IP Addressing

CLARUSWAY©
WAY TO REINVENT YOURSELF

Table of Contents

CLARUSWAY©
WAY TO REINVENT YOURSELF

0 Network Recap

Network Basics

- LAN vs. WAN
- Throughput vs. Latency
- Bus, Ring, Star Topologies

OSI Model

- OSI 7-layer model
- Encapsulation
- De-encapsulation
- Segment
- Packet
- Frame

Protocols

- Ethernet
  - Layer 1, 2
  - Cables: Cat “x”, Ethernet, RJ45, Fibre, xBaseT
  - MAC Address
  - CSMA/CD
- Network Protocols - IP (part of TCP/IP)
  - Network layer (layer 3)
  - IP address
  - packet routing
  - IP, ICMP, ARP

Protocols

- Transport Protocols TCP (part of TCP/IP)
  - Layer 4
  - Port + Protocol (TCP, UDP)
  - TCP vs. UDP
  - 64K (65535) ports (1K = 1024)

Protocols

- Application Layer Protocols
  - Layer 7
  - Examples:
    - File transfer, secure connection, mail, etc…
  - Implemented by programs/applications/services
  - Implementations:
    - HTTP/HTTPS
    - FTP/FTPS
    - SSH, RDP
    - POP, IMAP, SMTP

CLARUSWAY
WAY TO REINVENT YOURSELF

Break
return @ 11am

1 IP Terminology

IP Terminology

- **Octet** - Same as byte, made up of 8 bits
- **Network Address** - This is the designation used in routing to send packets to a remote network—for example, **10**.0.0.0, **172.16**.0.0, and **192.168.10**.0.
- **Host Address** - A logical address used to define a single host
- **Broadcast Address** - Used by applications and hosts to send information to all hosts on a network. For example 255.255.255.255, which designates all networks and all hosts

2

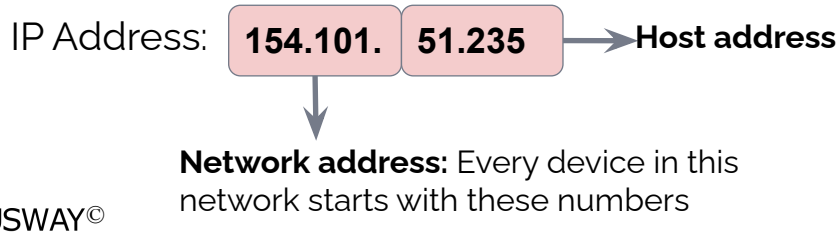
The Hierarchical IP Addressing Scheme

The Hierarchical IP Addressing Scheme

- IP address consists of **32 bits** or **4 bytes** or **4 octets**
- Represented as:
  - 54.164.151.235 or
  - 00110110.10100100.10010111.11101011 or
  - 66.A4.97.EB
- 32-bit IP address is *structured* (or *hierarchical*) address to make routing possible
- If IP address was *flat* (or *non hierarchical*) routing would be impossible

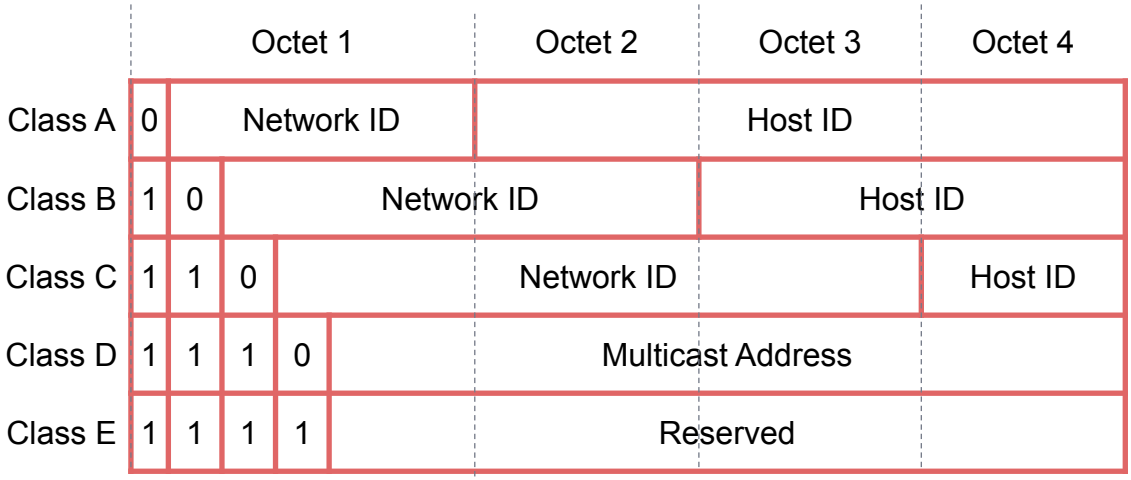
The Hierarchical IP Addressing Scheme

- The **network address** (or **network number**) uniquely identifies each network
- Every machine on the same network shares that network address as part of its IP address
- For example:



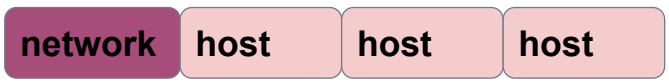
The Hierarchical IP Addressing Scheme

Network addresses are divided into 5 classes:



The Hierarchical IP Addressing Scheme

Class A Addresses



- Class A Network address is 1-byte long, first bit is always **0**
- Maximum 2^7 = 128 Class A networks can be created
- Maximum 2^{24} = 16,777,214 hosts (excluding 2 reserved addresses)
- Class A network addresses start with 1-126
  - First network is: 00000001 = 1 (0 is reserved)
  - Last network is: 01111110 = 126 (127 is reserved)

The Hierarchical IP Addressing Scheme

Class B Addresses

- Class B Network Address is 2-byte long, first 2 bits are always **10**
- Maximum 2^{14} = 16,384 Class B networks can be created
- Maximum 2^{16} = 65,534 hosts (excluding 2 reserved addresses)
- First 2 bits are always **10** then
  10000000 = 128
  10111111 = 191
- Class B Network Addresses start with 128-191

The Hierarchical IP Addressing Scheme

Class C Addresses

- Class C Network Address is 3-byte long, first 3 bits are always **110**
- Maximum 2^{21} = 2,097,152 Class C networks can be created
- Maximum 2^{8} = 254 hosts (excluding 2 reserved addresses)
- First 3 bits are always **110** then
  11000000 = 192
  11011111 = 223
- Class C Network Addresses start with 192-223

Class A, B, C Networks

Class	First Byte	Networks	Available IPs
A	0-126*	128	16M+
B	128-191	16K+	65K+
C	192-223	2M+	256

(*) the 127 IP range is a loopback (e.g. 127.0.0.1)

The Hierarchical IP Addressing Scheme

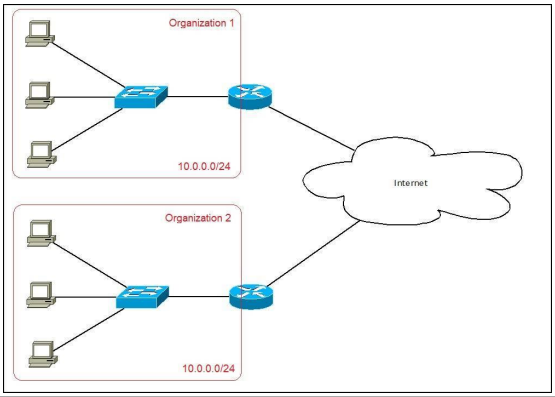
IP Address Classes:

Address Class	1st Octet Range	1st Octet Bits	Network & Host Parts	# of Possible Networks # of Hosts per Network
A	**1-127**	**00000000 - 01111111**	**N.H.H.H**	128 nets (2^7) 16,777,214 hosts per net (2^{24})-2
B	**128-191**	**10000000 - 10111111**	**N.N.H.H**	16,384 nets (2^{14}) 65,534 hosts per net (2^{16})-2
C	**192-223**	**11000000 - 11011111**	**N.N.N.H**	2,097,150 nets (2^{21}) 254 hosts per net (2^8)-2

The Hierarchical IP Addressing Scheme

Private IP Addresses (RFC 1918)

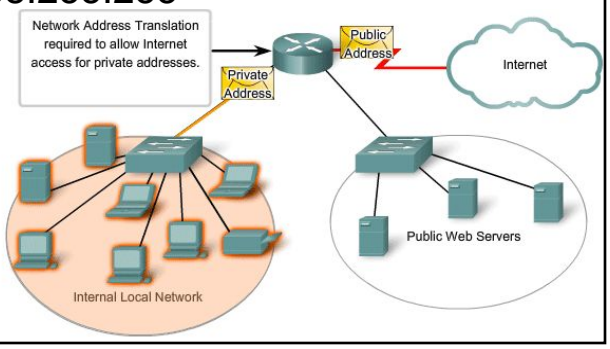
Every host on every network should have a routable IP address. But if every host on every network in the world was required to have an unique IP address, we would have run out of IP addresses!



The Hierarchical IP Addressing Scheme

Private IP Addresses (RFC 1918)

- The IANA reserved the following IP address blocks for use as private IP addresses:
  - Class A: 10.0.0.0 to 10.255.255.255
  - Class B: 172.16.0.0 to 172.31.255.255
  - Class C: 192.168.0.0 to 192.168.255.255



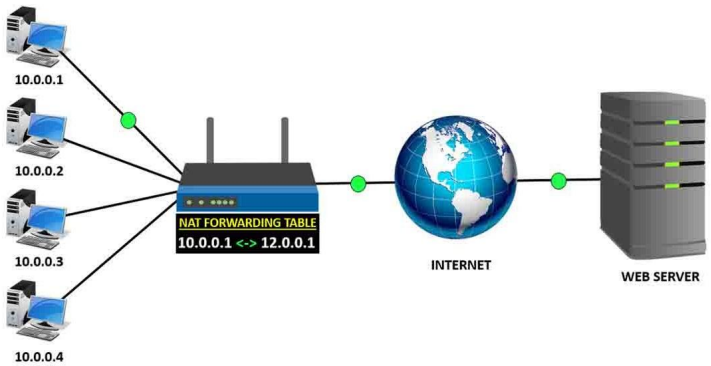
CLARUSWAY
WAY TO REINVENT YOURSELF

amazon web services

Break
return @ 12pm

Introduction to NAT

- NAT is a process in which one or more local IP addresses are translated into one or more global IP address and vice versa to provide Internet access to the local hosts
- NAT allows multiple devices to access the Internet through a single public address



Introduction to NAT

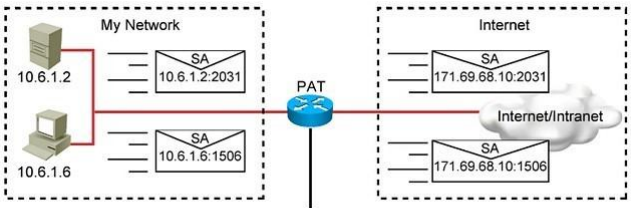
- Advantages:
  - Hides internal structure of the network from the outsider and thus increases network security
  - Eliminates address renumbering when a network evolves
  - Allows unlimited private IP address range

- Disadvantages:
  - Changes the IP addresses, thus troubleshooting becomes more complex
  - Translation results in switching path delays
  - Certain applications will not function while NAT is enabled
  - Complicates tunneling protocols such as IPsec

Introduction to NAT

Types of NAT:

- **NAT Overloading or Port Address Translation (PAT)**:
  - Most popular type of NAT
  - Port numbers are used to distinguish the traffic
  - Cost-effective as lots of users can be connected by using only one public IP address



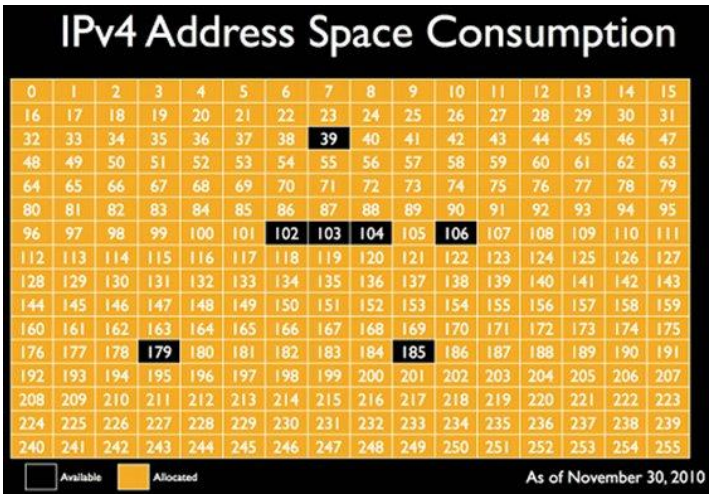
NAT Table

Inside Local IPv4 Address	Inside Global IPv4 Address
10.6.1.2:2031	171.69.68.10:2031
10.6.1.6:1506	171.69.68.10:1506

4 Internet Protocol Version 6 (IPv6)

Internet Protocol Version 6 (IPv6)

Why do we need IPv6?



Internet Protocol Version 6 (IPv6)

- IPv4 → 4,294,467,295 IP addresses

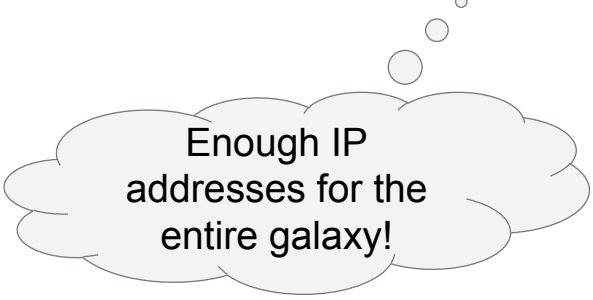
  Class A → 16,777,216
  Class B → 65,535
  Class C → 256

Large companies (Apple, IBM, Microsoft, etc.) allocated one or more Class A addresses

Internet Protocol Version 6 (IPv6)

- IPv6 is 128-bit long:

340,282,366,920,938,463,463,374,607,431,768,211,456



Internet Protocol Version 6 (IPv6)

- IPv6 is 128-bit long:
    - 340 - undecillion
    - 282 - decillion
    - 366 - nonillion
    - 920 - octillion
    - 938 - septillion
    - 463 - sextillion
    - 463 - quintillion
    - 374 - quadrillion
    - 607 - trillion
    - 431 - billion
    - 768 - million
    - 211 - thousand
    - 456

Internet Protocol Version 6 (IPv6)

- More Efficient Routing
- More Efficient Packet Processing
- Directed Data Flows - No broadcasts!
- Simplified Network Configuration
- Support For New Services - No need for NAT!
- Security

Internet Protocol Version 6 (IPv6)

- IP Address representation:

  IPv4 → 51.151.64.242
  IPv6 → 2041:1234:140F:1122:AB91:564F:875B:131B

  Octet

  Hexadectet or **hextet**

- On browsers:

  IPv4: http://51.151.64.242/index.html

  IPv6: http://[2041:1234:140F:1122:AB91:564F:875B:131B]/index.html

Internet Protocol Version 6 (IPv6)

- Shortening IPv6 Addresses:

  Original : 2041:0000:140F:0000:0000:0000:875B:131B
  Short : 2041:0000:140F::875B:131B

  Original : 2001:0000:0000:0012:0000:0000:1234:56ab
  Wrong! : 2001::0012::1234:56AB

  You can remove zeros only once!

Internet Protocol Version 6 (IPv6)

- Shortening IPv6 Addresses:

  Original : 2041:0000:140F:0000:0000:0000:875B:131B
  Short : 2041:0:140F::875B:131B

  Original : 2001:0001:0002:0003:0004:0005:0006:0007
  Short : 2001:1:2:3:4:5:6:7

- Rules:
  - An entire string of zeros can be removed, you can only do this once
  - 4 zeros can be removed, leaving only a single zero
  - Leading zeros can be removed

Dual Stack

Support for IPV4 and IPV6

THANKS!

Any questions?

You can find me at:

- @Altaz - Instructor
- altaz@clarusway.com