

Binary, Types, and Internet Basics

In this lecture, we will discuss:

- Network layouts
- What is the internet
- Binary and why it matters

Your future in CS

I used to include this on my slides, but since these slides have changed - going to just leave it up here for every notebook. I get a lot of questions about more programming courses, the concentrations, and minors in computer science. Here is a brief reminder.

CS 164 – Next Course In Sequence, also consider CS 220 (math and stats especially)

- CO Jobs Report 2021 – 77% of *all* new jobs in Colorado require programming
- 60% of all STEM jobs requires *advanced* (200-300 level)
- 31% of all Bachelor of Arts degree titled jobs also required coding skills
- 2016 Report found on average jobs that require coding skills paid \$22,000 more
- Concentrations in CS:
 - Computer science has a number of concentrations.
 - [General concentration](#) is the most flexible, and even allows students to double major or minor pretty easily.
 - [Software Engineering](#)
 - [Computing Systems](#)
 - [Human Centered Computing](#)
 - [Networks and Security](#)
 - [Artificial Intelligence](#)
 - Computer Science Education.
 - Minors:
 - [Minor in Computer Science](#) - choose your own adventure minor
 - [Minor in Machine Learning](#) - popular with stats/math, and engineering
 - [Minor in Bioinformatics](#) - Biology + Computer Science

Networks

- Everyday, we are connected to networks around us
- But what are those networks?
- What types of connections exist?
- How many devices are connected?

Discussion Thought:

Count the number of connected devices at your table. Expand that to the number of devices at your house!

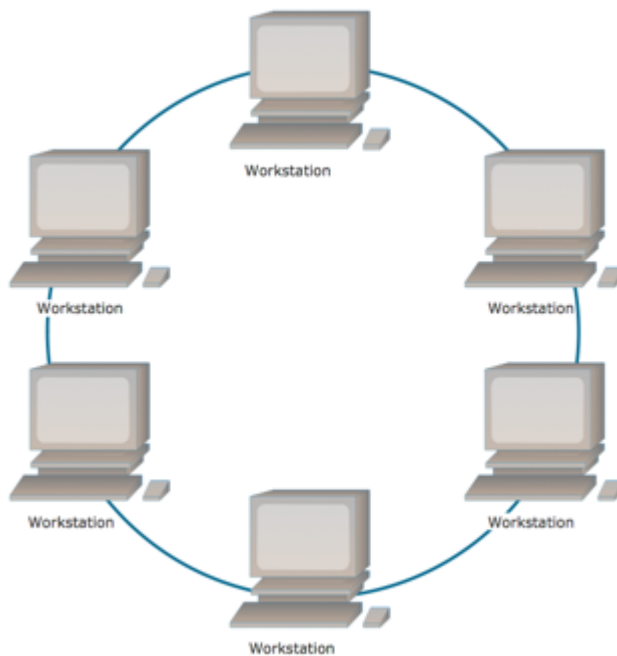
We are a networked society, but most people take it for granted.

Network Types

- Ring
- Star
- Mesh

Ring Networks

- Early network models
- Advantages a ton of data quickly
- Disadvantage every computer sees everything



Telephone game:

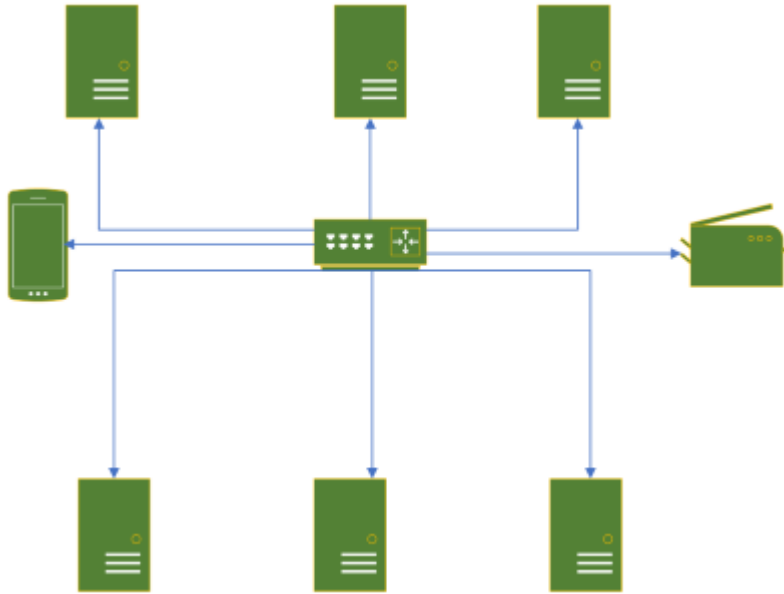
How easy is it for the message to get lost?

Star Networks

- Used daily
 - Where? Think about your home!
 - Routers are the center of the star
- Easy to setup
- Easy to take down/break

Telephone game - only one step:

How does this change the risk of messages getting lost?



Mesh Networks

- The design of the internet
- Arguably it is a series of network types connected together
 - Your router connects to the internet
 - That is a star network connecting to other networks
 - These other networks are mesh and star networks
- Pro: Really redundant / hard to break
- Cons: Requires more advanced "routing" rules
 - A route is the path you take in the network
 - We will cover how they do this for the internet over the next couple weeks

Telephone Game:

This is more like a cocktail party with gossiping across the party



The Internet is really, really great...

[Code.org What is the Internet](http://code.org/what-is-the-internet)

(Actually a pretty good video on how the internet started)

Definitions to know

- URL - Uniform Resource Locators - <http://www.cs.colostate.edu/~cs150b>
 - The protocol is the portion ending in ://
 - http, https, ftp, scp, ssh, etc
 - The host or top-level domain
 - colostate.edu
 - The filename or page name itself
 - Can also include directories, such as ~cs150
 - In this case, there is a default file - index.html
- HTTP - HyperText Transfer Protocol (HTTPS - encrypts it as Secure)
- IP Address - Internet Protocol
 - 128.0.0.1 (IPv4)
 - 2001:CDBA:0000:0000:0000:0000:3257:9652 (IPv6)
- DNS - Domain Name Server
 - Converts URL host names to IPs
 - Routers then have you connect to that server using the IP

The internet is built on **layers** over the next few weeks we will be exploring these layers.

The first layer is the hardware:

Hardware Below The Internet

[The Internet: Wires, Cables & Wifi](#) (watch on your own)

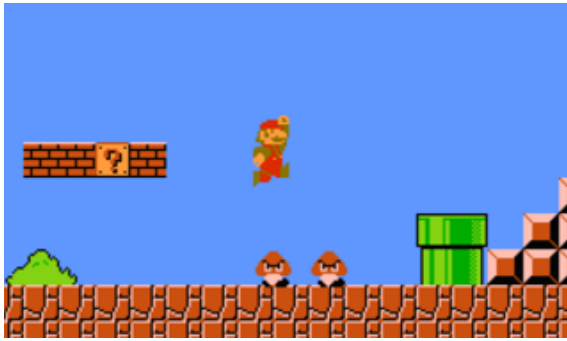
- Cables
 - Copper or fiber optic
 - Primary means of sending information
 - 1 means "on", 0 is off.. but how to detect off?
- Counters
 - Computers keep counters, and track every "window" how many 1s they get
 - They assume 0s in the other parts of the window
 - Generates binary for them to operate
- Latency or Lag
 - Both measures of how delayed the 1s and 0s are getting to us
- Bandwidth
 - The amount of 1s and 0s that can get to us per second
- Wifi
 - Radio signals translated to 1 and 0
 - Thus why wifi has limited range, and walls mess it up - it distorts the signal!

1010101011 1111101111

Binary

- Computers are large sets of memory
- Each memory location has a state of 'on' (1) or off (0).
- These states are how everything is stored
 - And the focus of Computer Engineering majors
 - They are also called 'finite state machines'
 - Finite number of states (one or zero - yes or no, on or off)
 - A machine full of them
- Not magic but science
 - Having tons of tiny states allows us to represent all the things computers do!
 - This is a much deeper topic for a 200 level class.
- Knowing binary
 - Will help us understand how much memory is being used and data in general
 - As every thing created takes up a portion of the finite states in the machine. (over simplified)

Memory Allocation



Mario 8 Bit



Mario 16 Bit

- A **byte** has 8 bits of data
- Each bit is a power of 2 (doubles)
- We add the bits together based on what is on or off

128	64	32	16	8	4	2	1		standard
0	0	0	0	0	0	0	1	=	1
0	0	0	0	0	0	1	1	=	3
0	0	0	0	0	1	1	0	=	6
0	0	1	0	1	0	1	0	=	42
1	1	1	1	1	1	1	1	=	255

- **8 bits of data can hold 256 different values (0 to 255)**
- Also, counting from 0 starts to make more sense, allows for an additional state

Discussion

Thinking deeper. How many different values can 9 bits hold? You can approach this two ways, by adding 256+255, or figuring out the value of the 10th bit!

Note: In python, you can write a binary value by 0b##

```
python val = 0b111 print(int(val)) # prints 7
```

```
In [ ]: ## so what is the value printed?
```

```
val = 0b00001111
print(int(val))
```

15

```
In [ ]: val = 0b10000000
print(int(val))
```

128

```
In [ ]: val = 0b00101010
print(int(val))
```

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Python Types?

- Python does not require 'types' for variables when you declare
- Many languages do, and are called strongly typed languages
 - Barbra Liskov -- a reason why we know types as we do today
- However python does have 'type' for each variable
 - The type groupings share common characteristics and functions
- **Numeric Types**
 - int
 - float
 - bin
 - Not covered in the book, `bin(val)` converts values to binary
- **Sequential types**
 - string
 - list
 - tuple (type of list, that can't be modified - covered in the book, and code along)
 - set (list with unique values only)
 - dict
 - Stands for dictionary, we will cover this in a few weeks
 - Allows for 'named' indices via mapping

Which means, we can easily convert between types. Let's try converting from int to binary!

```
In [ ]: val = 15
        binary_val = bin(val)
        print(binary_val)

        val = 1
        binary_val = bin(val)
        print(binary_val)
```

```
0b1111
0b1
```

Notice, it does not have 'leading' 0s, but only shows exactly the type of bits you need

Also, you can do this in many search engines!

- type 11 to binary and click search.

Your turn!

```
In [ ]: val = 8
        binary_val = bin(val)
        print(binary_val) ## what is printed?
```

```
0b1000
```

```
In [ ]: val = 10
        binary_val = bin(val)
        print(binary_val) ## what is printed?
```

0b1010

```
In [ ]: val = 13  
        binary_val = bin(val)  
        print(binary_val) ## what is printed?
```

0b1101

Overall

Binary is useful to know. We don't go into depth in this class. Think about the following:

- Knowing binary means you can greatly increase your representational power
 - you can count from 0-31 on one hand! :D
- Knowing binary means you have a better understanding of the limitations of computers
 - The most notable limitation you can only be in one state at once, so you to 'break encryption' you have to loop through possible states which takes time.
 - Quantum computing breaks this model!