Networks and Routing

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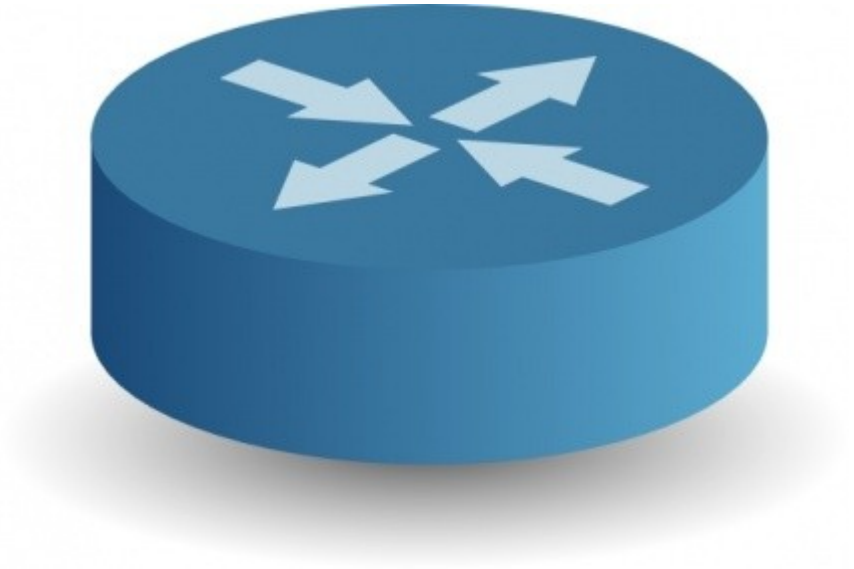


Network Building
Getting Ready

-Before you start ***PREPARE***!
-Understand the purpose and goals for the network
-The first step in understanding and developing networking solutions is knowledge of the business needs
-What are the top 5 fundamental planned usages of the network
-What are the physical environment's strengths and weaknesses
-Do specific goals drive the decisions?

Examples:
-On-premise vs Off-premise such as cloud based services
-Is VoIP going to be present?
-Will the company need WiFi, guest WiFI networks?
-Will the company allow staff to BYOD?

Network Building blocks

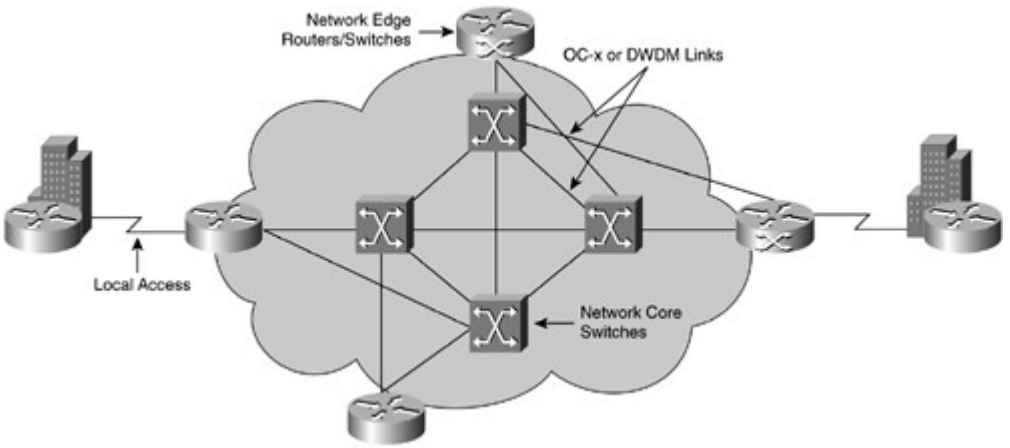
- Get the building blocks correct from the beginning
- What your building needs to be maintainable
- Clean demarcation of responsibilities

Examples:

- Attention to detail such as cabling quality and color coding does matter
- Layer 1 separation of VoIP and Data is my recommendation to keep each vendor responsible for their own services
- Layout how and where the physical devices will be positioned

Network Example Scenario

We will use a greenfield example throughout this presentation. The example will be a typical organization that needs 25 computers to function and be productive.



Network Standards

Who makes the rules:

- IEEE Institute of Electrical and Electronics Engineers for items such as Ethernet, WiFi, Bluetooth, etc...
- IETF, Internet Engineering Task Force who produce IP, TCP, HTTP, etc... via the Request for Comments (RFC) system
  - (Note RFCs are available online and very readable... some even funny)
- Vendors and OEMs
- Others

What is a Network

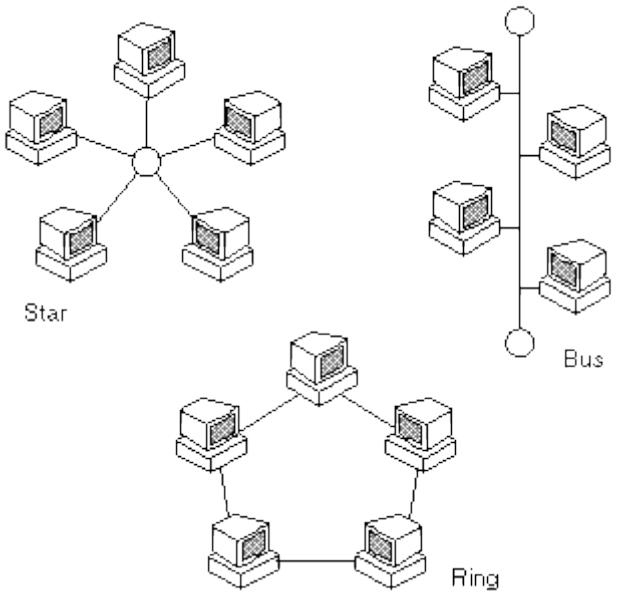
A network is two or more computer systems linked together.

There are many types of common computer networks, including:

•Local Area Networks (LANs) : The computers are geographically close together (that is, in the same building).

•Wide Area Networks (WANs) : The computers are farther apart and are connected by telephone lines or radio waves.

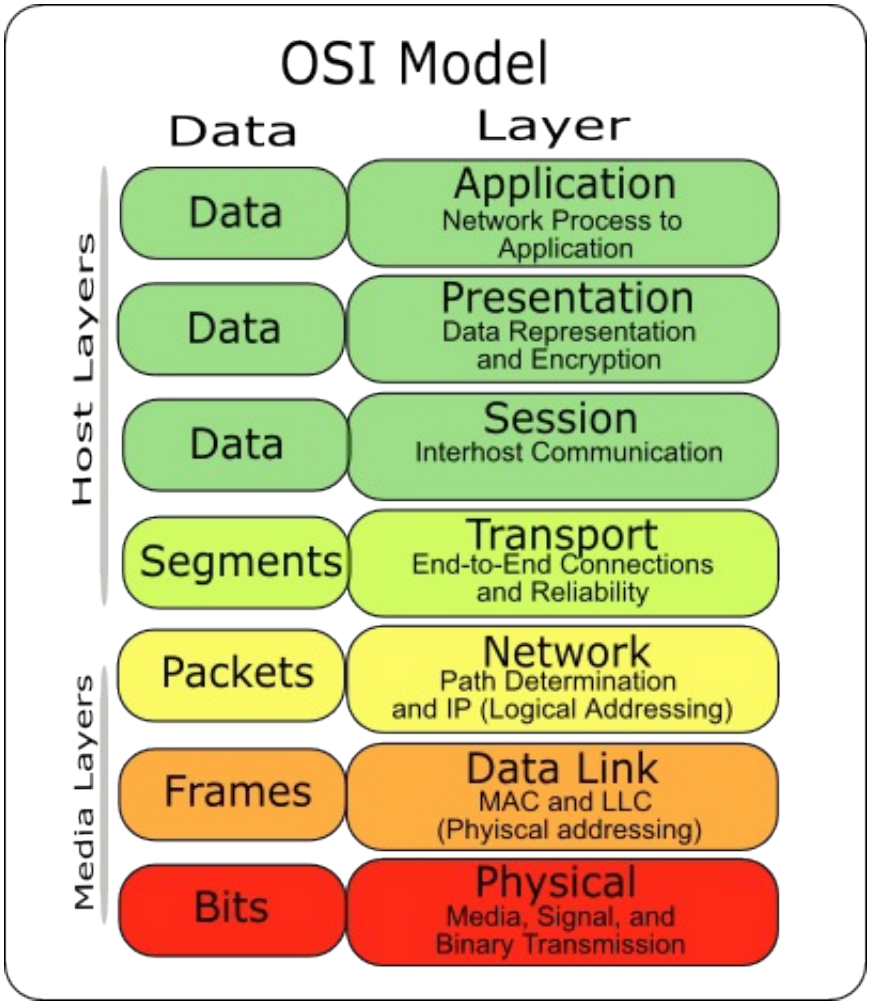
•Metropolitan Area Networks (MANs): A data network designed for a town or city



LAN Topologies

- Star
- Ring
- Bus
- Mesh

Network OSI Model



OSI Layer 1: Physical

-Media Types
- --Copper
  - ---Unshielded Twisted Pair (3,5,5e,6,7)
  - ---Shielded Twisted Pair
  - ---Coaxial Cable (Thinnet, Thicknet)
  - ---Heliax
- --Fiber Optic
  - ---Single-mode
  - ---Multi-mode
- --Infrared
- --Radio & Microwave

-Network Types
- --Token Ring
- --Ethernet: Introduced 1980s IEEE 802.3
- --Fast Ethernet:
- --Gigabit Ethernet:

OSI Layer 1:Physical

Best Practices

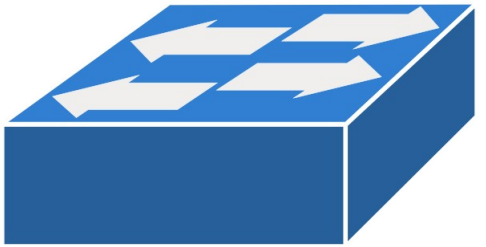
- Take this step seriously
- Vet and qualify your contractor
- Have the infrastructure tested by the cabling contractor before acceptance of the job completion
- Require that all jacks be numbered and a floor diagram be part of the project.
- Be ready to test and verify
- At a minimum you should always have a continuity tester

<<<< Autotest Failed >>>>

```
WAVETEK LANTEK PRO XL                    Circuit ID: AZURE SU 5019
Autotest Summary                         Date/Time: 05/02/13 11:10:00
Company Name: DYNAMIC CONNC              Cable Type: TIA Cat 5 UTP  BASIC
User Name: CESAR
PRO Serial Number: 8020084               Prop Rate    = .72c
                                         Frequency    = 1.0 - 100.0MHz
-------------- Line Mapping -------------
Pins:                  1 2 3 4 5 6 7 8 S
Line Map:              1 2 3 4 5 6 7 8
Pins used:             x x x x x x x x


---------------------- Dual NEXT ----------------------
 End        Pair      Worst Case NEXT      Margin   Limit
-----      -------  --------------------   ------   ------
Display    3,6/1,2  35.0 dB  @  97.0 MHz   5.4dB    29.6dB
Display    3,6/4,5  54.0 dB* @   3.1 MHz  -0.7dB*   54.7dB--------FAIL*
Display    3,6/7,8  51.2 dB* @   2.7 MHz  -4.6dB    55.8dB--------FAIL
Display    1,2/4,5  41.6 dB  @  98.2 MHz  12.1dB    29.5dB
Display    1,2/7,8  43.1 dB  @  65.5 MHz  10.7dB    32.4dB
Display    4,5/7,8  38.6 dB  @  63.9 MHz   6.0dB    32.6dB
Remote     3,6/1,2  30.9 dB  @  99.8 MHz   1.6dB    29.3dB
Remote     3,6/4,5  39.2 dB  @  91.8 MHz   9.2dB    30.0dB
Remote     3,6/7,8  57.1 dB* @   1.0 MHz  -2.9dB   >60.dB--------FAIL
Remote     1,2/4,5  41.7 dB  @  95.7 MHz  12.0dB    29.7dB
Remote     1,2/7,8  43.7 dB  @  54.5 MHz   9.7dB    34.0dB
Remote     4,5/7,8  42.8 dB  @ 100.0 MHz  13.5dB    29.3dB

---------- Attenuation -------------    ------Atten/Length-----
Pair     Worst Case Atten      Limit       Value          Limit
----   --------------------   -------   -----------   ---------
3,6   15.4 dB* @   3.2 MHz     4.0dB     0.131 dB/ft*    0.088 dB/ft-----FAIL
1,2    7.6 dB  @ 100.0 MHz    21.6dB     0.063 dB/ft     0.088 dB/ft
4,5    7.3 dB  @ 100.0 MHz    21.6dB     0.061 dB/ft     0.088 dB/ft
7,8    9.5 dB  @  98.6 MHz    21.4dB     0.078 dB/ft     0.088 dB/ft

-------------------------Link Measurements--------------------------
Pair  Length
----  -------
3,6   117.8ft
1,2   119.7ft
4,5   119.1ft
7,8   121.4ft
----  -------
Limit 308.4ft
```

OSI Layer 2:Data Link

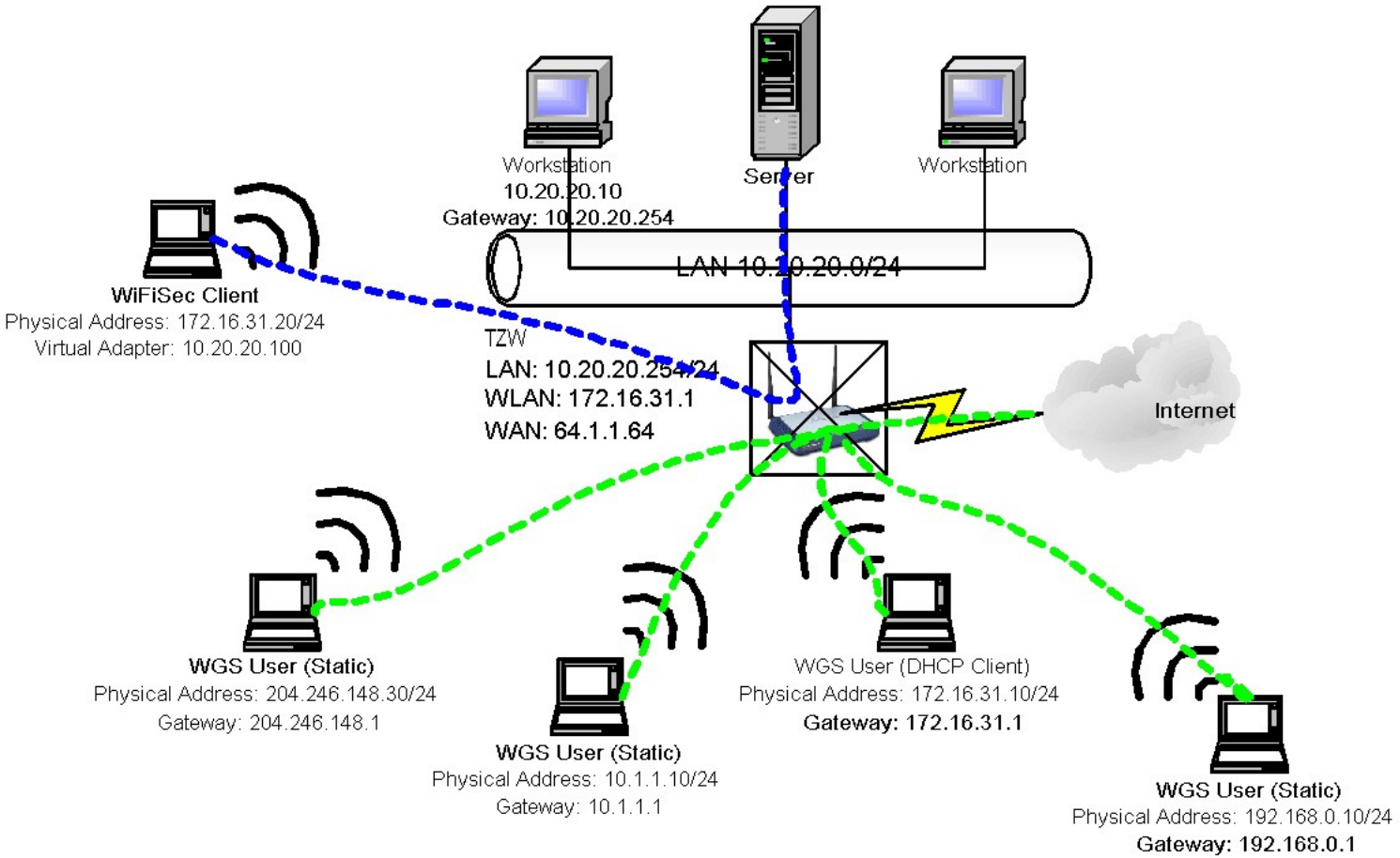
-Hubs & Switches
-Hubs vs Switches
-Switches vs Smart / Manageable Switches
-MAC Addresses
-VLANs
-QoS / CoS



LOVE LOVE LOVE THIS LAYER
*It can do more then you realize
Example – DAT (Dynamic Address Translation)
*Thrill! - your MAC can access to VLANs (Not all Windows machines can do this… depending on the network card).

OSI Layer 2:Data Link

Dynamic Address Translation (DAT)



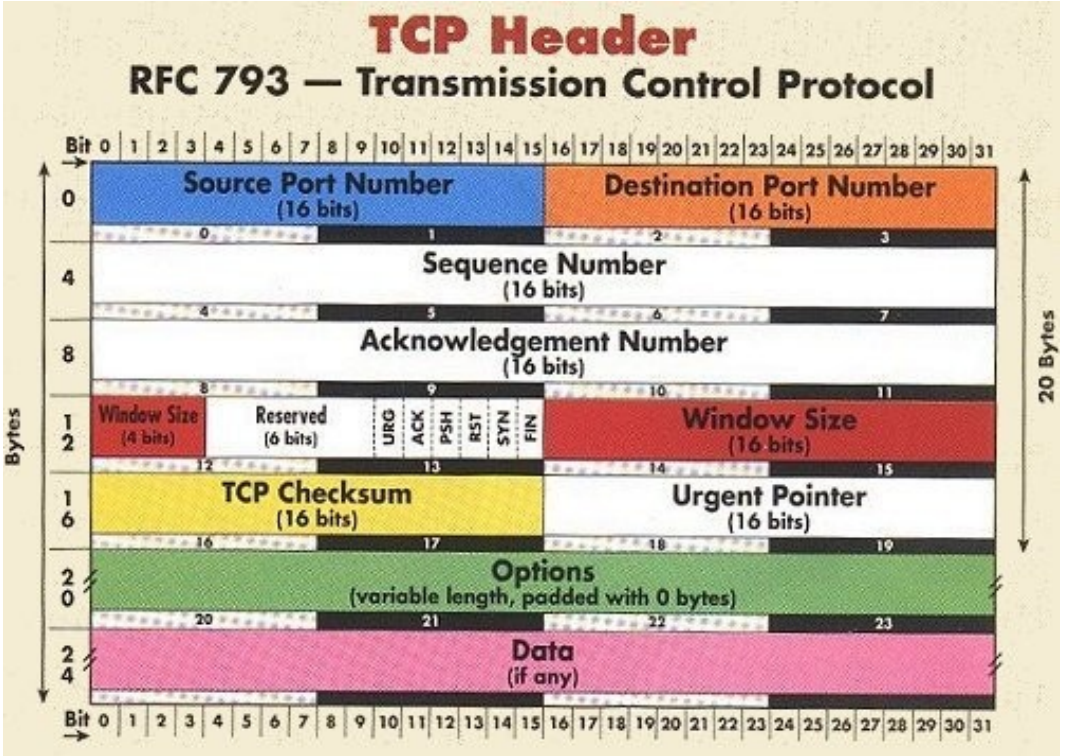
OSI Layer 3:Network

-Broadcast protocols such as IPX/SPX
-Routable protocols such as Internet Protocol

Internet Protocol (IP)
•How is a packet formed? (Header / Data)

OSI Layer 3:Network

IPv4 Header Packet Header
- Internet Header Length (IHL)
- Differentiated Services Code Point (DSCP)
- Explicit Congestion Notification (ECN)
- Total Length
- Identification
- Fragment Offset
- Time to Live (TTL)
- Protocol
- Header Checksum
- Source Address
- Destination Address



OSI Layer 3:Network

IP Subnetting

Components of sub-netting

- Network declaration
- Usable IPs
- Broadcast
- Subnet mask 255.255.255.0 vs bit declaration /24

OSI Layer 3:Network

Making Smaller Subnets
Example: Office of 25 users with 2-3 servers.
Instead of a /24 (255.255.255.0) LAN,
consider 2 x /25 (255.255.255.128) LANs.

Network 1: 192.168.0.0/25
• Hosts: 192.168.0.1 - 192.168.0.126

Network 2: 192.168.0.128/25
• Hosts: 192.168.0.129 - 192.168.0.254

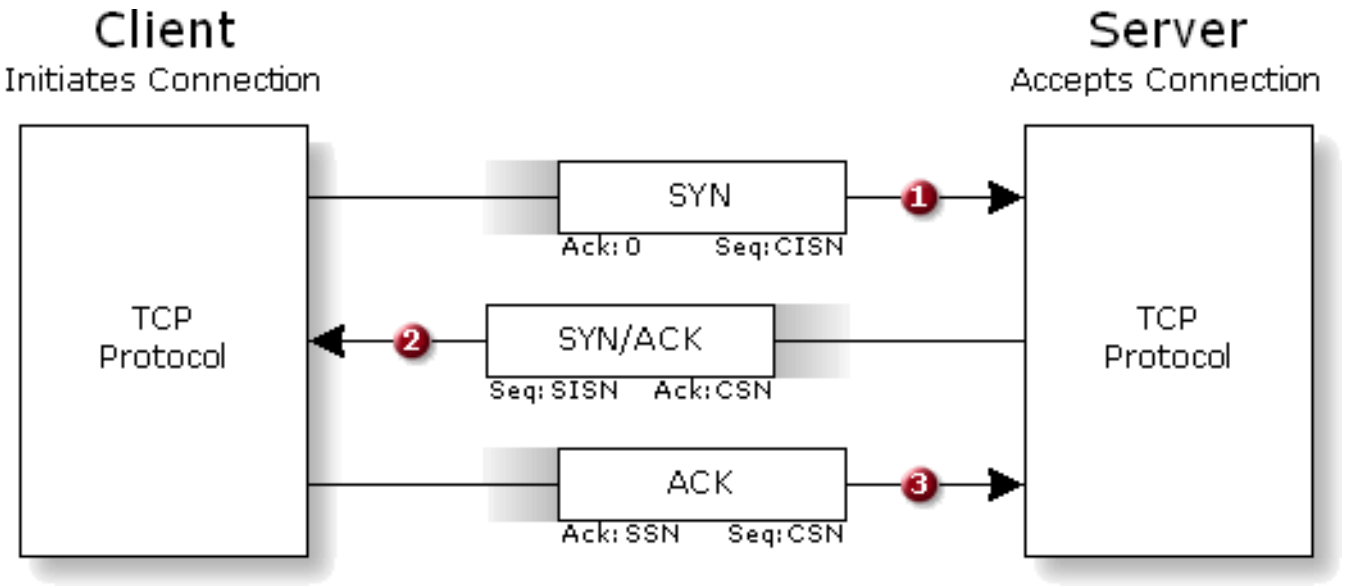
	Hosts	Netmask	Amount of a Class C
/30	4	255.255.255.252	1/64
/29	8	255.255.255.248	1/32
/28	16	255.255.255.240	1/16
/27	32	255.255.255.224	1/8
/26	64	255.255.255.192	1/4
/25	128	255.255.255.128	1/2
/24	256	255.255.255.0	1
/23	512	255.255.254.0	2
/22	1024	255.255.252.0	4
/21	2048	255.255.248.0	8
/20	4096	255.255.240.0	16
/19	8192	255.255.224.0	32
/18	16384	255.255.192.0	64
/17	32768	255.255.128.0	128
/16	65536	255.255.0.0	256

OSI Layer 3:Network

Protocols

TCP vs UDP vs other types
Other types such as ICMP (Ping and Traceroute)
List of Protocol Numbers:
http://www.iana.org/assignments/protocol-numbers/protocol-numbers.xhtml

How is a TCP connection established



OSI Layer 3:Network

Standard IP Service Ports

```
#
# Network services, Internet style
#
# Note that it is presently the policy of IANA to assign a single well-known
# port number for both TCP and UDP; hence, most entries here have two entries
# even if the protocol doesn't support UDP operations.
#
# The latest IANA port assignments can be gotten from
#
#       http://www.iana.org/assignments/port-numbers
#
# The Well Known Ports are those from 0 through 1023.
# The Registered Ports are those from 1024 through 49151
# The Dynamic and/or Private Ports are those from 49152 through 65535
#
# $FreeBSD: src/etc/services,v 1.89 2002/12/17 23:59:10 eric Exp $
#       From: @(#)services     5.8 (Berkeley) 5/9/91
#
# WELL KNOWN PORT NUMBERS
#
rtmp              1/ddp    #Routing Table Maintenance Protocol
tcpmux            1/udp     # TCP Port Service Multiplexer
tcpmux            1/tcp     # TCP Port Service Multiplexer
nbp               2/ddp    #Name Binding Protocol
compressnet       2/udp     # Management Utility
...
ftp-data         20/udp     # File Transfer [Default Data]
ftp-data         20/tcp     # File Transfer [Default Data]
ftp              21/udp     # File Transfer [Control]
ftp              21/tcp     # File Transfer [Control]
ssh              22/udp     # SSH Remote Login Protocol
ssh              22/tcp     # SSH Remote Login Protocol
telnet           23/udp     # Telnet
telnet           23/tcp     # Telnet
...
smtp             25/udp     # Simple Mail Transfer
smtp             25/tcp     # Simple Mail Transfer
…
finger           79/udp     # Finger
finger           79/tcp     # Finger
#                          David Zimmerman <dpz@RUTGERS.EDU>
http             80/udp     www www-http # World Wide Web HTTP
http             80/tcp     www www-http # World Wide Web HTTP
#                          Tim Berners-Lee <timbl@W3.org>
```

OSI Layer3:Network

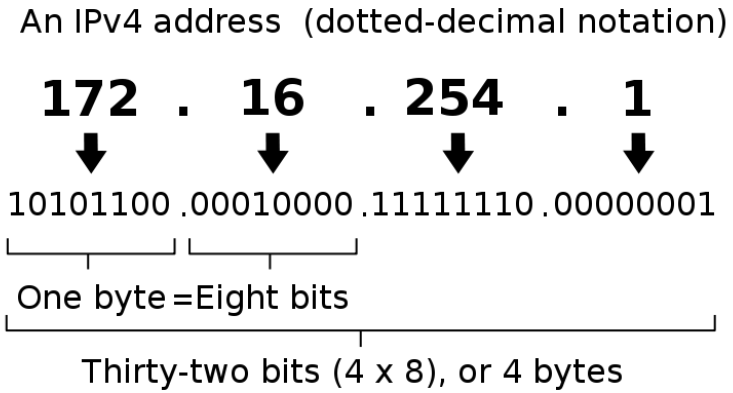
IP Address Space
-Public IP vs Private IP
-RFC 1819
-Selecting and Acquiring IP space
-Who controls public space allocation?

“The Internet Assigned Numbers Authority (IANA) is the department of ICANN, a nonprofit private US corporation, which oversees global IP address allocation, autonomous system number allocation, root zone management in the Domain Name System (DNS), media types, and other Internet Protocol-related symbols and numbers.”

OSI Layer3:Network

Selecting Private IP space

- -Multiple sites need their own IP space
- -Use something logical
- -If Voice is to be separated from Data you will need two spaces
- -DO NOT USE 192.168.1.0/24



OSI Layer3:Network

Network Address Translation (NAT) & Port Forwarding

NAT

-What is it
-Why is it needed
-Translates the IP header, keeps track of state
-NAT has extended the life of Ipv4

Port Forwarding

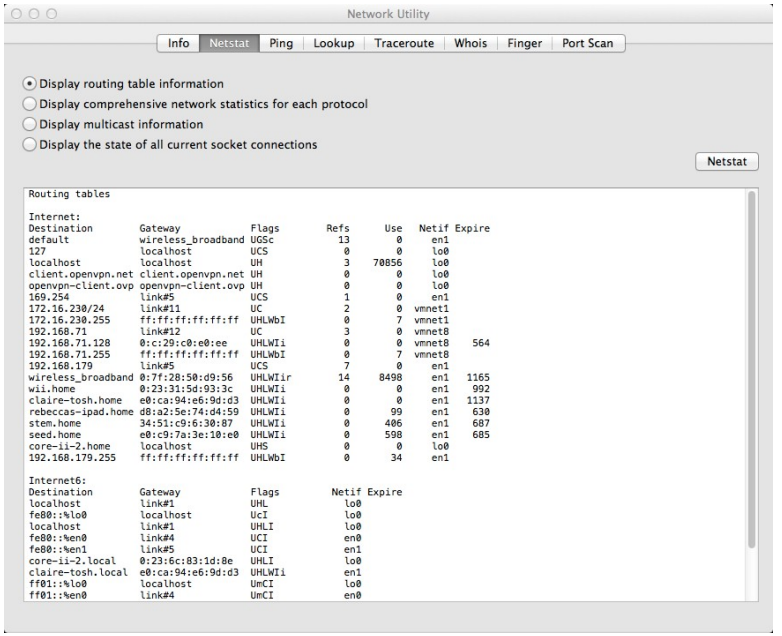
-Allows ports inside network to be exposed to outside

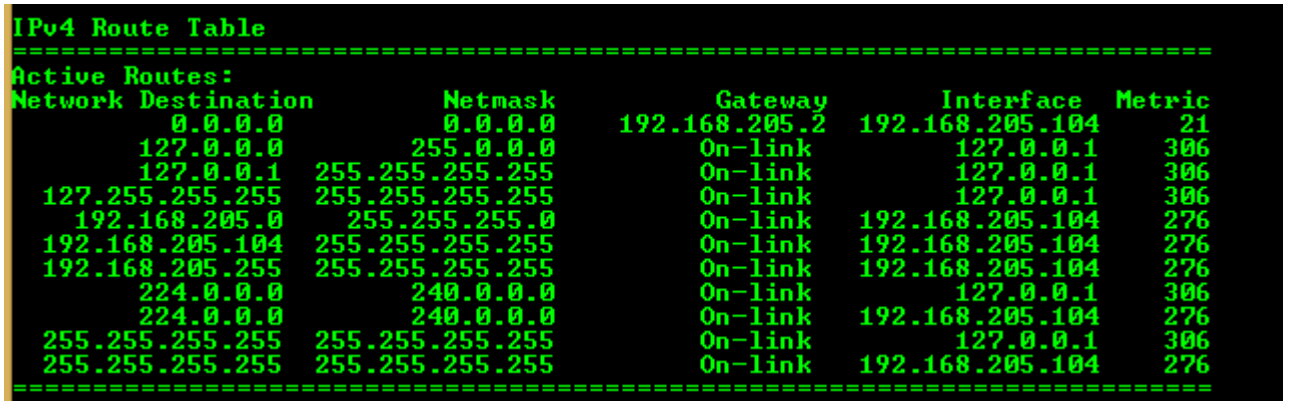
Layer3:Network Routing IPv4

Routing IPV4
Ways to get to the routing table:
- Network Utility
- netstat -nr

Static Routing vs Dynamic Routing

Setting Preferences in MAC OSX routing





Troubleshooting

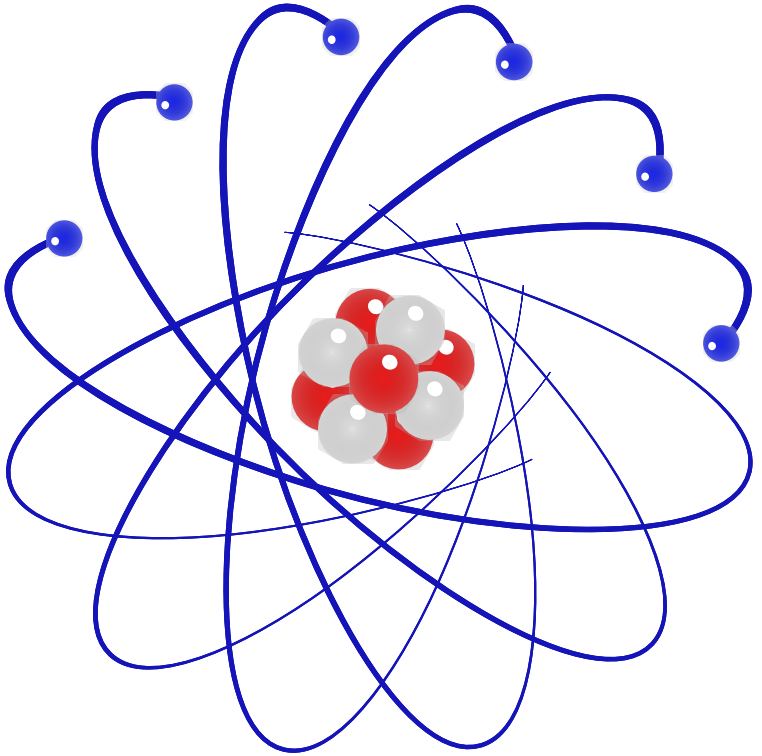
-Diagnosing issues
-Trust but verify
-Baby steps test all pieces in a logical manner
-Follow the scientific method
-Know your tools

The Scientific Method

The Scientific Method is the key to troubleshooting your computer and network problems.

There are six steps in the scientific method:

- Gather Information
- State the Problem
- Form a hypothesis
- Test the hypothesis
- Observe Results & Draw conclusions
- Repeat as necessary



IPv6

- What is it
- Supported by dual stack on most devices
- How is it different from Ipv4
  - 128-bit address space, enough addresses for foreseeable future
  - You'll likely get a /64, so 18,446,744,073,709,551,616 addresses
- Smaller ISP's probably aren't ready... but that is changing
- Adoption Challenges
- Much more important for carriers, Asia, etc...

Questions?