Module 3 - NLP, ICs, 5G, Quantum Computing

General Notes

- Google Slides

Natural Language Processing (Domain of AI)

NLP Definition

- **N** - Natural
- **L** - Language
- **P** - Processing

A subfield of linguistics, computer science, information engineering and AI concerned with the interactions between computer and human (natural) languages.

Human vs Computer Language

- Computers are very literate, you need to tell them exactly what they need.

    - AI has found models where you don't need to tell it as closely, but the basis
      behind computers is very literal.

Computer Hardware And Software

[How Computers Work: Hardware and Software]

The CPU

The CPU is the master chip that controls all other parts of the computer.

- It has smaller, simpler parts that handle specific tasks.
- It has circuits to do simple math and logic.
- It has other circuits to send and receive information to and from different parts of the computer.
- It knows which circuits to use and when to use them.

The cpu receives simple commands that tell it which circuit to use to do a specific job.

- An **Add** command tells the cpu to use it's **Adder** circuit to calculate a new number.
- The **Store** command tells the cpu to use a different circuit to save that result into memory.

All of this data is represented in on and off electrical signals (binary).

Binary

The most basic form of software that controls all the hardware of a computer.

Software

Software tells the CPU what to do.

Operating System

The operating system is the master program that manages how software uses the hardware of a computer.

- Allows users to install other programs by storing them in the computer's memory.
- Decides when a program is run.
- Accesses the input / output
- When you believe that there's multiple things running, it's actually the OS controlling all of them and switching very fast.

Arrangement of Words / Meaning

- **Syntax:** What is grammatical?
- **Semantics:** What does it mean?

There are multiple meanings for words and possible arrangements that could make it difficult for a computer to interpret:

- His face turns red after an embarrassing joke
- The red car zoomed past the stop sign
- His face turned red after the bee stung him

All three of the above examples use **red** differently, and one of the challenges of NLP is interpreting those.

Perfect syntax does not mean that the meaning is there:

- *Chickens flow extravagantly while the moon drinks tea*

The above sentence has perfect syntax, but it doesn't have any meaning.

Challenges of NLP

- Languages can be ambiguous
- Language changes as frequently as the world changes
- When we talk, we make grammar mistakes
- Phrases can sound similar
    - "Recognize speech" vs "Wreck a nice beach"
- Language has dialects and accents
- Sarcasm
- Words are vague - "Is water wet?"

Microsoft's Bot

- March 23rd, 2016, Microsoft launched Tay to learn about conversation over twitter. It was a learning experiment, and was taken down.

Uses of NLP

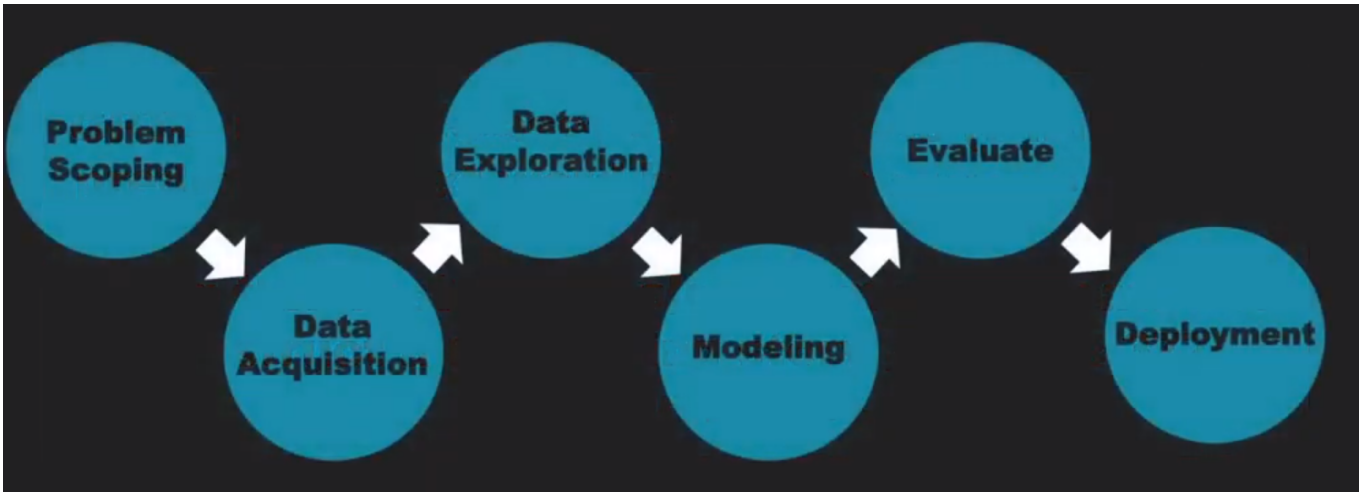
- Medical
  - recognition and prediction of disease based on patient speech
- Advertisement
  - Sentiment analysis
- Cognitive Personal Assistant
- Spam Filtering
- Voice Driven Interfaces
- Talent Recruitment
- Language Translation

There are general patterns in language in AI, and it does a great job in finding those patterns. However, in minor cases when using AI for things like **talent recruitment**, Amazon had problems with the minority cases where it was not able to accurately analyze the language.

Use Cases

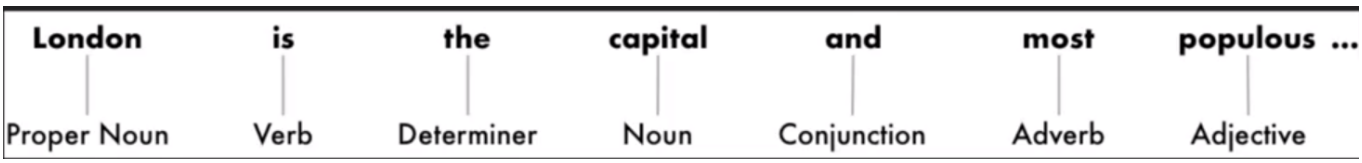
- Improving Sales
- Fighting Depression
- Content Creation

The AI Process In NLP



1. Problem Scoping
2. Data Acquisition
3. Data Exploration
4. Modeling
5. Evaluate
6. Deployment

The Overall Flow



1. **Speech Segmentation:** Split the sentences by punctuation.
2. **Word Tokenization:** Spit the words by spaces between words
3. Associate words to word classes
    - Word classes are things like nouns, verbs, adverbs, etc.
4. **Text Lemmatization**
    - In this case, "**is**" from the above photo changes to "**be**".
5. Identify Stop Words
6. Dependency Parsing

7. Named Entity Recognition

Text Lemmatization

- I had a **pony**.
- I had two **ponies**.

Same for humans, but different for computers.

Lemmatization - Figuring out the most **basic** form or *lemma* of each word in
the sentence.

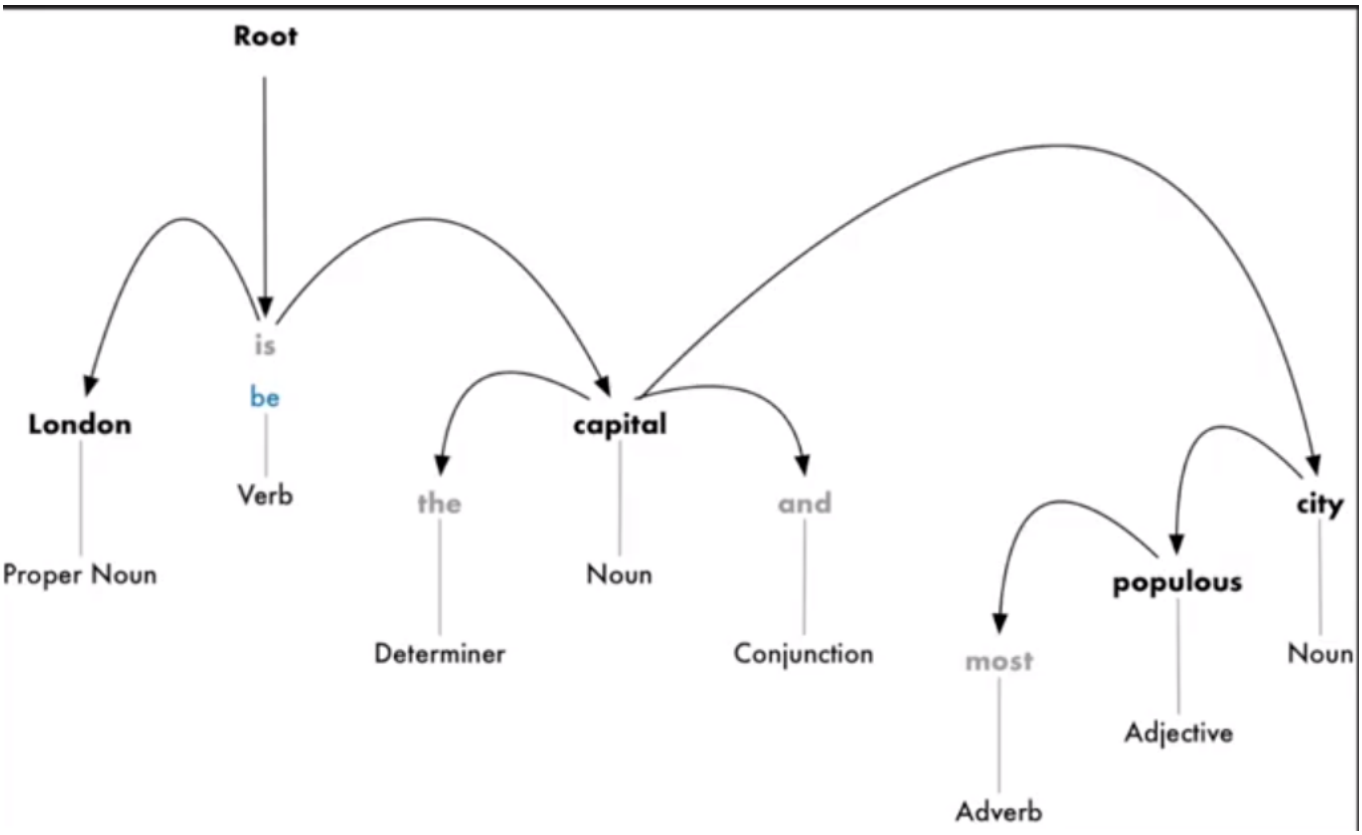
Identify Stop Words

English has a lot of filler words that appear frequently like:

- *and*
- *the*
- *a*
- *is*
- *most*

Stop words are typically identified by checking a hardcoded list. They are supposed to remove those filler words, because they don't give much context within a sentence. We want to focus on the important things.

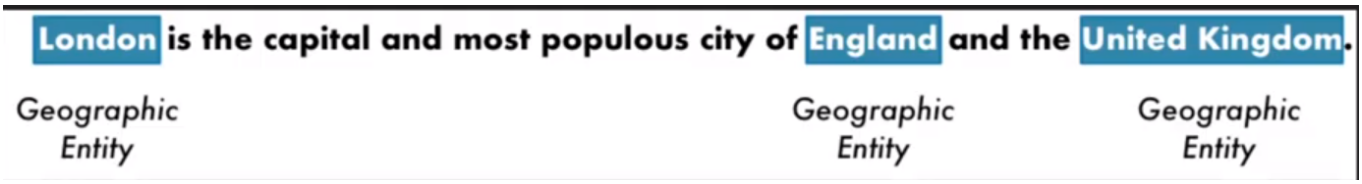
Dependency Parsing



- How we know how all these word classes are connected.
- [Dependency Parsing Visualizer]

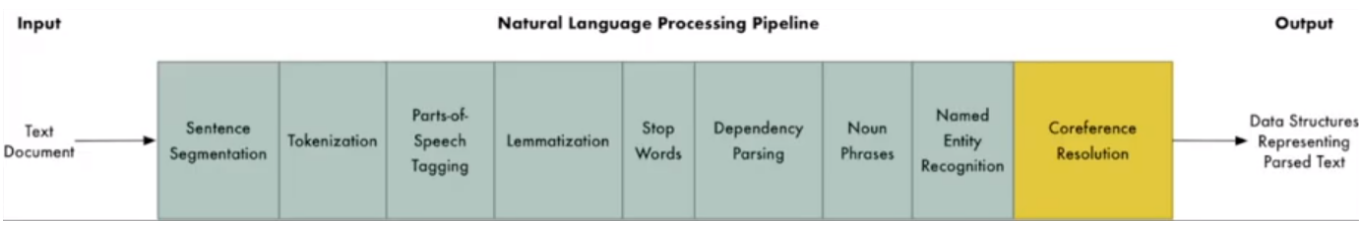
Named Entity Recognition

What are some nouns in the sentence that we can recognize as real-world concepts?



Named entity recognition recognizes whether portions of the sentence are significant, like geographic entities.

Summarization Model



Chatbots

- Eliza
- Mitsuku
- Cleverbot
- Replika

Traditional vs AI-Powered Chatbot

Script Bot	Smart Bot
Limited Functionality	Very flexible / powerful
Easy to make	Learns with more data
No or little programming	Some coding required
Free, easy to integrate	Understands ambiguity

Future of NLP

Boris Katz (Innovator for IBM's Watson) said the following:

> *On one hand these programs like Siri and Alexa are so incredibly stupid. So there is a feeling of being proud and being almost embarrassed with NLP. You launch something that people feel is intelligent, but we are not even close.*

The next step for NLP is to take a step forward from data analytics and computer science, and step into neuroscience, cognitive science, and psychology

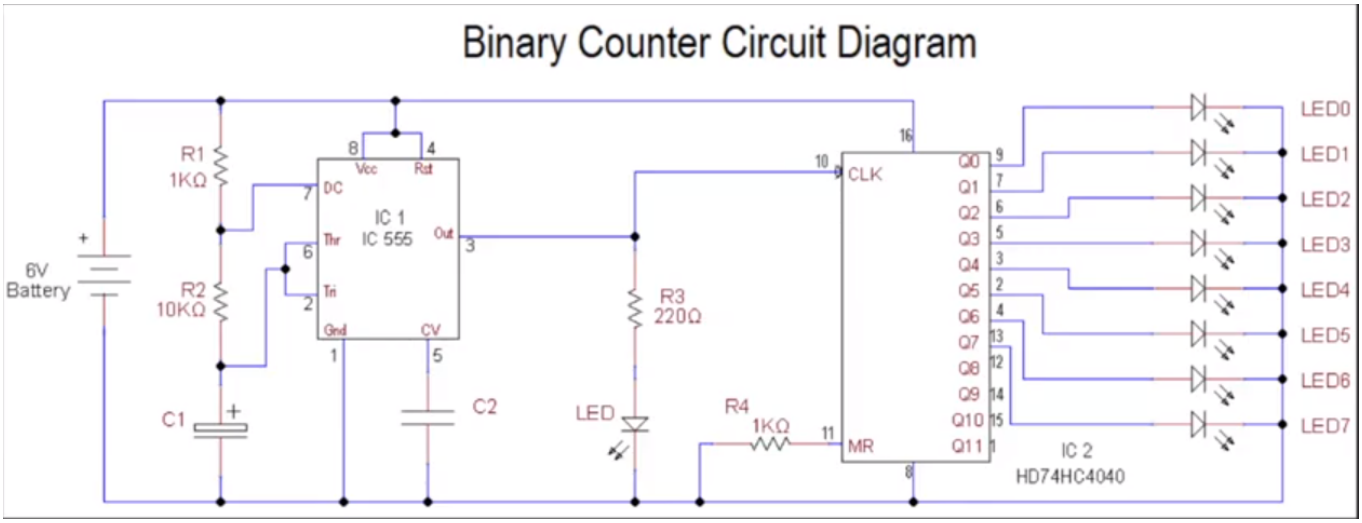
Integrated Circuits (ICs), 5g, Quantum (Emerging Tech)

- These tools support and accelerate our capabilities with AI.

The History of the Integrated Circuit

- Bob Noyce is the inventor of the integrated circuit.

- The very first computer at scale ran on valves, using vacuum tubes.
- ICs changed everything as they took solid state transistors and made them flat, and they were capable of being supercharged.
- Moore's law states that either the size will get smaller, the capacity will get greater, or the price will get cheaper by a factor of 2 every two years.
    - The number of transistors and resistors on a chip doubles every 24 months.
- In quantum computing, you still have the traditional 1s and 0s, but there is also a superimposed state where they can be both 1 and 0 at the same time.
    - Quantum computers would be 1 million - 1 billion times faster than today's supercomputers.
- The age of statistics is over in that things no longer need to be sampled, they can be measured because Moore's law has embedded intelligence into everything.



Testing Your PC Components

- CPU Benchmark
- GPU Benchmark
- Hard Drive Benchmark
- RAM Benchmark
- Android Benchmark
- IoS Benchmarks

Windows

1. Type in *Processor*
2. Get the processor name

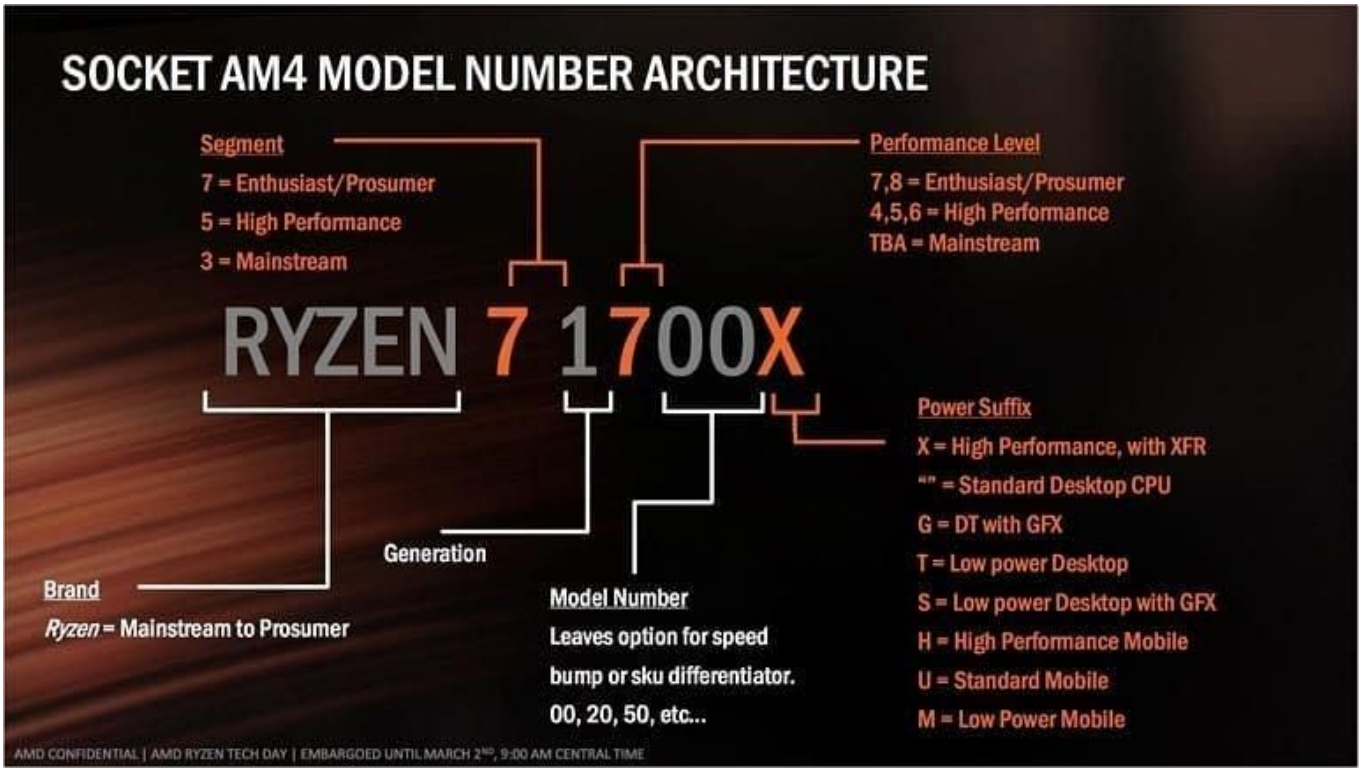
3. Go to a cpu benchmark page and put in your cpu

Linux

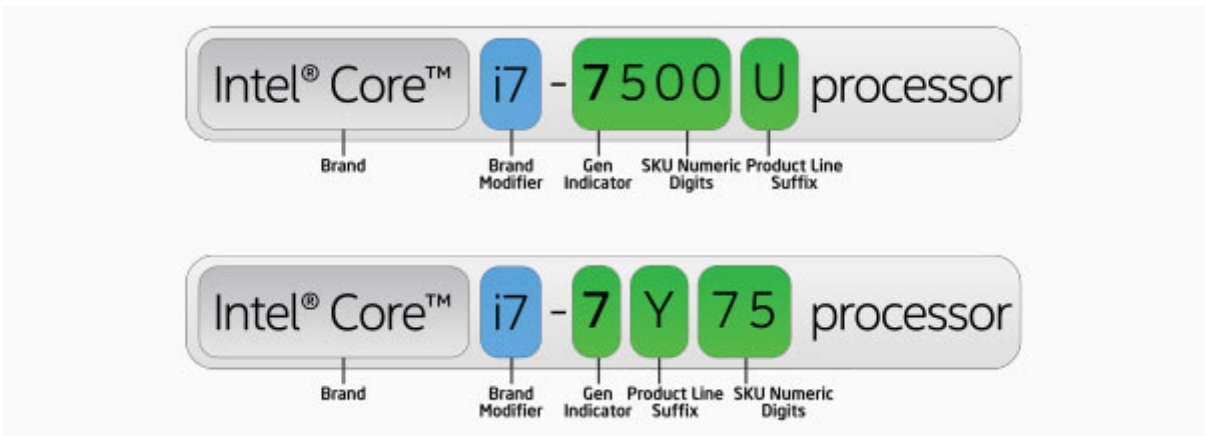
1. Open terminal
2. Type `lscpu`
3. Get the processor name
4. Go to a cpu benchmark page and put in your cpu

Buying a CPU

AMD



Intel



- The **Brand Modifier** tells you how many cores are in the processor.
- With **Gen Indicator**, the higher, the better. It means it's the most recent processor that came out.
- The **SKU (Stock Keeping Unit)** is the unique identifier for your specific processor.
- The **Product Line Suffix** can vary, and with **K**, they can be overclocked.

5G Technology

- The Truth About 5G ft. MKBHD - ASAP Science
  - *Watch until 7:15*
- The Truth About 5G - Real Engineering

Amplitude vs Frequency Modulation

Let's say you have a simple 100Hz Sine Wave you want to apply to an 850 Hz Carrier Wave, a wave with much higher frequency. There are two options:

- **Amplitude Modulation (AM):**
  - Applies the data to the amplitude of the carrier frequency, so it will vary
    the amplitude of the carrier frequency, basically tracing the original wave
    with its peaks and troughs.
- **Frequency Modulation (FM):** Applies the data to the frequency of the carrier wave, varying the distance between peaks to trace the original wave.
  - To transfer a call like this, you need a dedicated frequency band defined by
    the lowest and highest frequencies used.
  - If another user is using the same frequency band, you need to use a different one. The more bands a tower has, the more calls it can handle This is called **bandwidth**.

Adding more frequencies is a challenge as there's a lot of competition, and they need to be licensed:

- Weather Radar
- Military
- GPS

- Television
- Radio
- Radio Astronomy
- Air Traffic Control

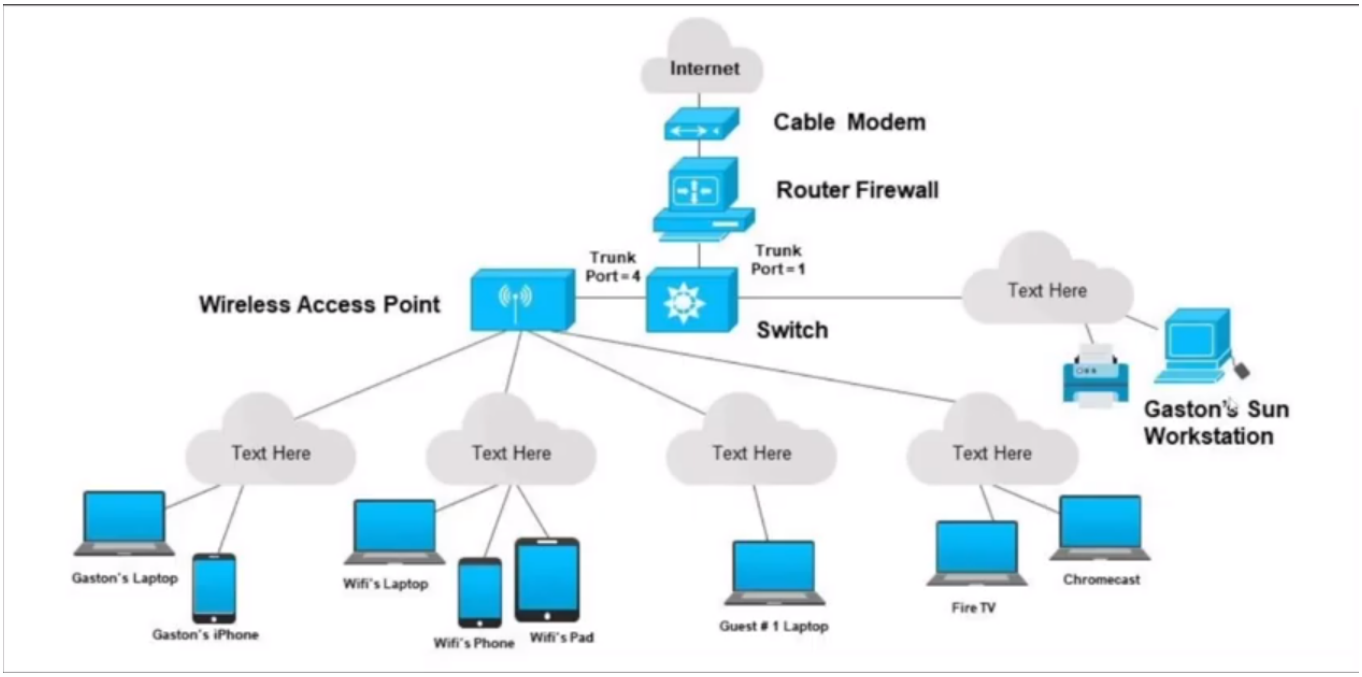
Millimeter Waves are like visible light in that they need a direct line of sight in order to properly make contact.

Higher frequency and shorter wave lengths equate to higher energy.

Different Types of Waves:

- Low Band
  - Slowest
- Mid Band
  - Faster
  - Short distance
  - MM Wave / High Band
    - Fastest
    - Shortest Distance

Networking



5GHz vs 2.4GHz

- 5GHz provides faster data rates at a shorter distance

- 2.4GHz provides coverage for farther distance, but performs at lower speeds.

Quantum Computing

- Quantum Computers Explained – Limits of Human Technology
- Demonstrating Quantum Supremacy

As transistors are shrinking to the size of only a few atoms, electrons may just transfer themselves to the other side of a blocked passage via **Quantum Tunneling**.

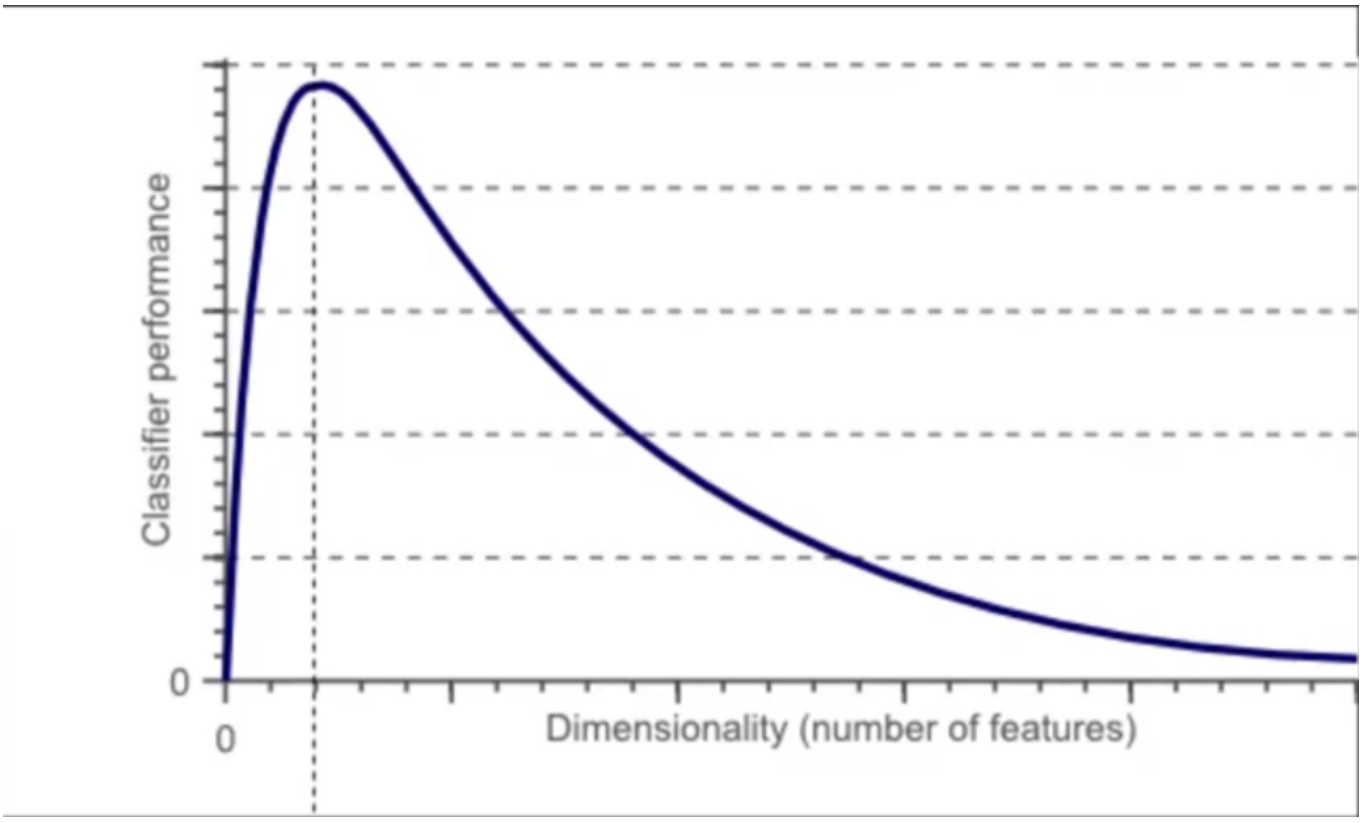
- As you get into the quantum world, computers are not able to function the same way as things work differently.

In Quantum computing, instead of bits there are **qubits**.

The processor that achieved **Quantum Supremacy** is called the Sycamore Processor.

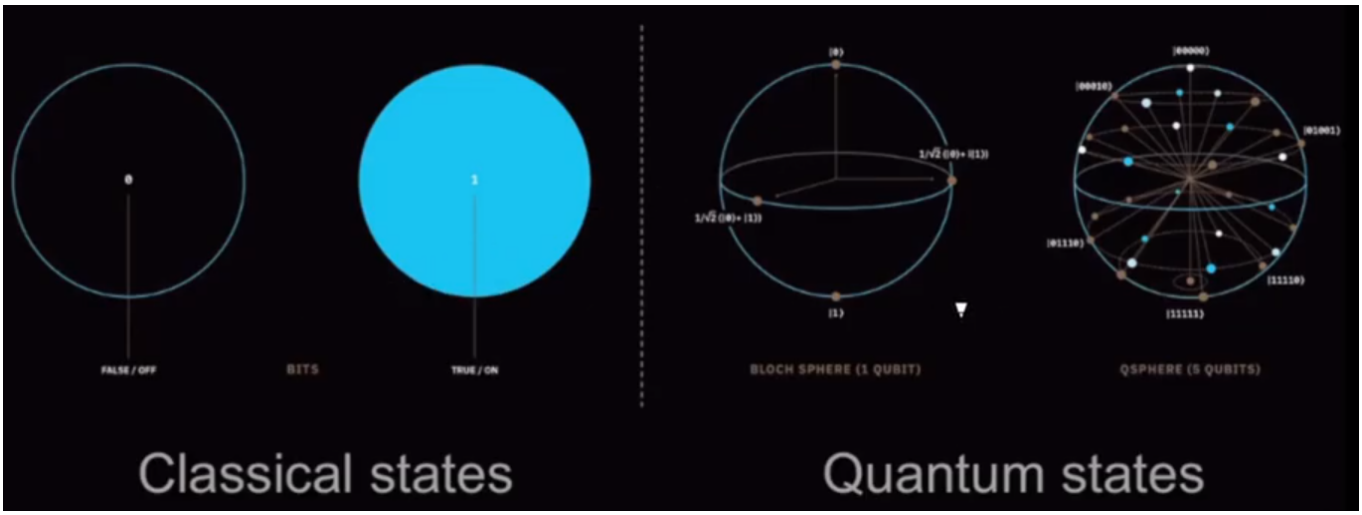
- Quantum supremacy is when a quantum computer is able to outperform a traditional computer when both are given increasing complexity tasks

Curse of Dimensionality



As we add more features, it becomes harder and harder to compute.

Why Is Quantum Computing Different?



- Quantum computing will only accelerate our ability to perform computing quicker.
- A **Qubit** is faster than a bit.

How Do These Factors AffectAI?

Quantum Computing, **Integrated Circuit**, and **5G Networks** give us more ability to compute things with artificial intelligence.

- As our computing capabilities increase, we have a better capability to model the world with computers.
- We will have more efficient and stronger models available to us.
- 5G increases the interconnectivity of the devices.
- Computation power has a direct effect on how much we can do with our algorithms.

Our computing power over the years:

Labs

Sources

- https://teachablemachine.withgoogle.com/train/image
- https://web.archive.org/web/20210305170224/http://www.image-net.org/synset?wnid=n02123159
- https://www.kaggle.com/jessicali9530/celeba-dataset

Overview - Teachable Machine by Google

- A web-based tool for creating machine learning models that is accessible to everyone
- No prior machine learning knowledge required
- Allows the computer to recognize images, sounds, and poses without writing code
- Can be used in own projects, sites, apps, etc.

Part 1 - Downloading the datasets

- Download the required assets for training the model

Part 2 - Create first model (Cats vs Tigers)

Follow the video tutorial on YouTube: https://youtu.be/"HQxdGEXOeQ

1. Use Google Images to find photos of cats and tigers to verify the model
2. Try to find a photo that gives less accurate results
3. Find 3 photos of cats, tigers, or both to verify the model
4. Use Windows Snippit (or Windows Key + Shift + S) to take snapshots of the output
5. Try verifying with a picture of a dog and include the snapshot of the output

Part 3 - Understanding the Model

- The model created only recognizes the appearance of the objects, not what they actually are.
- The computer does not have memories, emotions, or knowledge about cats or tigers.
- The model only knows how to differentiate between objects based on the datasets provided.
- When evaluating, the model tries to determine how closely the image conforms to one dataset or the other.
- The model is memorizing the appearance of the datasets, not the actual knowledge of the things in the images.
- The model only knows the difference between the objects based on the datasets.

Part 4 - Creating own Dataset and Model (Various Fruits)

- Use webcam to create a new project in Teachable Machine
- Stop by the grocery store to get 3 different fruits (apple, orange, and banana)
- Create a new project in Teachable Machine
- Add Image Samples for each fruit class using the webcam

    - Name each class after the chosen fruit
- Hold and record one fruit at a time while moving it around in the captured images
    - Add at least 50 Image Samples of each fruit
- Train the model
- Preview the model with the webcam by holding each fruit up and observing the output prediction changes.

Notes

- Troubleshoot webcam issues if necessary
- The goal is to create a model based on the various fruits.

Troubleshooting

- Chrome Support
- Firefox Support
- Mac Support