Network Fundamentals

Module 6

Objectives

- Identify Common Network Devices
- Define Protocols
- Fundamentals of DNS
- Network Configuration Tools

Common Network Devices

- Network Interface Card (NIC)
  - Allows computer to talk to a network
- Hub
  - Allows multiple network devices to connect. A signal comes in one port and is transmitted to all other ports.
- Switch
  - Allows multiple network devices to connect, but does not distribute signals without verifying whether it really needs to propagate to a given port or ports

Common Network Devices

- Wireless Access Point (WAP)
  - Allows users to connect to a network without ‘wires’
    - RF signals are used to communicate instead of physical wires
  - Wireless access standards are broadly divided into 802.11a, 802.11b, and 802.11g
- Router
  - Forwards data packets between networks; used to connect different networks and transfer packets between them
- Gateway
  - Used to connect two different types of networks
- Modem
  - Translates digital signals from a computer into analog signals

Protocols

- Protocols
  - A set of rules that governs the communications between computers on a network
  - Not hardware (cable, routers, etc.); rather what makes all the hardware function together and allows it communicate
- Internet Protocol (IP)
  - A set of related network protocols (TCP, UDP, HTTP, FTP, ARP, ICMP) used to move data around the Internet and other networks
- Protocols allow the following to occur
  - Streaming video or music online (UDP)
  - Changes www.google.com to 74.125.45.99 (DNS)
  - Safely perform transactions online (SSL)
  - Chat online (IRC)

Protocols

- TCP/IP – Transmission Control Protocol/Internet Protocol
  - Most commonly used protocol for Internet communication
- IP Addressing
  - The IP address uniquely identifies computers on a TCP/IP network
  - Every “node” (client, server, router) on a network has to have a unique IP address (192.168.1.15 for example)
- UDP - User Datagram Protocol
  - A connectionless service
  - Main alternative to TCP
- DNS - Domain Name System
  - Translates network address (such as IP addresses) into terms understood by humans (such as Domain Names) and vice-versa

Protocols

- DHCP - Dynamic Host Configuration Protocol
  - Can automatically assign Internet addresses to computers and users
- FTP - File Transfer Protocol
  - A protocol that is used to transfer and manipulate files over the network
- HTTP - HyperText Transfer Protocol
  - An Internet-based protocol for sending and receiving web pages
- HTTPS - HyperText Transfer Protocol Secure
  - An Internet-based protocol for sending and receiving WebPages securely
- IMAP - Internet Message Access Protocol
  - A protocol for e-mail messages on the Internet

Protocols

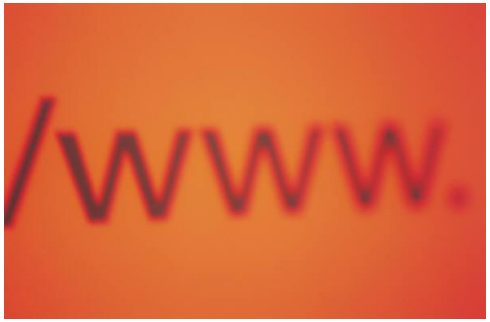
- IRC - Internet Relay Chat
  - A protocol used for Internet chat and other communications
- POP3 - Post Office protocol Version 3
  - A protocol used by e-mail clients to retrieve messages from remote servers
- SMTP - Simple Mail Transfer Protocol
  - A protocol for e-mail messages on the Internet
- ARP – Address Resolution Protocol
  - Converts an IP address to its corresponding physical network address

Protocols

- SNMP - Simple Network Management Protocol
  - A standard TCP/IP protocol used to monitor and map network availability, performance, and error rates
- Telnet
  - A remote terminal access protocol
- SSH – Secure Shell
  - A secure remote terminal access protocol
- SSL - Secure Sockets Layer
  - A security protocol to enable Web sites to pass sensitive information securely in an encrypted format
- LDAP - Lightweight Directory Access Protocol
  - A network protocol and a standard architecture for organizing the directory data

TCP

- Most communications are handled using TCP
- TCP is reliable
  - Acknowledgements indicate delivery of data
  - Checksums are used to detect corrupted data
  - Sequence numbers detect missing, or mis-sequenced data
  - Corrupted data is retransmitted after a timeout
  - Mis-sequenced data is re-sequenced
  - Flow control prevents over-run of receiver
  - Uses *congestion control* to share network capacity among users
  - TCP is *connection-oriented*
- Commonly used for
  - World Wide Web
  - E-mail
  - File transfer

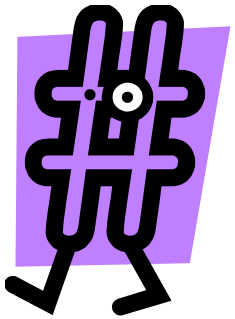


UDP

- UDP is not reliable
  - Not guaranteed that packets will be received
  - No acknowledgements to indicate delivery of data
  - Data may arrive out of sequence
  - Data may be duplicate or go missing
  - Congestion of data is common
  - Checksums are used to detect tampering or corruption
- Commonly used for
  - Streaming music or video
  - Voice over IP (VoIP)
  - Gaming
  - DNS

File Integrity

- Network data transmissions often produce errors, such as toggled, missing or duplicated bits
  - The data received might not be identical to the data transmitted
- Checksums are used
  - Ensures the integrity of data portions for data transmission or storage
- Hash functions
  - A hash value is generated for each given message
  - Used for data comparison and detecting duplicated data
  - Commonly used to check data integrity

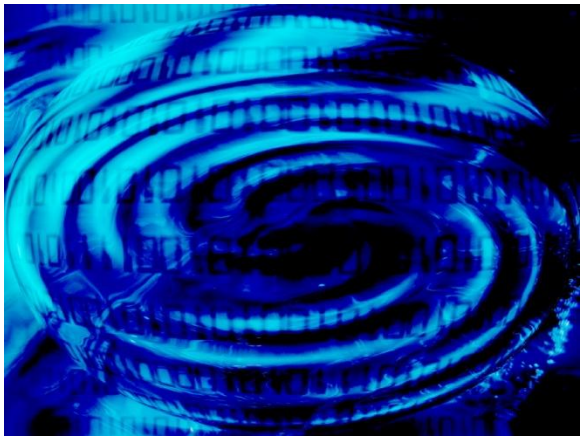


File Integrity

- Md5
  - A command line utility usable on either Unix or MS-DOS/Windows which generates and verifies message digests using the MD5 algorithm
  - Security has been compromised as an encryption protocol, however, used mostly to provide some assurance that a transferred file has arrived intact and uncorrupted
  - How to use md5
    - http://www.openoffice.org/dev_docs/using_md5sums.html

Ports

- Port
  - A virtual connection point that allows software applications to share hardware resources without interfering with each other
  - Computers and routers automatically manage network traffic traveling via their virtual ports
  - Used in protocols to name the ends of logical connections which carry long term conversations
- Well known (privileged) ports
  - 1-1023
- Registered ports
  - 1024-49151
- Dynamic or private ports
  - 49152-65535



Common Ports

- A service contact port is defined for providing services to unknown callers
- These are common ports that are easily targeted
  - TCP port 21 - FTP (File Transfer Protocol)
  - TCP port 23 - Telnet
  - TCP port 25 - SMTP (Simple Mail Transfer Protocol)
  - TCP and UDP port 53 - DNS (Domain Name System)
  - TCP ports 80 and 443 - HTTP (Hypertext Transport Protocol) and HTTPS (HTTP over SSL)
  - TCP port 110 - POP3 (Post Office Protocol version 3)
  - TCP and UDP port 135 – Windows RPC
  - TCP and UDP ports 137–139 - Windows NetBIOS over TCP/IP
- On a Unix/Linux system, ports and associated service names are listed in the /etc/services file
- For a complete list of ports and services, see http://packetlife.net/media/library/23/common-ports.pdf

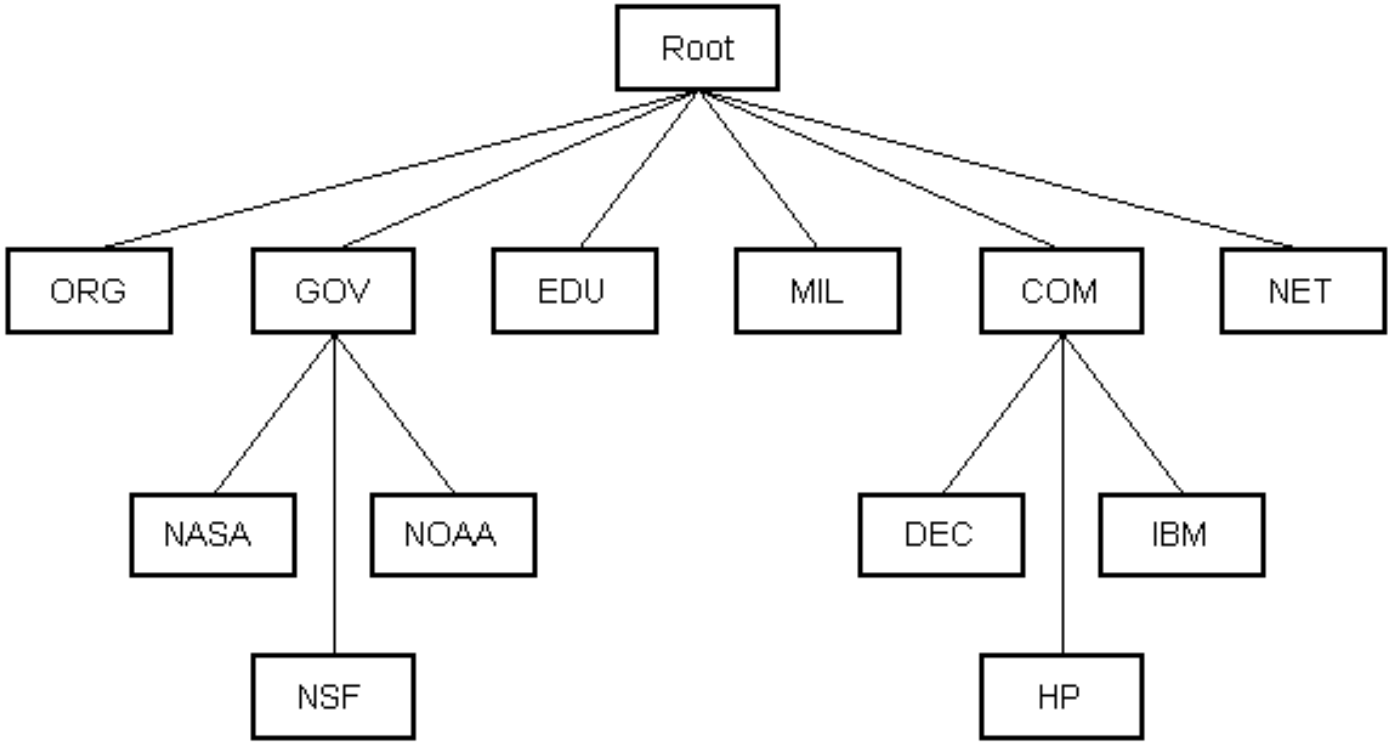
DNS

- Domain Name System (DNS)
  - Associates information with domain names
  - It translates human-readable computer hostnames (e.g., *ww.wikipedia.org*) into the IP address
  - Requests and responses are normally sent as UDP packets (to port 53)
- DNS is a distributed database: parts of the tree (called "zones") are held in different servers
  - DNS servers do not contain the entire database, but rather a subset
- Each zone has two or more authoritative nameservers
  - These authoritative DNS servers publish information about that domain and the nameservers of any domains "beneath" it

    (See next slide for illustration)
- Every caching nameserver is seeded with a list of root servers
- Currently there are only 13 root servers

http://en.wikipedia.org/wiki/DNS

DNS



DNS is structured as a hierarchy similar to the IP routing hierarchy. The computer requesting a name resolution will be re-directed 'up' the hierarchy until a DNS server is found that can resolve the domain name in the request.

Tools

- Nslookup
  - Tool used to query DNS for a domain name or IP address
- At a command line, type ‘nslookup <hostname>’ and hit enter.

```
C:\Users\mel>nslookup utsa.edu
Server:  clinton1604.utsarr.net
Address:  129.115.102.165

Non-authoritative answer:
Name:    utsa.edu
Address:  129.115.102.107
```

Tools

- Whois
  - Command returns information about a domain name or IP address such as domain name, registrant, contacts, nameservers, and domain name dates (i.e., activation, expiration)
  - To perform a Whois search online go to http://www.internic.net/whois.html

Domain Name: UTSA.EDU

Registrant:
University of Texas at San Antonio
6900 North Loop 1604 West
San Antonio, TX 78249
UNITED STATES

Name Servers:
JULIET.IT.UTSA.EDU 129.115.102.150
BERRY.IT.UTSA.EDU 129.115.102.151

Domain record activated: 14-Dec-1990
Domain record last updated: 29-Jun-2011
Domain expires: 31-Jul-2012

Tools

- Traceroute
  - Command that shows the path a network packet takes from origination to destination
- The command displays how many ‘hops’ from router to router it takes for the packet to reach its destination
- Also displayed are the addresses of each router and the time it takes for a packet to go from router to router
- If a router is not reachable, you will see a request timeout
- In UNIX machines the command is ‘traceroute’, in MS Windows machines it is called ‘tracert’.
  - This command is not always effective as many sites block ICMP to minimize DDoS issues
- The next slide shows an example of running the command

Tools

- Traceroute
  - See results for ‘tracert www.yahoo.com’

```
C:\Users\mel>tracert www.yahoo.com

Tracing route to any-fp3-real.wa1.b.yahoo.com [209.191.122.70]
over a maximum of 30 hops:

  1     1 ms     1 ms     1 ms  rrcs-24-173-46-81.sw.biz.rr.com [24.173.46.81]
  2     2 ms     2 ms     2 ms  rrcs-24-73-242-153.sw.biz.rr.com [24.73.242.153]

  3     6 ms     *        6 ms  24.73.242.30
  4     *        6 ms     6 ms  gig3-0-0.snantx5000-m-rtr01.texas.rr.com [24.93.
60.144]
  5     7 ms     6 ms     7 ms  gig2-0-1.hstntxl3-pe-rtr01.texas.rr.com [24.93.3
5.22]
  6     7 ms     6 ms     7 ms  gig3-0-1.hstntxl3-p-rtr01.texas.rr.com [24.93.35
.20]
  7    14 ms    12 ms    10 ms  gig4-2-0.hstntxl3-rtr1.texas.rr.com [24.93.60.66
]
  8     6 ms    12 ms     6 ms  ae-4-0.cr0.hou30.tbone.rr.com [66.109.6.54]
  9    11 ms    11 ms    10 ms  107.14.17.141
 10    13 ms    10 ms    10 ms  66.109.9.191
 11    11 ms    12 ms    11 ms  ae-1-d111.msr2.mud.yahoo.com [216.115.104.103]
 12    11 ms    11 ms    11 ms  te-8-1.fab2-a-gdc.mud.yahoo.com [209.191.78.141]

 13    28 ms    11 ms    12 ms  te-8-2.bas-c1.mud.yahoo.com [209.191.78.173]
 14    11 ms    11 ms    11 ms  ir1.fp.vip.mud.yahoo.com [209.191.122.70]

Trace complete.
```

Tools

- Netstat
  - A tool for checking network configuration and activity such as
    - All connections including what protocol and its current state
    - Display contents of the IP Routing table
    - Network interface statistics
  - Displays different information by using different parameters or 'flags' with the command (e.g., 'netstat –a')

    Note: Windows and Unix have different 'flags' and options available
- For Windows XP
  - http://www.microsoft.com/resources/documentation/windows/xp/all/proddocs/en-us/netstat.mspx?mfr=true
- For Linux
  - http://tldp.org/LDP/nag2/x-087-2-iface.netstat.html
  - http://www.thegeekstuff.com/2010/03/netstat-command-examples/

Tools

- Netstat
  - Display all connections and current state using ‘netstat –a’
  - (Windows XP)

```
C:\Users\mel> netstat -a

Active Connections

  Proto  Local Address          Foreign Address        State
  TCP    0.0.0.0:135            TRN44:0                LISTENING
  TCP    0.0.0.0:445            TRN44:0                LISTENING
  TCP    0.0.0.0:912            TRN44:0                LISTENING
  TCP    0.0.0.0:17972          TRN44:0                LISTENING
  TCP    0.0.0.0:49152          TRN44:0                LISTENING
  TCP    0.0.0.0:49153          TRN44:0                LISTENING
  TCP    0.0.0.0:49154          TRN44:0                LISTENING
  TCP    0.0.0.0:49157          TRN44:0                LISTENING
  TCP    0.0.0.0:49158          TRN44:0                LISTENING
  TCP    0.0.0.0:57621          TRN44:0                LISTENING
  TCP    127.0.0.1:4370         TRN44:0                LISTENING
  TCP    127.0.0.1:4380         TRN44:0                LISTENING
  TCP    127.0.0.1:5354         TRN44:0                LISTENING
  TCP    127.0.0.1:5354         TRN44:49155            ESTABLISHED
  TCP    127.0.0.1:27015        TRN44:0                LISTENING
  TCP    127.0.0.1:27015        TRN44:49164            ESTABLISHED
```

Tools

- Netstat
  - Display contents of the IP Routing table using ‘netstat –r ‘
  - (Linux)

```
# netstat -r
Kernel IP routing table
Destination     Gateway         Genmask         Flags   MSS Window  irtt Iface
192.168.1.0     *               255.255.255.0   U         0 0          0 eth2
link-local      *               255.255.0.0     U         0 0          0 eth2
default         192.168.1.1     0.0.0.0         UG        0 0          0 eth2
```

http://www.thegeekstuff.com/2010/03/netstat-command-examples/

Tools

- Netstat
  - Display interface statistics using ‘netstat –i)
  - Linux only

```
# netstat -i
Kernel Interface table
Iface   MTU Met    RX-OK RX-ERR RX-DRP RX-OVR    TX-OK TX-ERR TX-DRP TX-OVR Flg
eth0       1500 0         0      0      0 0           0      0      0      0 BMU
eth2       1500 0     26196      0      0 0       26883      6      0      0 BMRU
lo        16436 0         4      0      0 0           4      0      0      0 LRU
```

  - The RX and TX columns show how many packets have been received or transmitted error-free (RX-OK/TX-OK) or damaged (RX-ERR/TX-ERR); how many were dropped (RX-DRP/TX-DRP); and how many were lost because of an overrun (RX-OVR/TX-OVR)
  - The last column shows the flags that have been set for this interface

http://www.thegeekstuff.com/2010/03/netstat-command-examples/

Tools

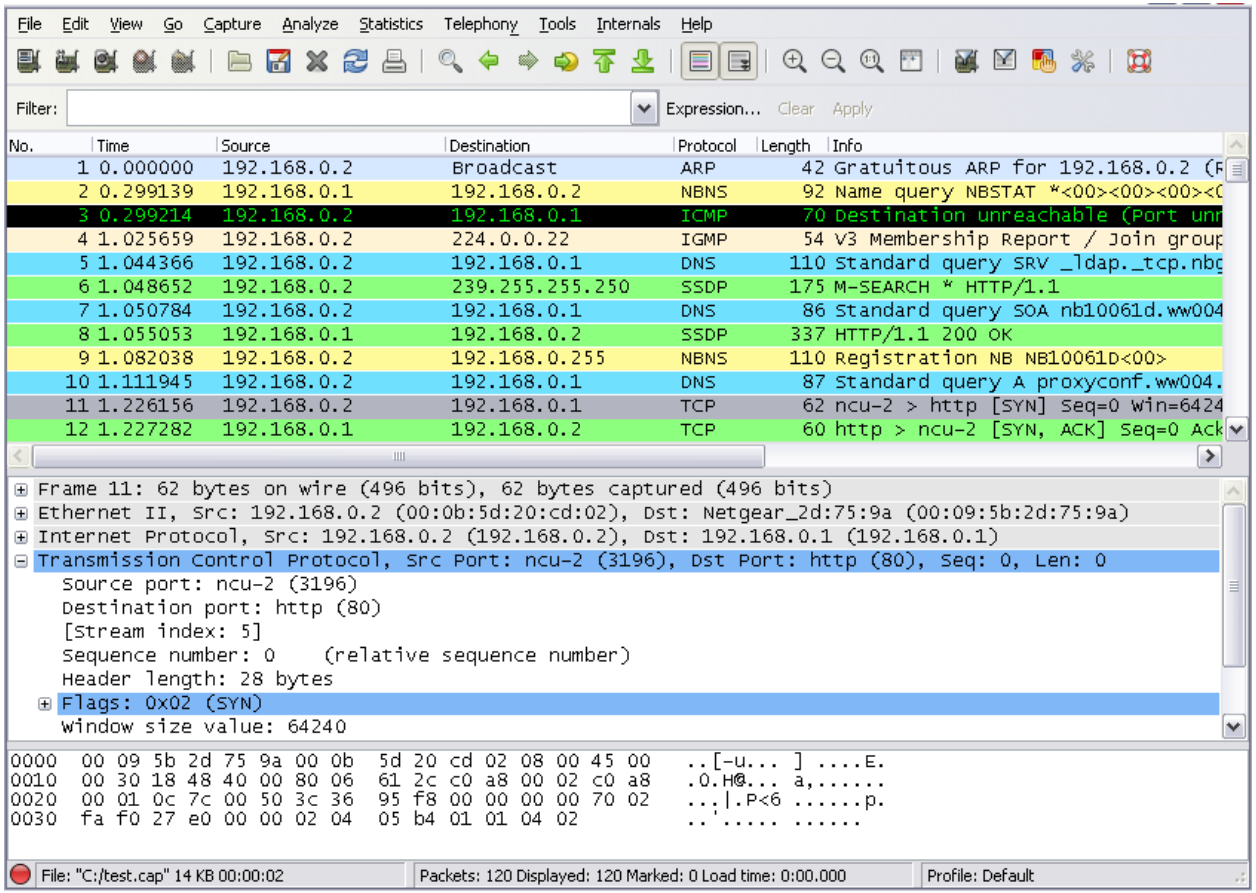
- Snort
  - An open source network intrusion prevention and detection system (IDS/IPS)
  - Can be configured in three main modes
    - Sniffer
      - Will read and display network packets
    - Packet logger
      - Records packets to disk
    - Network intrusion detection
      - Monitor and analyze network traffic according to a previously defined ruleset
      - Perform defined action based on what it found
  - Download at http://www.snort.org/snort-downloads
  - The Snort Manual - http://www.snort.org/assets/166/snort_manual.pdf

Tools

- Wireshark
  - A network packet analyzer that captures packets and displays that packet data for easier examination
  - Can be used to
    - Troubleshoot network problems
    - Examine security problems
    - Debug protocol implementations
    - Import and export packet data
    - Filter packets based on criteria
  - Makes it easy to differentiate protocols, traffic, etc. by color coding on screen
  - Download at http://www.wireshark.org/download.html
  - User guides and presentations at http://www.wireshark.org/docs/

Tools

- Screenshot of packets being captured using Wireshark
  - For more details, see http://www.wireshark.org/docs/wsug_html_chunked/ChUseMainWindowSection.html



Summary

- Identified common network devices
- Defined protocols
- Discussed the fundamentals of DNS
- Introduced some free network configuration tools

List of References

- http://www.starlancs.com/EducateMe/educate_network_devices.html
- http://www.cisco.com/univercd/cc/td/doc/product/iaabu/centri4/user/scf4ap1.htm
- http://www.theshulers.com/whitepapers/internet_whitepaper/index.html#http
- http://fcit.usf.edu/network/chap2/chap2.htm
- http://www.comptechdoc.org/independent/networking/cert/netterms.html
- http://packetlife.net/media/library/23/common-ports.pdf
- http://docs.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/3/html/Security_Guide/ch-ports.html
- http://www.mediacollege.com/internet/troubleshooter/traceroute.html
- http://www.thegeekstuff.com/2010/03/netstat-command-examples
- http://www.wireshark.org/download.html
- http://www.wireshark.org/docs/
- http://www.snort.org/snort-downloads
- http://www.openoffice.org/dev_docs/using_md5sums.html