Part 2: Internet Protocol Stack
How the Internet Works
communications protocol

- a set of standard rules for data representation, signaling, authentication, and error detection required to send information over a communications channel

- read first 3 paragraphs:

  Internet protocol suite = TCP/IP
THE MEDIUM OF THE MESSAGE

> **OSI model** for computer networking

> **Packet-switched networks** (Flash demo)

> **James Bond Meets the 7 Layer OSI Model**

> **Far and Near:**
  - WAN: the internet. Packet layer (packets)
  - LAN: ethernet. Media layer (bits)
OSI Network Model

Application
Presentation
Session
Transport
Network
Datalink
Physical

Routers
Switches
Hubs

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Every computer (a.k.a. *host*) on the Internet has a unique identifying number, called an IP Address:

(eg) 216.27.61.137

(eg) [www.whatsmyipaddress.com](http://www.whatsmyipaddress.com)

(eg) Domain Name: [www.howstuffworks.com](http://www.howstuffworks.com)

IP address 216.183.103.150

*domain name servers* (DNS) translate the human-readable domain name into the machine-readable IP address.
DNS

> DNS: resolves domain names to IP addresses

⇒ world’s largest distributed database
    7.5 M servers, 2006

> Domain Names:

    uoregon.edu -- a registered domain name

    fps.uoregon.edu -- a local domain
Figure 3.4. Hosts like Spiff make **requests** to a local DNS server.
4.3 billion possible IP addresses

humans express IP addresses using a "dotted decimal number:"
216.183.103.150

computers communicate in binary:
11011000.00011011.00111001.10001001
4.3 billion possible IP addresses

The four numbers in an IP address are called octets because they each have eight bits (1 Byte) in binary.

IP addresses are 32-bit binary numbers.

Four octets ➔ 4,294,967,296 unique values

Each octet can contain:
0 .. 255 (decimal)
0000000 .. 1111111 (binary)
Figure 3.3b. Two diagrams of domain hierarchy.
Figure 3.5. The TCP/IP postcard analogy.
Figure 3.7. A ping from the author’s machine

![VisualRoute](image)

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Node Name</th>
<th>Location</th>
<th>Tzone</th>
<th>ms</th>
<th>Graph</th>
<th>Network</th>
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</table>

Roundtrip time to eth.ch, average = 156ms, min = 156ms, max = 172ms -- 30-Apr-03 4:49:50 PM
IP Address is a *logical* address

- must be mapped to a *physical* address (MAC)

- In computer networking: *Media Access Control address (MAC address)* aka *Ethernet Hardware Address (EHA)* aka *hardware address*
MAC Address: The physical address

- 6 hexadecimal values: 00-D0-B7-A6-F1-11
- Every ethernet card in the world has a unique physical address
- How to find out what's the physical address of your ethernet card?

> **How to find the physical address?**
Resolving an IP Address to a MAC Addresses

A built-in feature of IP, **Address Resolution Protocol (ARP)** translates IP addresses to MAC addresses

ARP maintains a list of both IP addresses and matching MAC addresses called the "ARP cache." These caches are available on individual network adapters and also on IP **routers**
Definition: **ARP** (Address Resolution Protocol) converts an Internet Protocol (IP) address to its corresponding physical network address.

- ARP operates at Layer 2 of the OSI model
- When any device wishes to send data to another target device over Ethernet, it must first determine the MAC address of that target given its IP address
- These IP-to-MAC address mappings are derived from an **ARP cache** maintained on each device.
- If the given IP address does not appear in a device's cache, that device cannot direct messages to that target until it obtains a new mapping.
- To do this, the initiating device sends an ARP request message on the local **subnet**. The host with the given IP address sends an ARP reply in response, allowing the initiating device to update its cache
Figure 3.8. Media Layer
Robert Metcalfe’s original drawing of the Ethernet--computers “tap” onto the wire labeled “The Ether”
Definition: A **subnet** is a logical grouping of connected network devices.

Nodes on a subnet tend to be located in close physical proximity to each other on a **LAN**.

Devices on a subnet share contiguous ranges of IP address numbers:

- (eg) Uonet
- (eg) CISnet
Summary, Part 2

How computer networks move bits
Internet protocol stack / OSI 3-layer model

I. Application
II. Packet → WAN (packets)
III. Media → LAN (bits)

DNS → IP address → MAC address

Next: Internet Applications
Web 1.0 Analogy

by Philip Greenspun, photo.net.

The computer is the steam engine.
The network is the railroad.
Web 2.0 Analogy: universal virtual computer

Tim O'Reilly is the founder and CEO of O'Reilly Media, Inc.

applications revolve around the network as the planets revolve around the Sun

universal virtual computer, the internet as operating system.

Cloud Computing: Web 2.0 Office 2.0