The Internet

Basic Communication and Security

Notes for CSC 100 - The Beauty and Joy of Computing
The University of North Carolina at Greensboro

Warning....

Networking is complex, with many subtle issues and details

We only barely scratch the surface of the concepts

Want to know more?

Relevant UNCG classes:
- CSC 567: Principles of Computer Networks
- CSC 568: Principles of Wireless Networks
- CSC 580: Cryptography and Security in Computing

In-class exercise: You are the network!

First step: Divide class into four parts, representing four "locations"

Petty Building

UNCG

Appalachian STATE UNIVERSITY

CAP Building

Sullivan Science Building

Sanford Hall

In-class exercise: The setup

Four groups, one per location. Each group has:

- One "switch"
- The rest are "hosts" (one is special, but we'll get to that later)
- Your info sheet gives all necessary info

Each host (we're pretending to be Ethernet):

- Has a hardware (MAC) address
- Is connected to a particular port on the switch

The switch:

- Has a "MAC table" that says which addresses is connected to which physical port

About Ethernet MAC Addresses

MAC = "Media Access Control"

Example MAC address: `00:1b:21:79:6b:52`

Question 1: What do the numbers look like?
Question 2: How many bits in a MAC address?

Every network interface must have a unique address

How do manufacturers ensure addresses are unique?

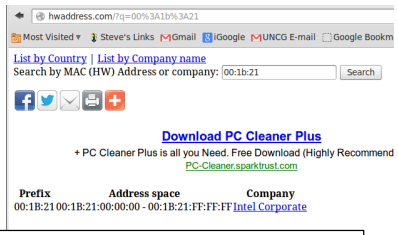
`00:1b:21` : `79:6b:52`

Assigned to one manufacturer — *Manufacturer chooses*

Manufacturer for given MAC prefix

First 24 bits of MAC address are assigned to a manufacturer
Several web sites will look up a MAC prefix and tell you the manufacturer

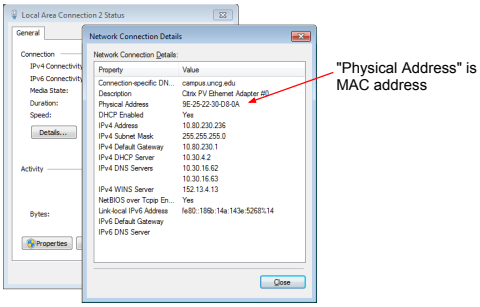
Example lookup using http://hwaddress.com/



So MAC address in our previous example is from a network card manufactured by Intel.

MAC Addresses

Finding MAC address in Windows 7



"Physical Address" is MAC address

Sending a message on a LAN

Our example: Ethernet

For hosts connected locally, through a switch, send packet to MAC address

For in-class activity:

- The blank index cards that were handed out represent "packets"
- Some of you have a "First activity" note on your information sheet

  Example: Send message "Welcome to the Matrix" to MAC 00:1b:21:79:6b:52

  If you have such a message write the destination MAC (you can use just the last 2 digits) and message on the index card and hand to the "switch"
- The "switch" has a "MAC table" that says who has what MAC address - they should "deliver" the packet (index card)

Notes:

- Easy to get packet from one host to another, since switch knows MAC addresses of all connected hosts
- No structure to MAC addresses (randomly assigned)
- How does this scale? What if all of the (billions) host in the Internet had to send through a central switch to an unstructured address?

Internet Protocol

IP = "Internet Protocol"

IP addresses look like aaa.bbb.ccc.ddd

In-class activity sheets: Each person (except the switch!) has a line that says "Your IP address" (e.g., 152.13.136.12)

Each of the 4 numbers is in the range 0..255 (1 byte)

Question 1: How many bits are in an IP address?

Question 2: From the in-class activity network sheets, every group of students in the same "building" - compare IP addresses and find a pattern.

Internet Protocol

Answer/Information to Question 1

Size of IP addresses:

- 4 numbers, each one byte (8 bits)
- Therefore, ***addresses are 32 bits***

Why important? Means at most 2^{32} different IP addresses.

2^{32} is about 4 billion - what happens when we run out of IP addresses???

InformationWeek

Internet Runs Out Of IP Addresses

The supply of IPv4 addresses is technically exhausted. It's time to accelerate the transition to IPv6.

By Thomas Claburn, InformationWeek
February 04, 2011
URL: http://www.informationweek.com/internet/policy/internet-runs-out-of-ip-addresses/229201157

The pool of Internet addresses has officially been drained. Four non-profit Internet administrative groups -- the Internet Corporation for Assigned Names and Numbers (ICANN), the Number Resources Organization (NRO), the Internet Architecture Board (IAB) and the Internet Society -- said at a press conference in Miami, Florida, on Wednesday that the supply of IPv4 addresses has been depleted.

"This is a major turning point in the ongoing development of the Internet," said Rod Beckstrom, ICANN's president and CEO, in a statement.

The situation however isn't imminently dire: It's not as if companies or individuals who want to launch a Web site will be unable to do so. There are likely to be addresses to be had for months if not years, and the dwindling supply may be extended through network addressing tricks. But the limits of IPv4 are no longer theoretical.

Oops - we are out of IP addresses!

Important points:

- These addresses are "IPv4" (or IP version 4) addresses
- There is a new version "IPv6" (version 6) - addresses are 128 bits

128 bits gives over 10^{38} addresses - we won't run out of these!

Internet Protocol

Answer/Information to Question 2

IP addresses for in-class activity

- All in UNCG's Petty Building look like 152.13.136.???
- All in UNCG's Sullivan Science Building look like 152.13.145.???
- All in AppState's CAP Building look like 152.10.10.???
- All in AppState's Sanford Hall look like 152.10.22.???

So: All in the same building agree on the first three numbers
All on the same campus agree on the first two numbers
All in the same multi-campus network (NCREN here) agree on first number

Hierarchical addressing allows us to ***route messages*** between LANs

Note: The in-class activity example is somewhat simplified (buildings, campuses, etc.). In reality things don't always match up to specific numbers in the IP address, but the ideas are similar!

Local Delivery

IP to Ethernet mapping using ARP

ARP = "Address Resolution Protocol"

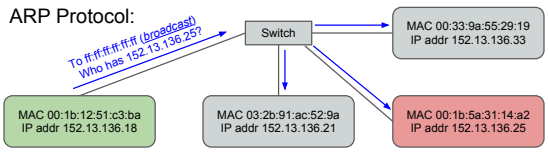
Example:

152.13.136.18 wants to send "hello" to 152.13.136.25

Important points

- Recognizes a "local connection" since only last number differs
- Problem: Local communication uses Ethernet MAC addresses

ARP Protocol:



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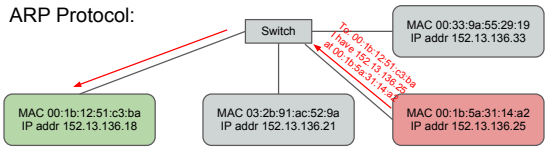

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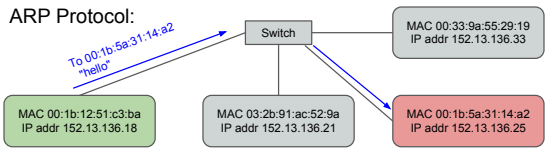
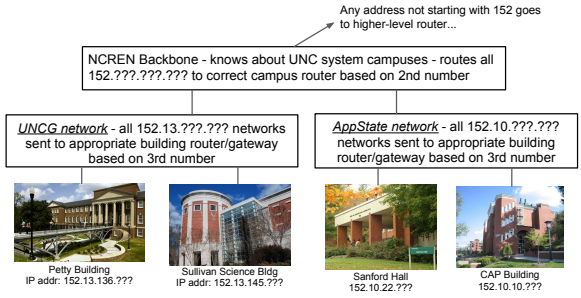


Internet Protocol

Routing: Simplified



Internet Protocol

Routing: Simplified - You do it!

In-class activity:

Look for "Activity 2" message on your info sheet

- This should be a local message (how can you tell?)
- Simulate the local protocol (ARP + transmit)

Look for "Activity 3" message on your info sheet

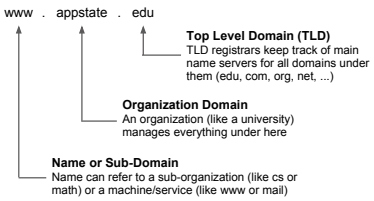
- This message goes between different LANs
- Simulate the protocol (don't forget ARP with your gateway!)

But I know a name, not an address!

Naming on the Internet

I want to connect to a name (e.g., www.appstate.edu) rather than a number

Names are also hierarchical



But I know a name, not an address!

Mapping from a name to an address: DNS

DNS = "Domain Name System"

DNS servers map from names to IP addresses (and vice-versa, sometimes!)

Super-simplified view:

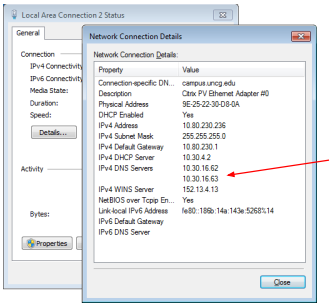
- I know the IP address (not the name!!!) of a DNS server I can use
- I ask it for the IP address of www.appstate.edu
- It returns IP address (152.10.1.83)

View from Unix utility "host":

```
user@host ~ $ host www.appstate.edu
www.appstate.edu has address 152.10.1.83
user@host ~ $
```

But I know a name, not an address!

Locating DNS servers in Windows 7



Note these DNS servers are for IPv4

Summary of addressing/naming

Just contacting the web server www.appstate.edu has a lot of complexities!

Example: I'm at 152.13.135.17 and want to contact www.appstate.edu

- Need to find IP address of www.appstate.edu, so need to locate IP address of DNS server (from my settings) - say that's 152.13.10.10
- I need to contact 152.13.10.10 - that's not on my local network, so I need to locate my gateway (from my settings) - say that's 152.13.135.1
- I need to communicate with 152.13.135.1 (my gateway), but I need a MAC address, not an IP address! So I send an ARP packet "Who has 152.13.135.1?"
- Gateway responds: "I have 152.13.135.1 at 00:11:39:4c:a2:61"
- I receive this message and store this IP <-> MAC address mapping for later
- I send "To: 152.13.10.10 - DNS query: where is www.appstate.edu?" to MAC address 00:11:39:4c:a2:61 (and other networks send subsequent ARP/routing to get this to 152.13.10.10)
- I eventually receive a response "Host www.appstate.edu has address 152.10.1.83"
- I look at IP address: 152.10.1.83 is not local, so must go through gateway again
- ARP efficiency: we just saw that gateway was at 00:11:39:4c:a2:61, so I can just re-use that (no ARP needed for now - but will eventually "expire")
- I send "To: 152.10.1.83 - Packet for www.appstate.edu" to 00:11:39:4c:a2:61

Believe it or not, even this description is slightly simplified!

Note: Slides after this point are placeholders for future semesters - we did not get to this in Fall 2012.

Where can things go wrong?

If I want to privately access www.bankofamerica.com, how could I get fooled?

Privacy: Postcards!
DNS issues (mention DNSSec)
Routing issues

Crypto to the rescue

Certificates and certification authorities
Encryption for privacy

Higher Level issues

How do I talk to a particular program/service on a remote computer (address refers to computer)?

What about reliability of transmission? Can I detect errors in packets? Can I tell if a packet was lost? Are packets delivered in the same order I sent them?

Then application-specific protocols: HTTP, IMAP, ...