



Network Knowledge



# Binary and Hexadecimal

- What is a base?
  - A number base is the number of digits or combination of digits that a system of counting uses to represent numbers. A base can be any whole number greater than 0.
- Base 10 Example with 42

$10^3 \Rightarrow 1000$	$10^2 \Rightarrow 100$	$10^1 \Rightarrow 10$	$10^0 \Rightarrow 1$
$42 // 1000$	$42 // 100$	$42 // 10$	$2 // 1$
0	0	4	2



# Binary and Hexadecimal

- Binary - Base 2

$2^5 \Rightarrow 32$	$2^4 \Rightarrow 16$	$2^3 \Rightarrow 8$	$2^2 \Rightarrow 4$	$2^1 \Rightarrow 2$	$2^0 \Rightarrow 1$
$42 // 32 \Rightarrow 1$ $42 \% 32 \Rightarrow 10$	$10 // 16 \Rightarrow 0$	$10 // 8 \Rightarrow 1$ $10 \% 8 \Rightarrow 2$	$2 // 4 \Rightarrow 0$ $2 \% 4 \Rightarrow 2$	$2 // 2 \Rightarrow 1$ $2 \% 2 \Rightarrow 0$	
1	0	1	0	1	0



# Binary and Hexadecimal

- Hexadecimal - Base 16

$16^2 \Rightarrow 256$	$16^1 \Rightarrow 16$	$16^0 \Rightarrow 1$
$42 // 256 \Rightarrow 0$ $42 \% 256 \Rightarrow 42$	$42 // 16 \Rightarrow 2$ $42 \% 16 \Rightarrow 10$	$10 // 1 \Rightarrow 10$
0	2	A

```
hexadecimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
decimal:      0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
```



# Number Practice

Decimal	Binary	Hexadecimal
4	0b100	0x4
6	0b110	0x6
31	0b11111	0x1F
37		
275		



# Number Practice

Decimal	Binary	Hexadecimal
4	0b100	0x4
6	0b110	0x6
31	0b11111	0x1F
37	0b100101	0x25
275	0b100010011	0x113



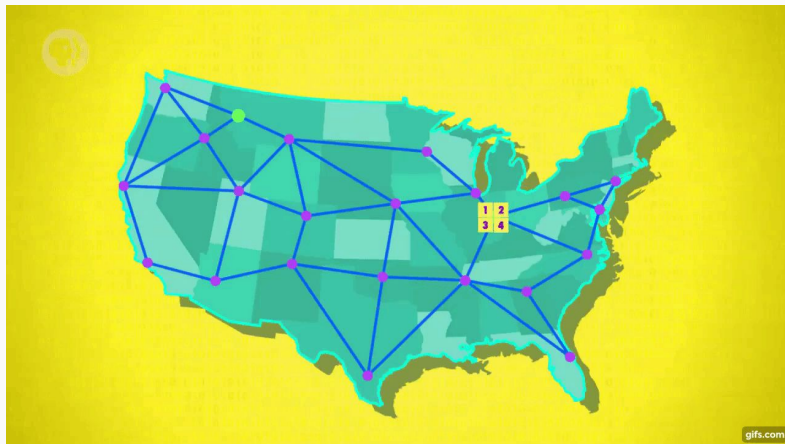
# Internet Protocol

- History lesson:
  - In late 1960s, technology is booming, but communication between networks is limited
  - Networks are generally limited to individual research labs or universities
  - In 1974 researchers for DARPA propose the *Transmission Control Program* which is a complex process that would allow for multiple networks to communicate with each other
- Key attributes of the Transmission Control Program
  - Fault tolerant -- data transmitted between networks can be cached and resent
  - End-to-end -- there is no single central systems that can take the whole network down (remember we're in the middle of the Cold War and worried about nuclear attacks)
- Transmission Control Program is too big and is divided into two sections
  - Transmission Control Protocol (TCP) -- responsible for fault-tolerance
  - Internet Protocol -- responsible for end-to-end nature



# What is the Internet?

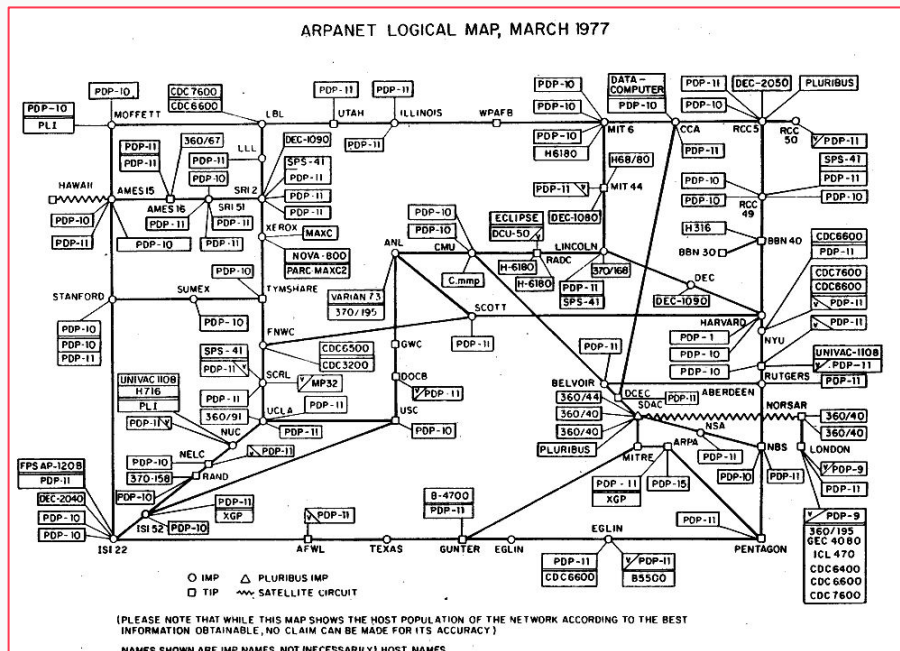
- A series of tubes
- Loose definition is a series of internetworked systems
- The internet protocol opened the door for this internetworked model
- IP data is transmitted using packets and IP's communication style is called *packet switching* -- messages are split up into separate packets, delivered to a destination and reassembled
- IP's primary responsibility is maintaining end-to-end state





# ARAPNET

World's first packet-switch network and ancestor of modern internet



# IPv4 and IPv6

- IPv4

- Best known version of IP - used when TCP/IP finalized by DARPA in 1983 and still most used today
- IPv4 packet's header consists of at least 13 fields (i.e. sequences of binary bits) and start with a version identifier 0100 (why is it 0100?)
- IPv4 addresses composed of 4 octets or 8-bit binary numbers such as `192.18.1.1`
- IPv4 can support around 4 billion unique addresses

- IPv6

- New protocol that allows more addresses
- Different packet header format -- only uses 8 header fields and starts with version identifier 0110
- IPv6 addresses uses 128 bits compared to 32 bits and uses eight colon-ed hexadecimal such as `2600:6c5e:157f:d48c:138f:e0ba:6fa7:d859`
- Supports 350 undecillion addresses (billion times a billion)



# Transport Protocols

- IP is a very low level protocol - there isn't much more information than the destination address in a packet -- packets can show up at a computer, but the computer doesn't know which application to give the data payload to
- Transport protocols were developed to help with this final step
- Transport protocols utilize their own form of addressing called ports
  - Every application will request a unique port
  - When packets arrive, the computer checks the port and sends the data to the application that requested it



# Transport Protocols

## TCP

- Connection oriented -- slow because it has large headers
- Reliable data transfer
  - Data can't be "lost" across a TCP connection -- receiver will ask transmitter to resend
- Persistent and consistent connections
- Use cases:
  - Websites
  - File downloads
  - Streaming video / audio

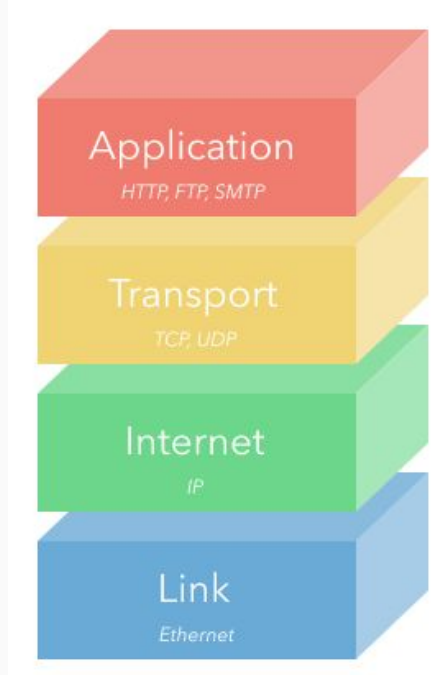
## UDP

- Connectionless and fast
- Provides no verifications for whether data is received
- Use Cases:
  - VoIP
  - Real-time video
  - Network services
  - Anything where performance matters more than quality



# Reference Models

## TCP/IP Reference Model



## OSI Reference Model



Reference models are high-level overviews of complex topics

# Domain Name System

- Allows us to look up a specific IP address by its domain
- Try typing 172.217.7.238:80 into your browser!
- Domain refers to the “friendly” name for the website’s host or the server providing the site’s content

<code>https://</code>	<code>students</code>	<code>.appacademy</code>	<code>.com</code>	<code>/my-homework</code>	<code>?username="CoolStudent"</code>
protocol	subdomain	second-level domain	TLD	application route	query parameters

- DNS Record Types
  - SOA: Start of Authority
  - NS: Name servers for the zone
  - A / AAAA: MOST IMPORTANT - map a resource directly to an IP address
    - A -- IPv4 addresses, AAAA -- IPv6 addresses
  - CNAME - acts as an alias linking one domain to another
  - MX - Mail Exchanger -- used by email clients to direct messages to the appropriate mail servers



# Network Hardware

- Hub

- Simplest networking device - performs no network management
- Often considered a 'dumb' device because it just repeats and rebroadcasts data.

- Switch

- "Intelligent hubs"
- Able to pass data to a specific device on a network (forward) if it already has a reference (the MAC address of the device), or it can broadcast to all devices (flood) if its MAC address is not in its table yet.
- Have an internal MAC address table

- Router

- Instead of identifying devices via MAC address, they use IP addresses to make decisions
- Can connect to external networks whereas hubs / switches operate only on the local network
- Routers utilize Network Address Translation:

- single IP address for all external communication then uses IP ports to map incoming data to internal device IP addresses in its routing table

