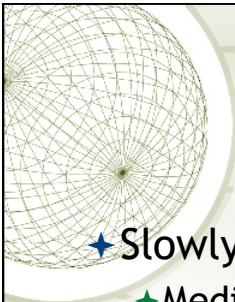


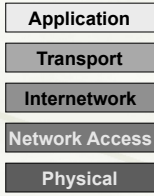
Frames, Ethernet and Wireless Networks

Info 341 Networking and Distributed Applications

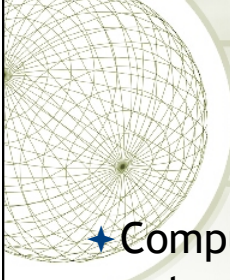


Some Context

- ★ Slowly working up the layers
 - ◆ Media and Transmission
 - ◆ Physical
 - ◆ Frames, Addressing, CSMA/CD
 - ◆ Network Access
- ★ Today Ethernet and Wireless



Internet Reference Model



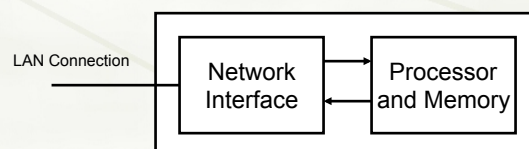
Getting Computers on a Network

- ★ Computers work in bytes, words - but network is in bits
 - ✦ How can we translate?
 - ✦ How can we attach the computer to the network?



Network Interface Card (NIC)

- ★ Network Interface
 - ✦ Dedicated hardware to help the computer get frames on and off the network
 - ✦ Translate bit-by-bit to the machine bytes





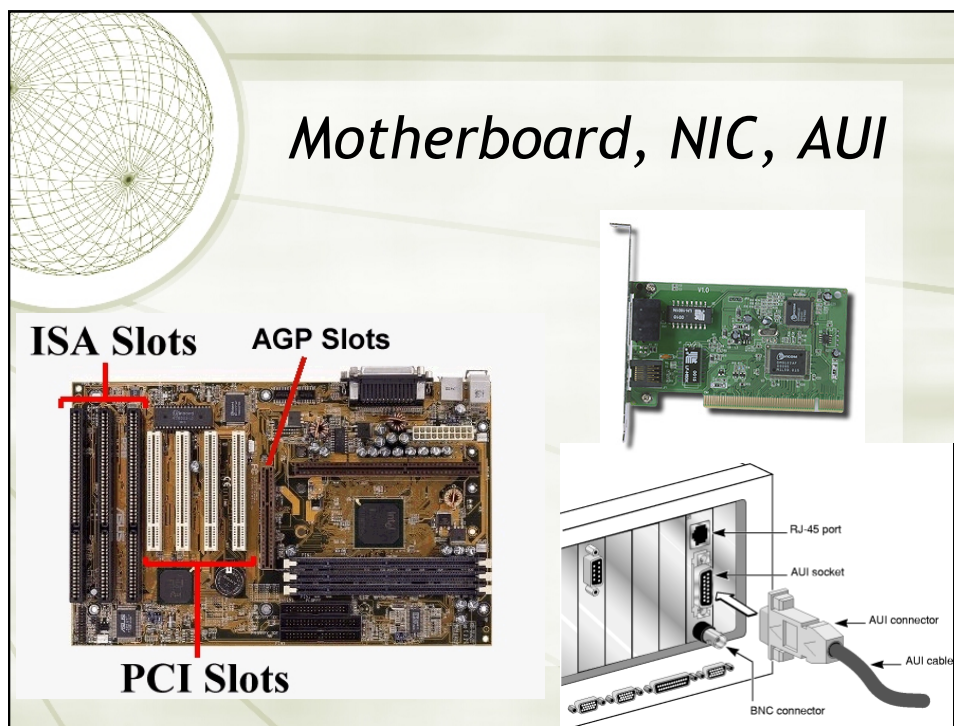
NIC

- ✦ Often built into the device
 - ✦ Computer motherboard, laptop, network printers
- ✦ Some external units connect through a USB port or a Firewire port.
- ✦ Software drivers allow the computer to communicate with the NIC



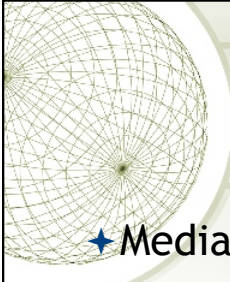
NIC functions

- ✦ Understands the electrical signals on the network, the rate data will be sent or received, all the physical layer details for that network type.
- ✦ Provides a connector so a physical connection can be made to the cable
 - ✦ Ethernet NICs - RJ-45 jack, or BNC connector (rare), or AUI (Attachment Unit Interface - very rare)



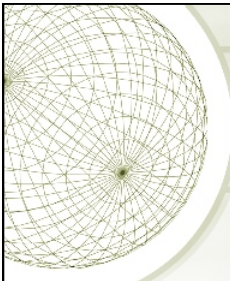
Physical Addresses

- ★ Every NIC (Computer) must have a locally unique address
 - ★ Why?



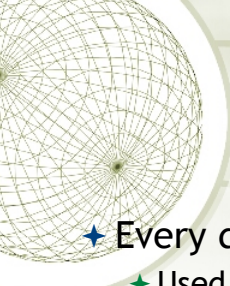
Physical Addresses

- ★ Media Access Address (MAC Address)
 - ★ Static - hardware manufacturer assigns the address
 - ★ Configurable - EPROM allows address to be set or reset - generally done once
 - ★ Dynamic - address assigned when the device starts up
- ★ What are the tradeoffs?



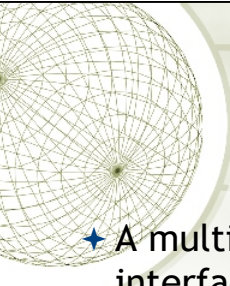
Special Addressing

- ★ Standard Addressing
 - ★ one-to-one (point-to-point)
- ★ Broadcast Addressing
 - ★ one-to-all (point-to-multipoint)
- ★ Multicast Addressing
 - ★ one-to-several (point-to-multipoint)



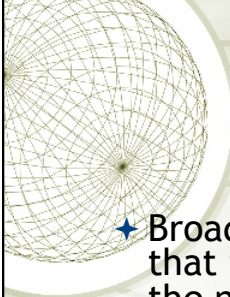
Broadcast

- ★ Every device receives these packets
 - ✦ Used by some applications for resource discovery or identification
 - ✦ Used by Ethernet to map a logical TCP/IP address to a MAC address
 - ✦ ARP - Address Resolution Protocol (more detail later)
 - ✦ Equipment that normally isolates traffic (bridges and switches) pass all broadcast packets



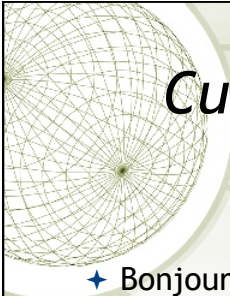
Multicast

- ★ A multicast is a group address that multiple interfaces can be configured with software to receive
- ★ Often used with video applications, disk cloning software
- ★ Any application that may use a significant portion of bandwidth and multiple devices need to receive the data at the same time.



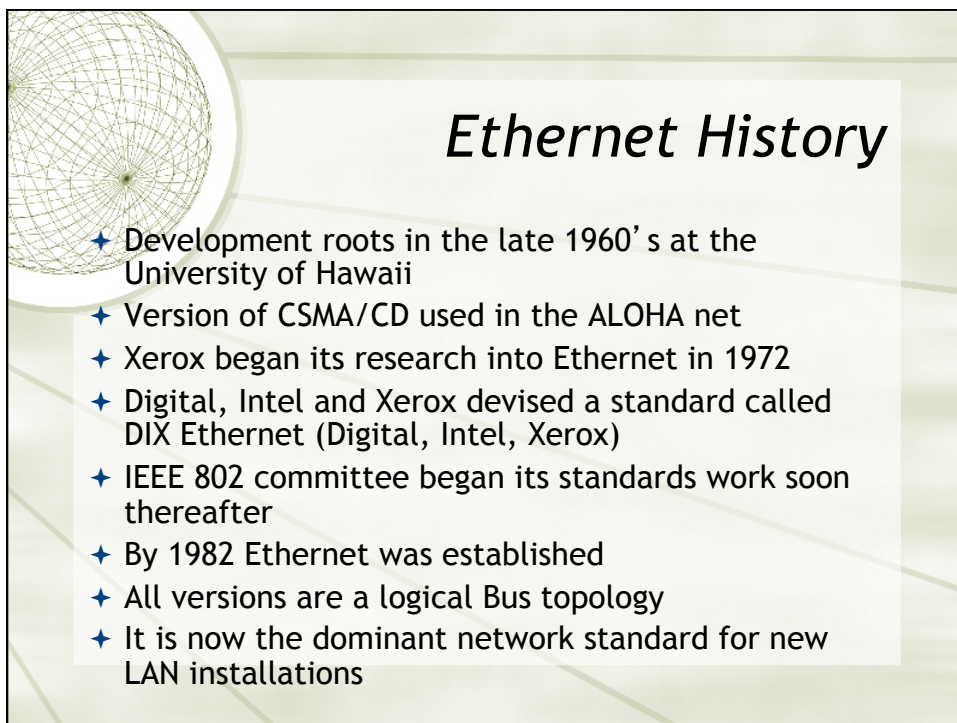
Broadcast / Multicast: How, Where?

- ✦ Broadcast and Multicast are so important that the concept exists at multiple layers in the network.
 - ✦ Hardware in Ethernet and other networks
 - ✦ Software in TCP
 - ✦ Application/Protocol specific
- ✦ The choice of where and how is a software architecture choice that can be facilitated with hardware support



Current Uses of Broadcast/ Multicast

- ✦ Bonjour (mDNS Multicast DNS/DNS-SD Domain Name Service - Service Discovery)
 - ✦ iChat, iTunes, Safari
- ✦ UPnP SSDP (Universal Plug & Play, Simple Service Discovery Protocol)
 - ✦ Windows Media Player, Zune
- ✦ None of these are “pure” - work at network, internetwork, application layers

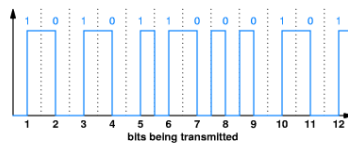


Ethernet Encoding

★ Manchester Encoding

★ Manchester encoding

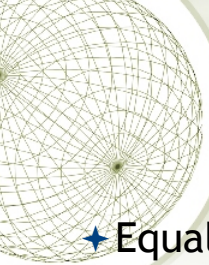
- ★ Edge triggered
- ★ Change in voltage from positive to zero is a "0", change from zero to positive encodes a "1"



Controlling Bus Access


★ Carrier Sense with Multiple Access & Collision Detection (CSMA/CD) provides contention based control

- ★ While one computer transmits, all the other computers must wait
- ★ Listen to the medium to see whether a message is being transmitted
- ★ If the medium is quiet, transmit message. If the medium is busy, wait for the signal to clear and then transmit.
- ★ If a collision occurs, wait for the signal to clear, wait a random interval, and then retransmit.
 - ★ Uses binary exponential backoff mechanism to guarantee contention will be reduced quickly



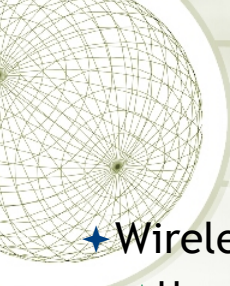
CSMA/CD Characteristics

- ★ Equal access for all computers
 - ◆ But access times are unpredictable
- ★ Highly susceptible to network congestion
 - ◆ > 40% utilization is often considered saturated
- ★ As network grows performance can become unpredictable



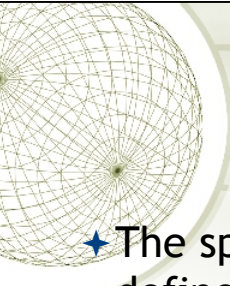
Wi-Fi (802.11)

- ★ Wireless version of Ethernet
 - ◆ Uses CSMA/CA



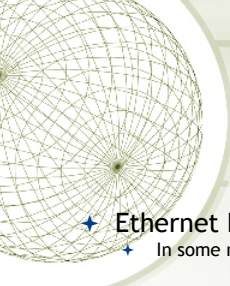
Wi-Fi (802.11)

- ★ Wireless version of Ethernet
 - ◆ Uses CSMA/CA
 - ◆ Carrier Sense Multiple Access/Collision Avoidance
 - ◆ Control packet - request to send - to request access to the medium



Frames & Packets On Ethernet

- ★ The specific network (hardware) defines the most outside “packet”
 - ◆ Call that a “frame”
- ★ What do Ethernet frames look like?



Ethernet Frames

- ✦ Ethernet Frames are variable in size
 - ✦ In some networks all frames are the same size (ATM)
- ✦ Ethernet frames can be sent any time
 - ✦ Other networks use fixed slot transmission times

Preamble (8 octets)

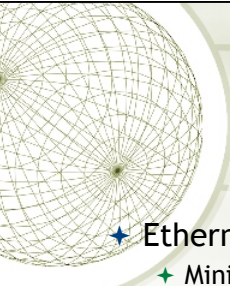
55:55:55:55:55:55:55:55

Header (6 dest, 6 source, 2 type/length = 14 octets)

00:01:00:00:00:01	00:01:00:00:00:04	08:00
-------------------	-------------------	-------

Payload (46 – 1500 octets) CRC (4 octets)

00:01:02:03:04:05:06:07:08:09:0A:0B:0C: ... :27:28:29:2A:2B:2C:2D:2E	08:10:36:AC
--	-------------



Ethernet Frames

- ✦ Ethernet frame size
 - ✦ Minimum size: $6+6+2+46+4 = 64$
 - ✦ Maximum size: $6+6+2+1500+4 = 1518$
 - ✦ MTU = Maximum Transmission Unit
 - ✦ On some hardware you can set “Jumbo Frames” (set larger MTU)

Preamble (8 octets)

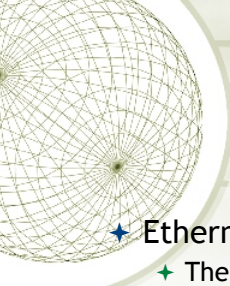
55:55:55:55:55:55:55:55

Header (6 dest, 6 source, 2 type/length = 14 octets)

00:01:00:00:00:01	00:01:00:00:00:04	08:00
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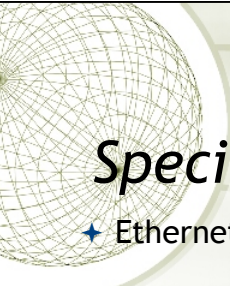
Payload (46 – 1500 octets) CRC (4 octets)

00:01:02:03:04:05:06:07:08:09:0A:0B:0C: ... :27:28:29:2A:2B:2C:2D:2E	08:10:36:AC
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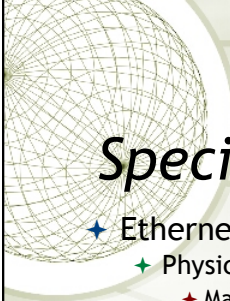
Frame Type

- ★ Ethernet frames have space to specify a 'type'
 - ✦ The type/content of the payload
 - ✦ The type indicates the content in the packet
 - ✦ Common types include:
 - ✦ 08:00 IPv4
 - ✦ 08:06 ARP
 - ✦ 81:37, 81:38 Novell IPX
 - ✦ 80:D5 IBM SNA
 - ✦ 80:9B AppleTalk
 - ✦ 65:59 Frame Relay
 - ✦ 08:05 X.25 (Europe)



Ethernet Example: Special Destination Addresses

- ★ Ethernet has special addresses
 - ★ Broadcast
 - ✦ FF:FF:FF:FF:FF:FF
 - ★ Multicast
 - ✦ The least significant bit of the first byte set to 1
 - ✦ 00:01:02:F3:D6:C6 (regular address)
 - ✦ 01:01:02:F3:D6:C6 (multi-cast address)



Ethernet Example: Special Destination Addresses

- ★ Ethernet Multicast
 - ★ Physical address is two parts
 - ★ Manufacturer code first three octets
 - ★ XX:XX:XX:...
 - ★ Last three octets device Address

- ★ Ethernet multicast is manufacturer specific
 - ★ Epson is assigned 00:00:48:...
 - ★ Epson multicast is 01:00:48:...

- ★ Can find manufacturer assignments on the web



Wireless Networks



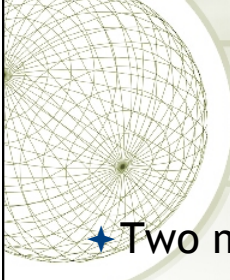
Wireless Networks

- ◆ Personal Area Networks (PANs)
 - ◆ Local Area Networks (LANs)
 - ◆ Metropolitan Area Networks (MANs)
 - ◆ Wide Area Networks (WANs)
- ◆ But really, these are not specific to wireless only



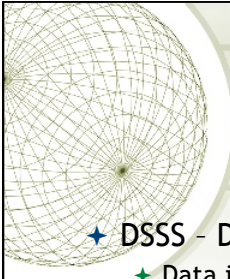
Wireless Bands

- ◆ Range of unlicensed spectrum
 - ◆ ISM - Industrial, Scientific and Medical
- ◆ 900 Mhz (902-928 Mhz)
- ◆ 2.4 Ghz (2400-2484 Mhz)
- ◆ 5 Ghz (5725-5850 Mhz)



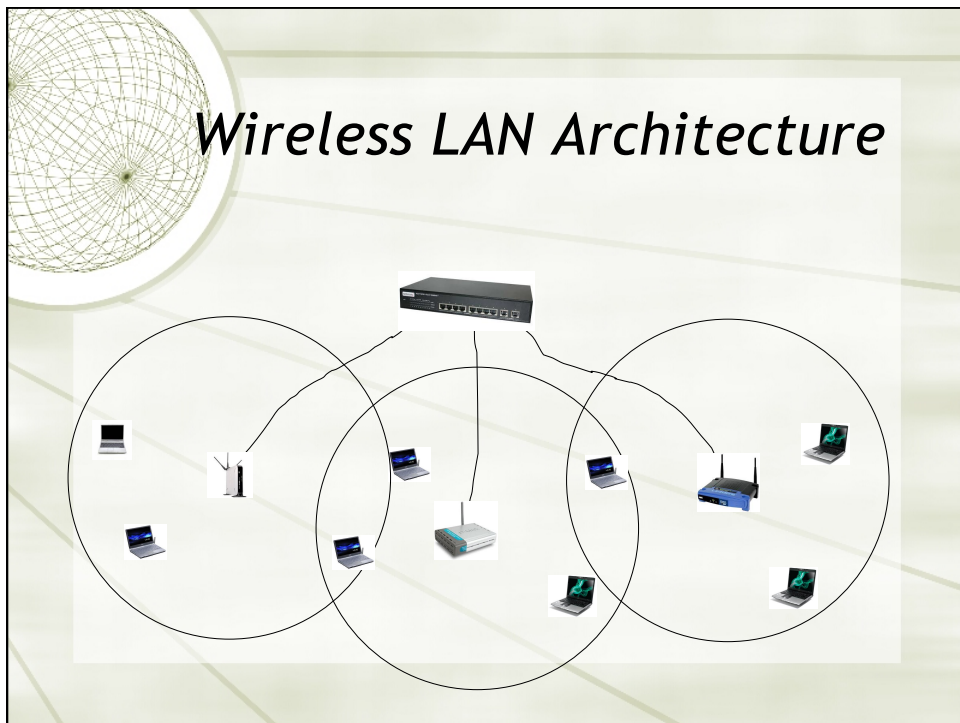
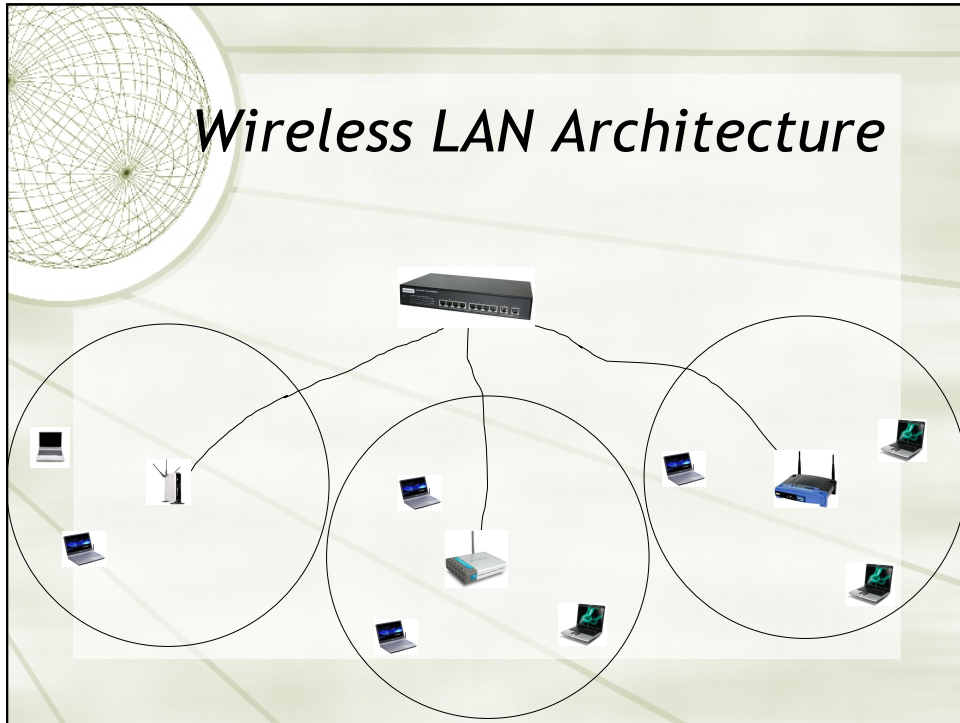
WiFi Wireless Networks

- ★ Two modes
 - ★ Ad-hoc - devices are peers, communicate among each other
 - ★ Infrastructure - designated base stations (access points) communicate with hosts and relay packets



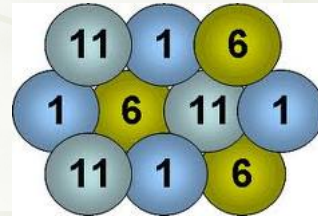
Multiplexing in WiFi

- ★ DSSS - Direct Sequence Spread Spectrum
 - ★ Data is multiplied by a numeric sequence which spreads the data across the allocated spectrum - multiple frequencies used at once
- ★ FHSS - Frequency Hopping Spread Spectrum
 - ★ A numeric sequence is used to 'hop' from one frequency to another during the sending of data.
- ★ OFDM - Orthogonal Frequency Division Multiplexing
 - ★ Spectrum has several orthogonal carrier frequencies that are used together



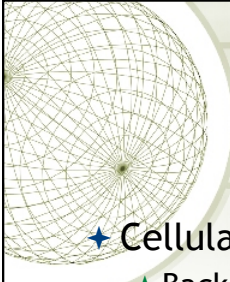
Wireless LAN Architecture

- ★ Limited set of non-overlapping frequencies (channels)
 - ★ 1, 6, 11
- ★ Deploy to avoid interference
 - ★ Example is for 1 floor
 - ★ What if it's multi story?



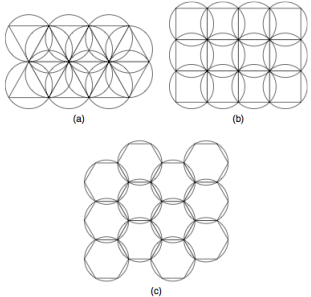
Wireless MAN

- ★ Have many of the same problems as we see in LANs
- ★ WiMAX
 - ★ 802.16 - no fixed spectrum, IEEE has definitions for 2.3, 2.5 and 3.5 Ghz
 - ★ Clear (clearwire) mostly using 2.5 Ghz in US
 - ★ Two types: Fixed WiMAX and Mobile WiMAX
 - ★ Using version of OFDM
 - ★ NLOS - non Line of Sight connections are wireless
 - ★ Backhaul - tends to be wire in urban/suburban area




Wireless WAN

- ★ Cellular is the main example WAN
 - ✦ Backhaul often wire
 - ✦ Cells allocated to provide best coverage with least interference
 - ✦ Logical layout may not correspond to the physical performance



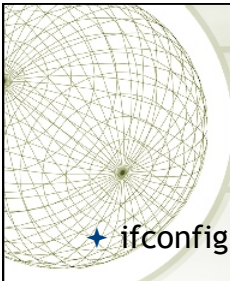
(a) (b) (c)





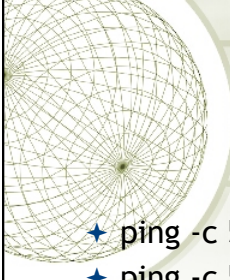
Some Tools

Linux/Mac OS	Windows
✦ ping	✦ ping
✦ Ifconfig	✦ ipconfig
✦ nslookup	✦ WinDump
✦ tcpdump	
✦ traceroute	
✦ netstat	



Configuration

- ✦ ifconfig (linux/mac), ipconfig (windows)



Network Saturation

- ★ ping -c 50 -s 8184 -v www.ischool.washington.edu
- ★ ping -c 50 -s 8184 -v www.irs.gov
- ★ ping -c 50 -s 8184 -v adhost.com
- ★ ping -c 50 -s 8184 -v www.akamai.com