation of an IP address:
  192.0.2.0/18
  - ✓ "18" is the prefix length. It states that the first 18 bits are the network prefix of the address (and 14 bits are available for specific host addresses)
- CIDR notation can replace the use of subnetmasks (but is more general)
  - ✓ IP address 128.143.137.144 and subnetmask 255.255.255.0 becomes 128.143.137.144/24
- CIDR notation allows to drop trailing zeros of network addresses:
  - ✓ 192.0.2.0/18 can be written as 192.0.2/18

Why do people still talk about

- CIDR eliminates the concept of class A, B, and C networks and replaces it with a network prefix
- Existing classfull network addresses are converted to CIDR addresses:

  128.143.0.0 -> 128.143.0.0/16
- The change has not affected many (previously existing) enterprise networks
  - ✓ Many network administrators (especially on university campuses) have not noticed the change

CIDR address blocks

- CIDR notation can nicely express blocks of addresses
- Blocks are used when allocating IP addresses for a company and for routing tables (route aggregation)

CIDR Block Prefix	# of Host Addresses
/27	32
/26	64
/25	128
/24	256
/23	512
/22	1,024
/21	2,048
/20	4,096
/19	8,192
/18	16,384
/17	32,768
/16	65,536
/15	131,072
/14	262,144
/13	524,288

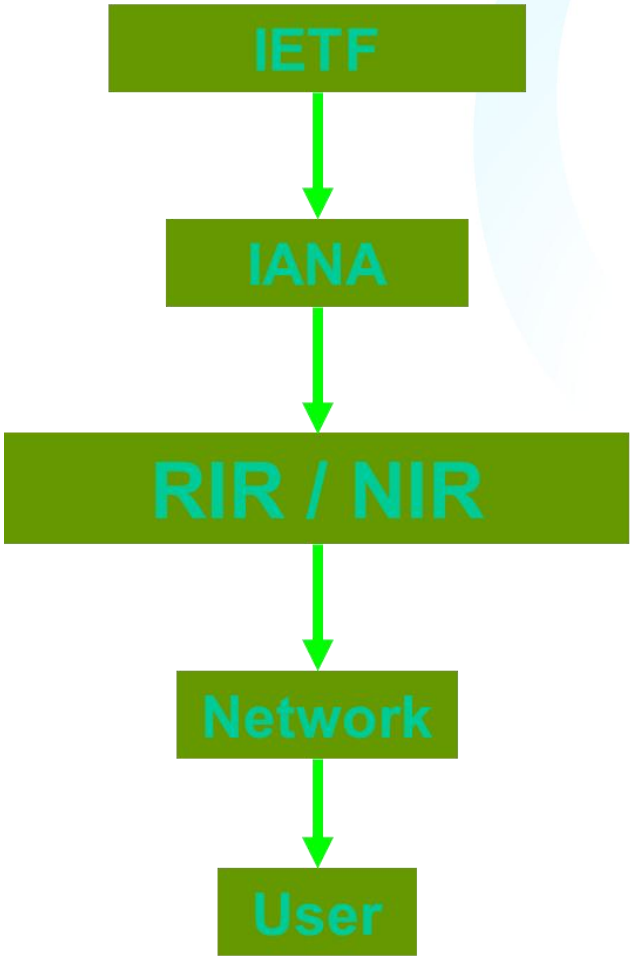
CIDR and Address assignments

- Backbone ISPs obtain large block of IP addresses space and then reallocate portions of their address blocks to their customers.

Example:

- ✓ Assume that an ISP owns the address block 206.0.64.0/18, which represents 16,384 (214) IP addresses
- ✓ Suppose a client requires 800 host addresses
- ✓ With classful addresses: need to assign a class B address (and waste ~64,700 addresses) or four individual Class Cs (and introducing 4 new routes into the global Internet routing tables)
- ✓ With CIDR: Assign a /22 block, e.g., 206.0.68.0/22, and allocated a block of 1,024 (210) IP addresses.

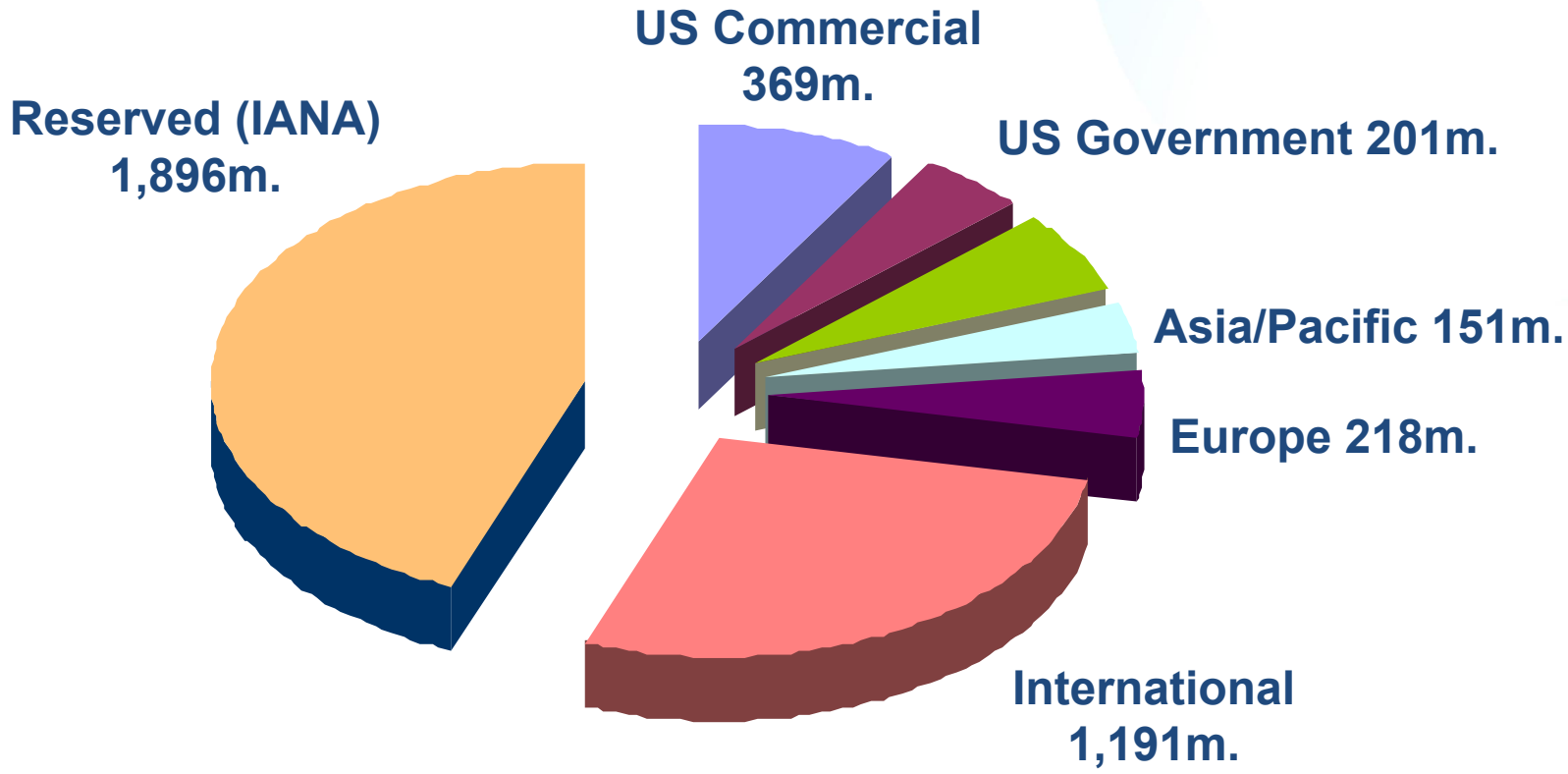
Where do IP addresses come from?



IPv4 Address Allocation

Source: iana.org

Total Addresses: 4,295m.



Special Address Summary

- 0.0.0.0 means “me”
- network.0 means “this network”
- network.255 means “broadcast”
- 255.255.255.255 means “broadcast
- everywhere”
- 127.0.0.1 means “loopback”
  - ✓ (actually: 127.anything)

What's Next ... ?

- Have you heard about IPv6 .....
- Do you know Why IPv6 plays major role in the current IT Infrastructure....

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