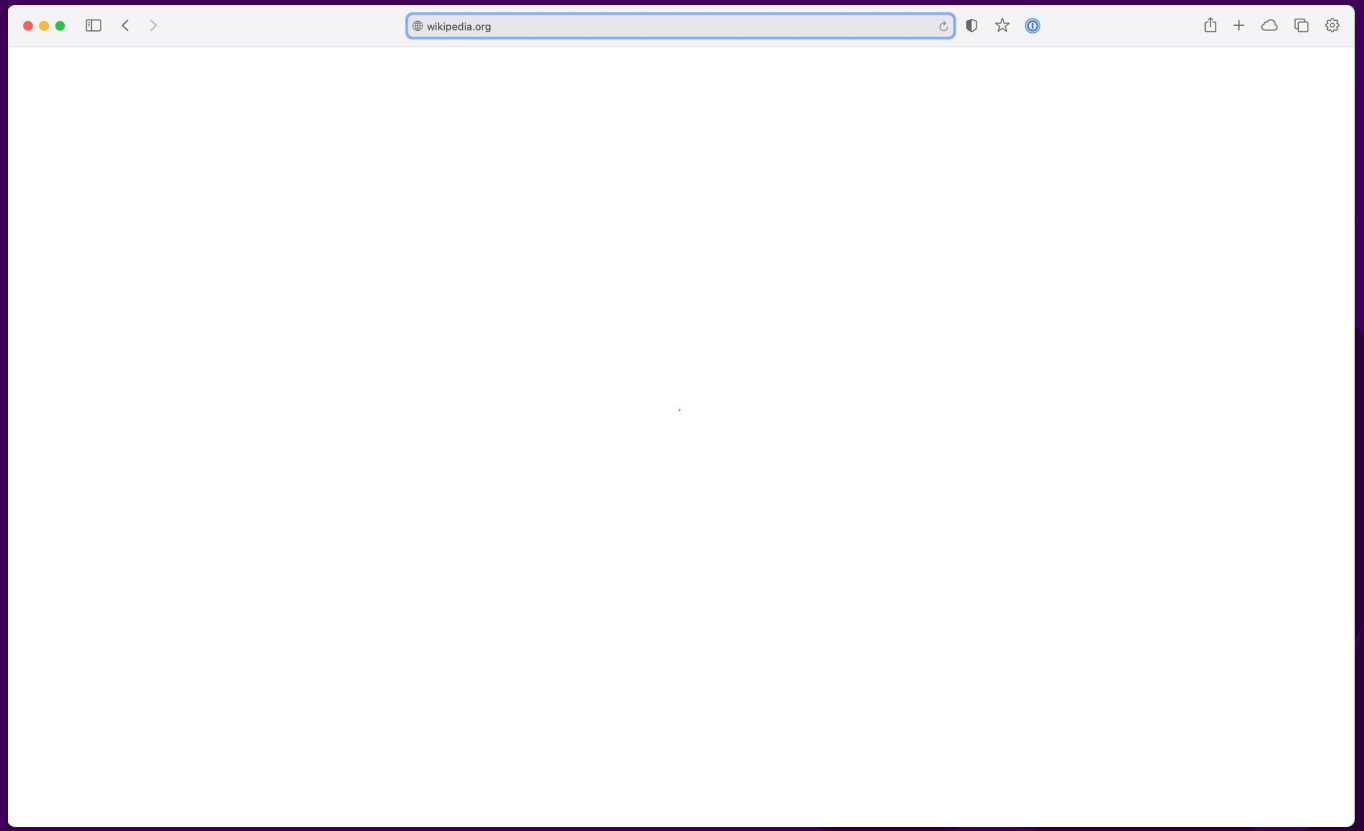
What happens when you press <enter>?

How the Magic of the Internet Works and Why it's Important

@aviflombaum



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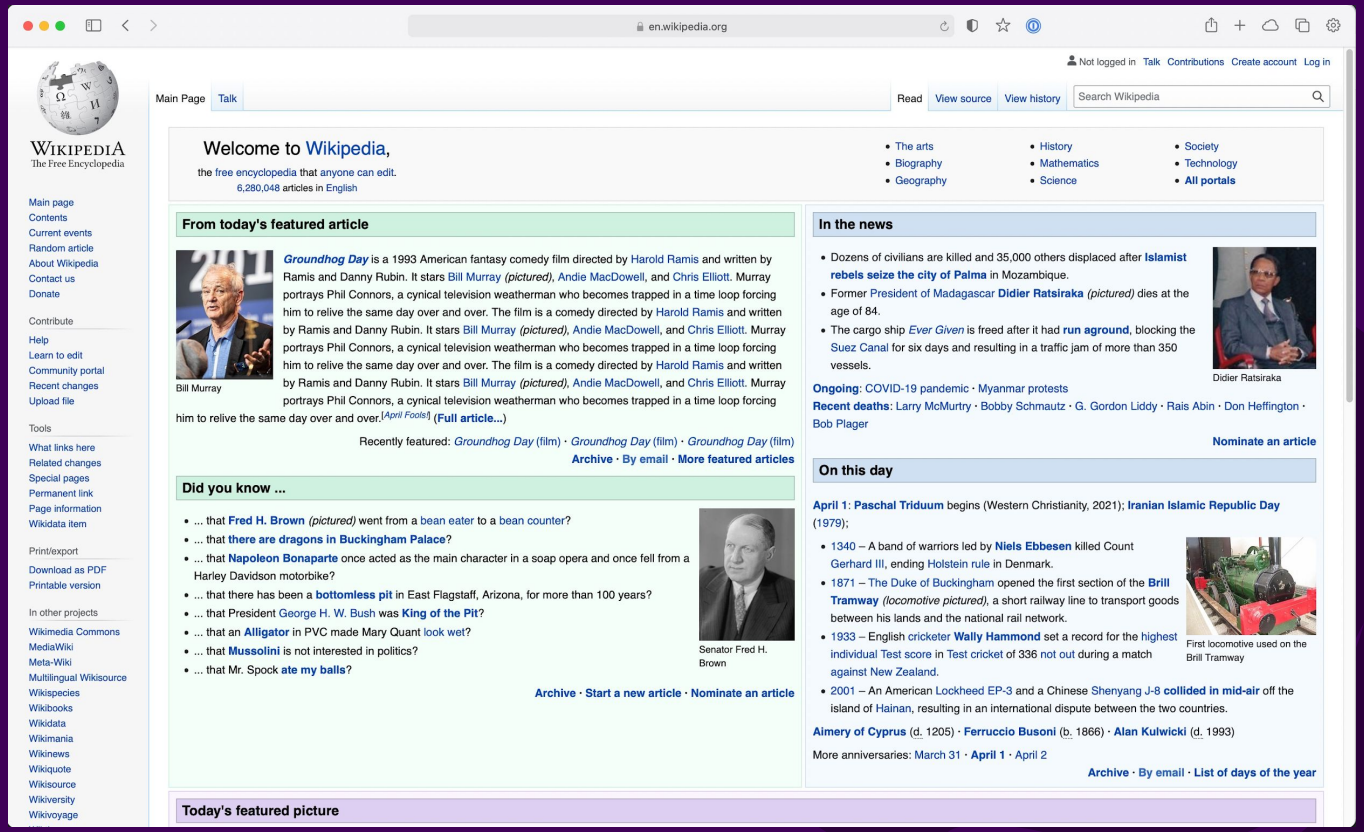
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From today's featured article
Groundhog Day is a 1993 American fantasy comedy film directed by Harold Ramis and written by Ramis and Danny Rubin. It stars Bill Murray (pictured), Andie MacDowell, and Chris Elliott. Murray portrays Phil Connors, a cynical television weatherman who becomes trapped in a time loop forcing him to relive the same day over and over. The film is a comedy directed by Harold Ramis and written by Ramis and Danny Rubin. It stars Bill Murray (pictured), Andie MacDowell, and Chris Elliott. Murray portrays Phil Connors, a cynical television weatherman who becomes trapped in a time loop forcing him to relive the same day over and over. The film is a comedy directed by Harold Ramis and written by Ramis and Danny Rubin. It stars Bill Murray (pictured), Andie MacDowell, and Chris Elliott. Murray portrays Phil Connors, a cynical television weatherman who becomes trapped in a time loop forcing him to relive the same day over and over.[April Fools!] (Full article...)
Bill Murray
Recently featured: Groundhog Day (film) · Groundhog Day (film) · Groundhog Day (film)
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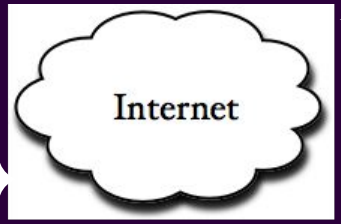
Did you know ...
... that Fred H. Brown (pictured) went from a bean eater to a bean counter?
... that there are dragons in Buckingham Palace?
... that Napoleon Bonaparte once acted as the main character in a soap opera and once fell from a Harley Davidson motorbike?
... that there has been a bottomless pit in East Flagstaff, Arizona, for more than 100 years?
... that President George H. W. Bush was King of the Pit?
... that an Alligator in PVC made Mary Quant look wet?
... that Mussolini is not interested in politics?
... that Mr. Spock ate my balls?
Senator Fred H. Brown
Archive · Start a new article · Nominate an article
In the news
Dozens of civilians are killed and 35,000 others displaced after Islamist rebels seize the city of Palma in Mozambique.
Former President of Madagascar Didier Ratsiraka (pictured) dies at the age of 84.
The cargo ship Ever Given is freed after it had run aground, blocking the Suez Canal for six days and resulting in a traffic jam of more than 350 vessels.
Didier Ratsiraka
Ongoing: COVID-19 pandemic · Myanmar protests
Recent deaths: Larry McMurtry · Bobby Schmautz · G. Gordon Liddy · Rais Abin · Don Heffington · Bob Plager
Nominate an article
On this day
April 1: Paschal Triduum begins (Western Christianity, 2021); Iranian Islamic Republic Day (1979);
1340 – A band of warriors led by Niels Ebbesen killed Count Gerhard III, ending Holstein rule in Denmark.
1871 – The Duke of Buckingham opened the first section of the Brill Tramway (locomotive pictured), a short railway line to transport goods between his lands and the national rail network.
1933 – English cricketer Wally Hammond set a record for the highest individual Test score in Test cricket of 336 not out during a match against New Zealand.
2001 – An American Lockheed EP-3 and a Chinese Shenyang J-8 collided in mid-air off the island of Hainan, resulting in an international dispute between the two countries.
First locomotive used on the Brill Tramway
Aimery of Cyprus (d. 1205) · Ferruccio Busoni (b. 1866) · Alan Kulwicki (d. 1993)
More anniversaries: March 31 · April 1 · April 2
Archive · By email · List of days of the year
Today's featured picture

How?


Internet


You are here

Agenda

- A complete history of human communication.
- A thorough history of machines and computing.
- Why the internet is super important.
- How the internet works.

Before we start, keep in mind.

- This is a lot.
- I talk fast.
- Take notes, questions, discussion after
- Don’t worry about remembering everything.
- Exposure and awareness are everything.
- You can learn this, I promise.

http://www.

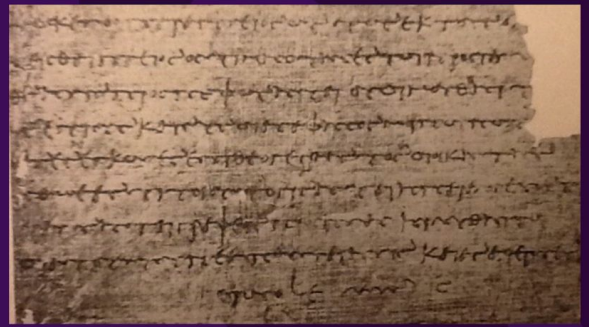
The internet is the world's largest and most advanced communication system, but it is not the first.

Let's spend 5 minutes looking at the past so that the present and the future have some context.

There is no new thing under the sun.

A history of communication in emojis.

🙌 40000 BCE



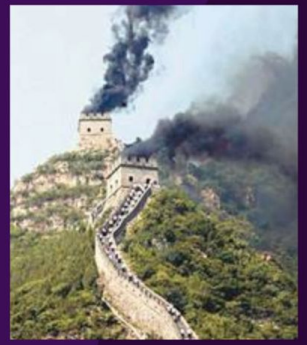
🔠 300 BCE

1000 CE

A brief history of communication

- Personal, proximal, physical, tribally precise, preservable, short-term multi-generational.
- Media - dyes, paints, inks.
- Medium - caves, papyrus, scrolls, wood, paper.
- Tech - fingers, brushes, quills, pens, movable types, ppresses

📖 1450 CE



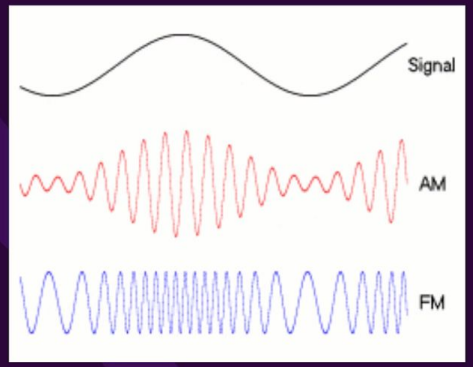
🔥 800 BCE

🥁 700 BCE

📫 500 BCE

🔍 400 BCE

📞 1790 CE

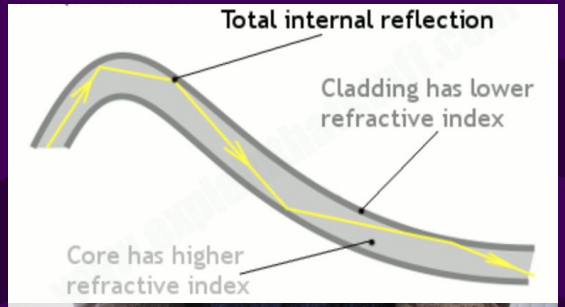


📻 1900 CE

🛰️ 1950 CE

A brief history of telecommunication

- Instrument, distance, metaphysical, computational, ephemeral.
- Media - smoke, sound, light, waves, radiation.
- Medium - Text, Audio, Visual, Data
- Tech - Fire, Drums, Mirrors, Telegraphs, Wires, Radio, Cables



1960 CE

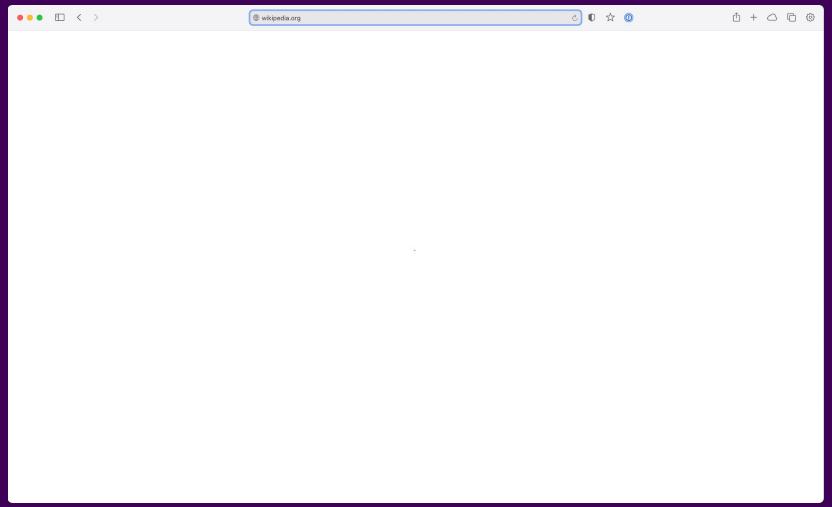
Communication is about sending information via signs that have meaning. It’s how we connect to each other. 😀

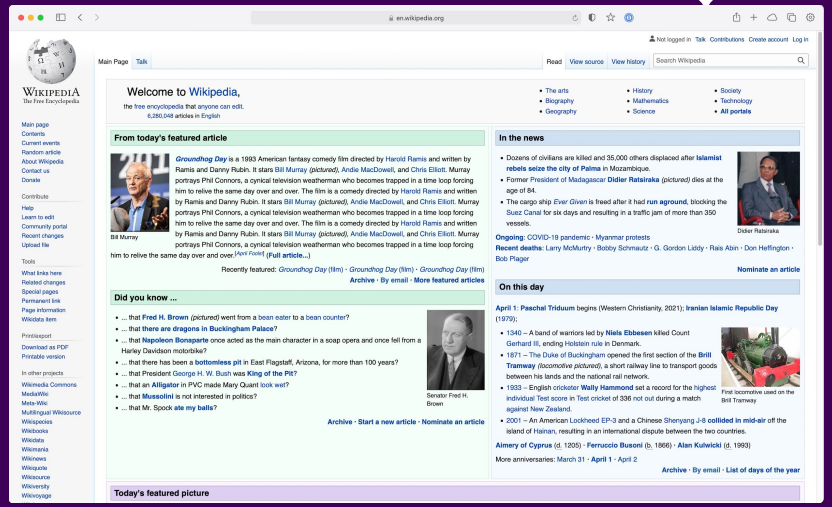
:-)

01101000 01100001 01110000 01110000 01111001 00001101 00001010

Happy

Back to the internet...





How?

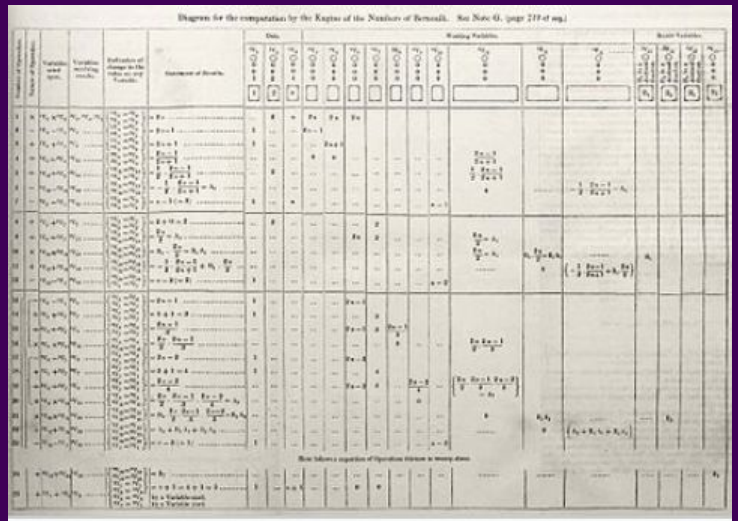
Machines Communicating.

Just a super quick history of machines...

Ben Franklin's Electrifying Discovery

- Discovered electricity in 1752.
- Kite experiment proved lightning was electricity.
- This discovery led to understanding electricity's properties and potential.
- Electricity powers machines.
- It✦the foundation for transmitting information across vast distances.

Babbage and Lovelace on Thinking Machines 1819–1840 CE



Lovelace's diagram from Note G, the first published computer algorithm

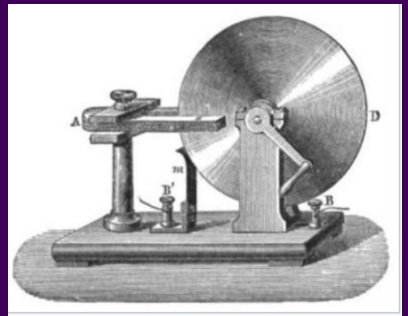
First the Difference Engine, for solving polynomial equations, and then the theoretical Analytical Engine, which can be “operated” to solve anything.

Ada Lovelace describes the future of Thinking Machines:

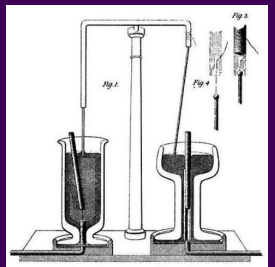
"A new, a vast, and a powerful language is developed for the future use of analysis, in which to wield its truths so that these may become of more speedy and accurate practical application for the purposes of mankind."

“The science of operations, as derived from mathematics more especially, is a science of itself, and has its own abstract truth and value.”

Babbage and Lovelace on Thinking Machines 1819–1840 CE



Built in 1831, the Faraday disk was the first electric generator. The horseshoe-shaped magnet *(A)* created a magnetic field through the disk *(D)*. When the disk was turned, this induced an electric current radially outward from the center toward the rim. The current flowed out through the sliding spring contact *m*, through the external circuit, and back into the center of the disk through the axle.



Electromagnetic rotation experiment of Faraday, *ca.* 1821[39]

Electricity and Magnetism are not 2 separate forces, but one interconnected force, electromagnetism, each capable of influencing the other.

Spinning a magnetic around a copper coil generates electricity through the movement of electrons in the coil.

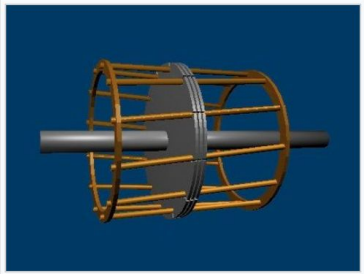
Electrify a magnetic and you can reverse its polarity, turning negative to positive.

With a magnet and electricity you can create motion, known as a motor.

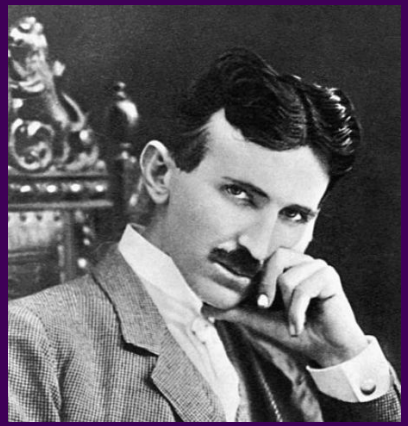
With motion, say from steam, you can spin a magnet to generate electricity, known as a generator.

Nikola Tesla Creates a Modern World – 1886/89/93 CE

A model of Tesla's first induction motor, in Tesla Museum, Belgrade



Squirrel cage rotor construction, showing only the center three laminations



Tesla invented Alternating Current that can transport electricity at great distances.

He creates the modern turbines used for generating huge quantities of electricity, including those used in Niagara Falls and the Hoover Dam.

He describes the earth as having “Acoustical Resonance,” capable of amplifying and bouncing waves back and forth, allowing for wireless communication.

The world is now electrified and connected.

Okay, let's move a little faster. Nothing super important (except splitting the atom) happens from 1900–1940.

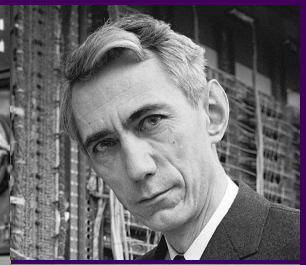
Anyone want to guess why?

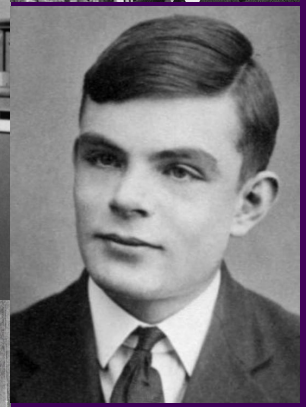
Turing, Shannon, and Hopper Invent Computing 40–50s

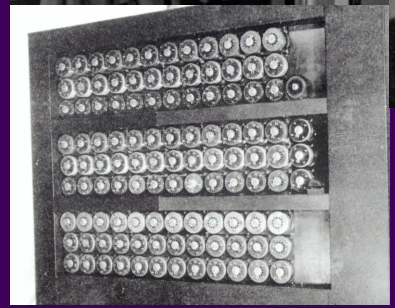
Alan Turing invents the first “universal machine” - the Manchester Mark 1 (watch Imitation Game it’s great).

Grace Hopper also works on one of the first computers in WW2 to solve imploding sphere problem and then after the war invents the idea of a “Compiler” and “Human Readable” code - COBAL. She was 39 when she started in computing.

Shannon coins the unit of measurement of a bit, creates information theory, a mathematical way of unifying all data into a singular notion.







A Mathematical Theory of Communication

“Information is the resolution of uncertainty, the negative reciprocal value of probability. One bit is typically defined as the uncertainty of a binary random variable that is 0 or 1 with equal probability, or the information that is gained when the value of such a variable becomes known.” Claude Shannon

“What lies at the heart of every living thing is not a fire, not warm breath, not a ‘spark of life’. It is information, words, instructions. If you want to understand life don’t think about vibrant, throbbing gels and oozes, think about information technology.” Richard Dawkins, Biologist

“It from Bit, every it, every particle, every field of force, even the space-time continuum itself. What we call reality, arises in the last analysis of posing of yes or no questions. All things physical are information-theoretic in origin, and this is a participatory universe. The whole universe is a thus seen as a computer - a cosmic information processing machine.”
Archibald Wheeler, Physicist

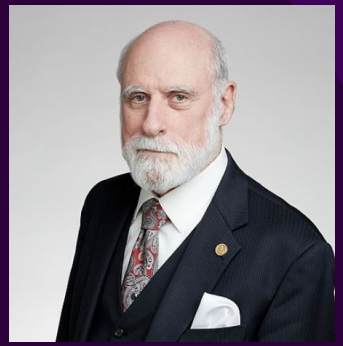
Kilby, Noyce, Faggin and XParc Invent Modern Computing 60-70s

The Integrated Circuit creates reliable and significantly smaller computers and Kilby makes Texas Instruments and Noyce makes Intel.

Faggin invents the CPU and the computational power of computers doubles every year (Moore's Law)

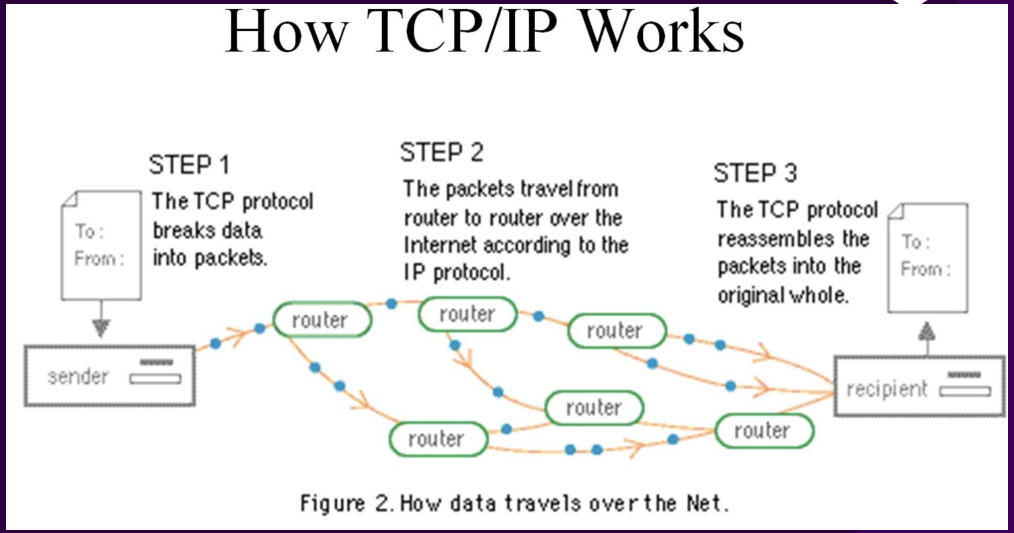
Adele Goldberg and Alan Kay at Xerox Palo Alto Research Center invents everything, the personal computer, object orientation, ethernet, the mouse, the graphic user interface, just everything. Apple steals it all.

Vint Cerf Networks All the Computers Together – 1982



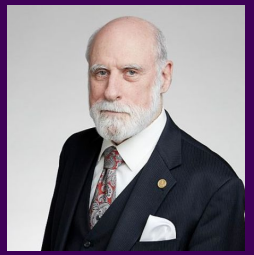
Vint Cerf created the TCP/IP Protocol that allows computers to reliably communicate with each other over long distances of Ethernet and Fiber Optic Cables.

The internet is born but it's mostly used by government and universities for POP, SMTP, FTP, and USENET.



Personal Computer - 1950-80s

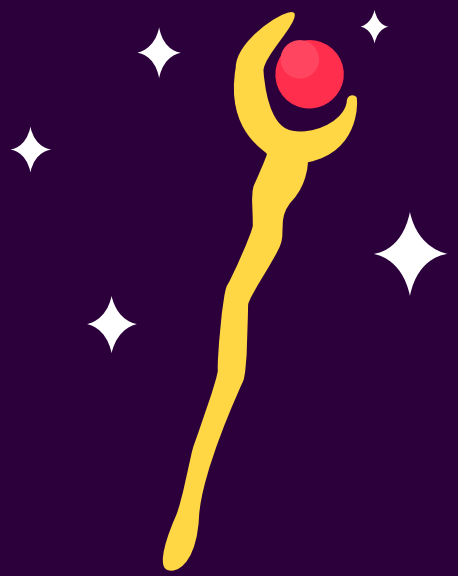


The integrated circuit and the Central Processing Unit made computers smaller and more reliable. XParc made computers personal. Apple made computers palatable. Vint Cerf networked them all together.

And now we're ready.
How does the Internet Work?

It's basically...



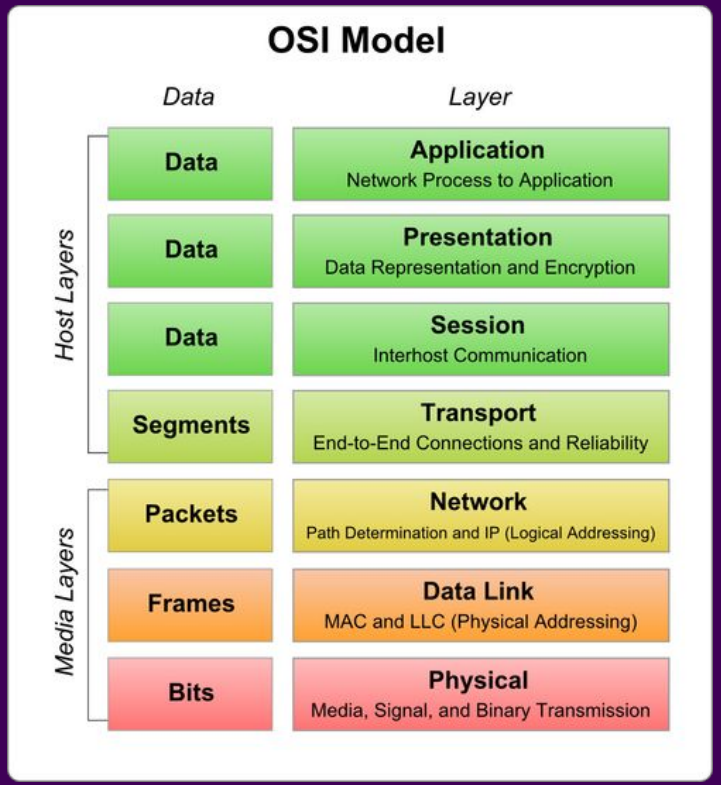
Abstraction

- If we hide information things become simpler. Everything we just covered that enables the World Wide Web doesn't need to be known by any individual programmer.

Technology creates black boxes of abstractions. You can build on top without needing to know how the box works.

The World Wide Web is an abstraction too. It's all about a standard interface.

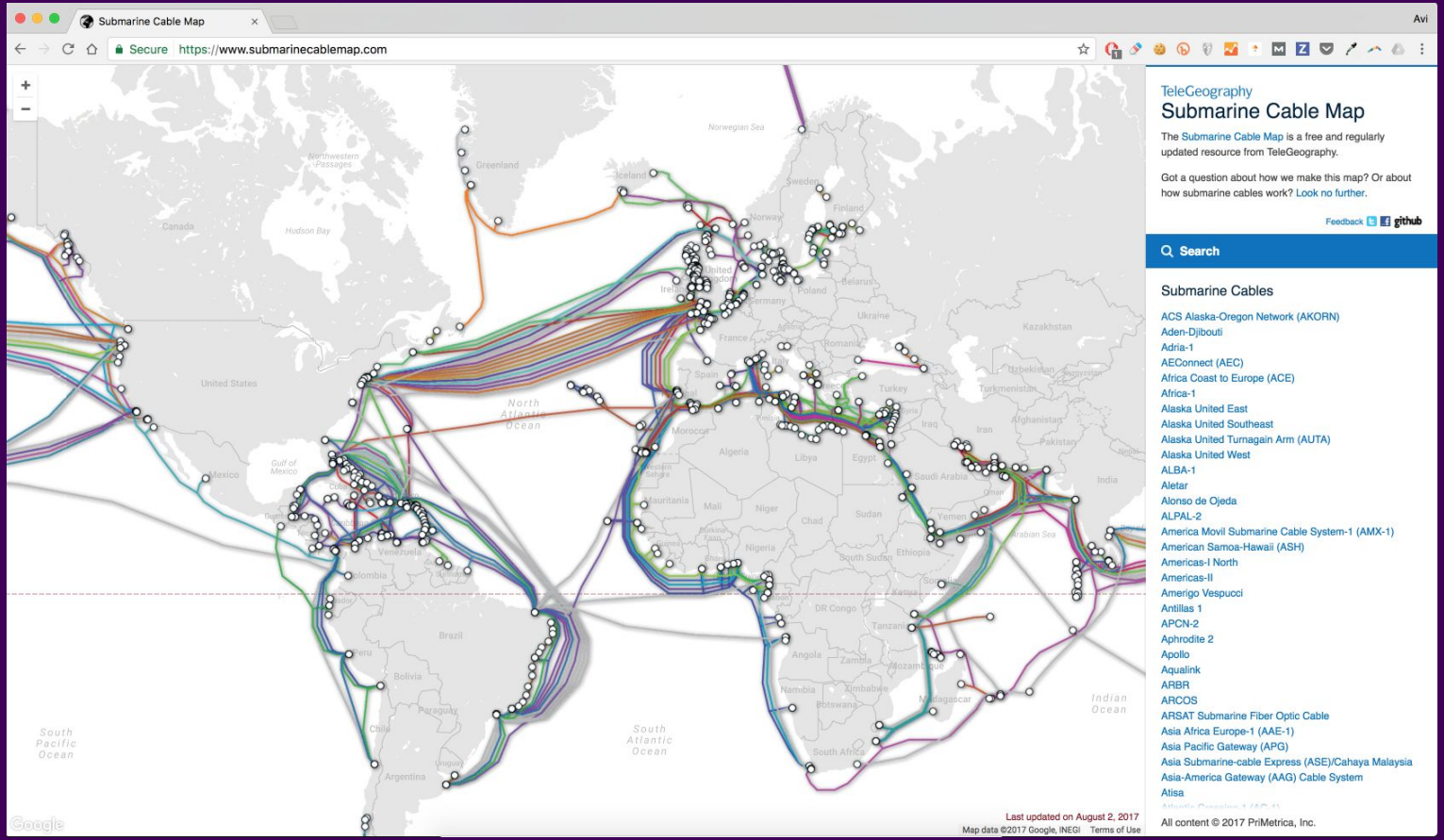
Lots of hardware



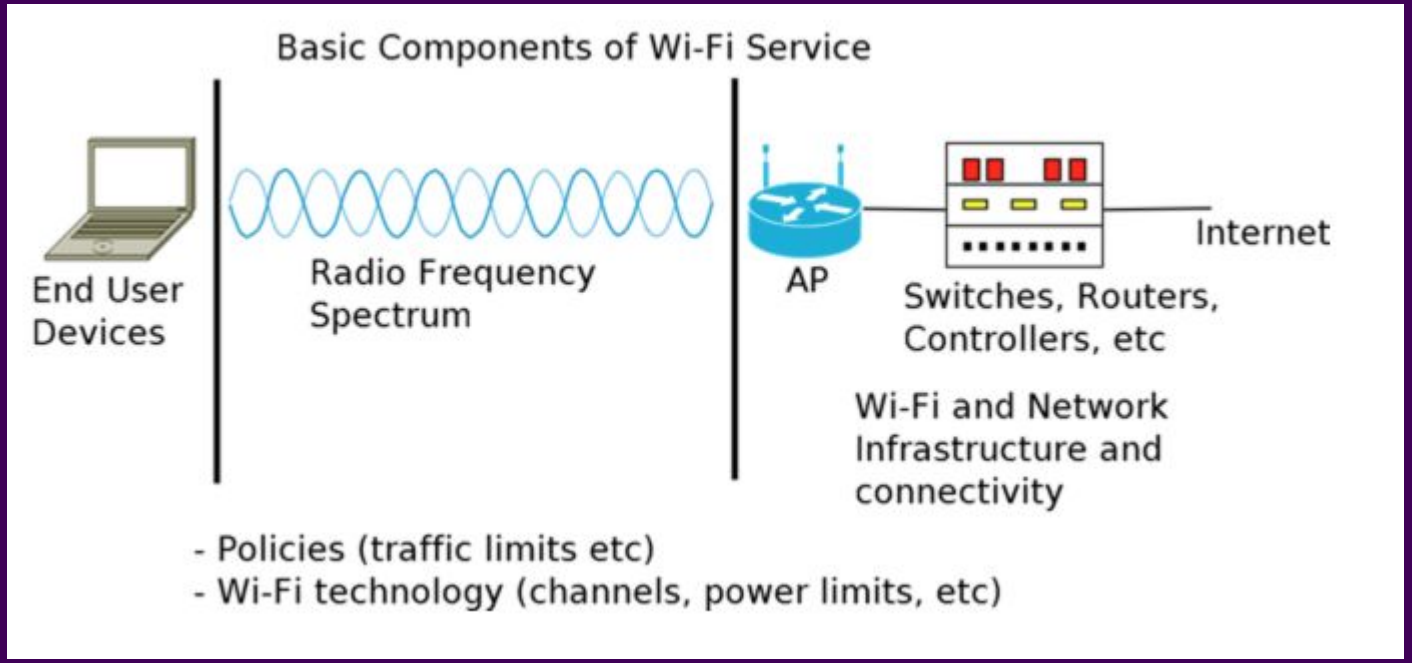
Lots of software

- HTTP
- URI
- Browser
- Web server
- DNS
- Operating system
- Interface
- Network
- Router
- HTML
- More

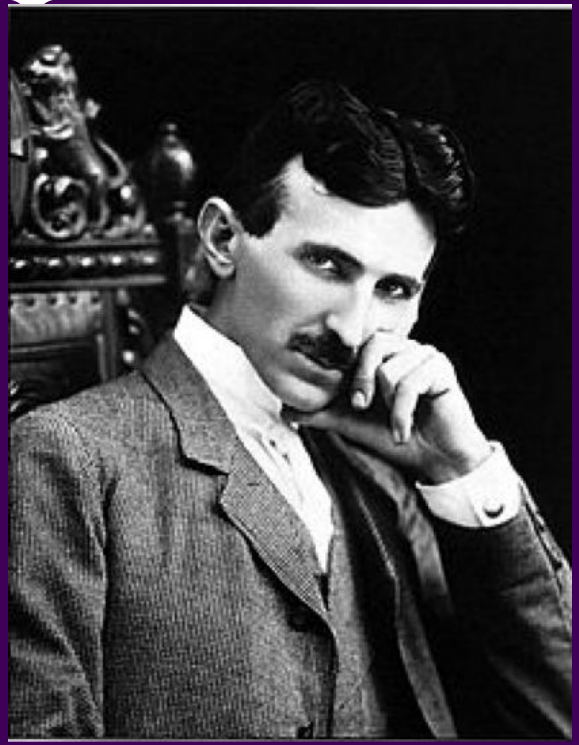
Very physical



Everything is...

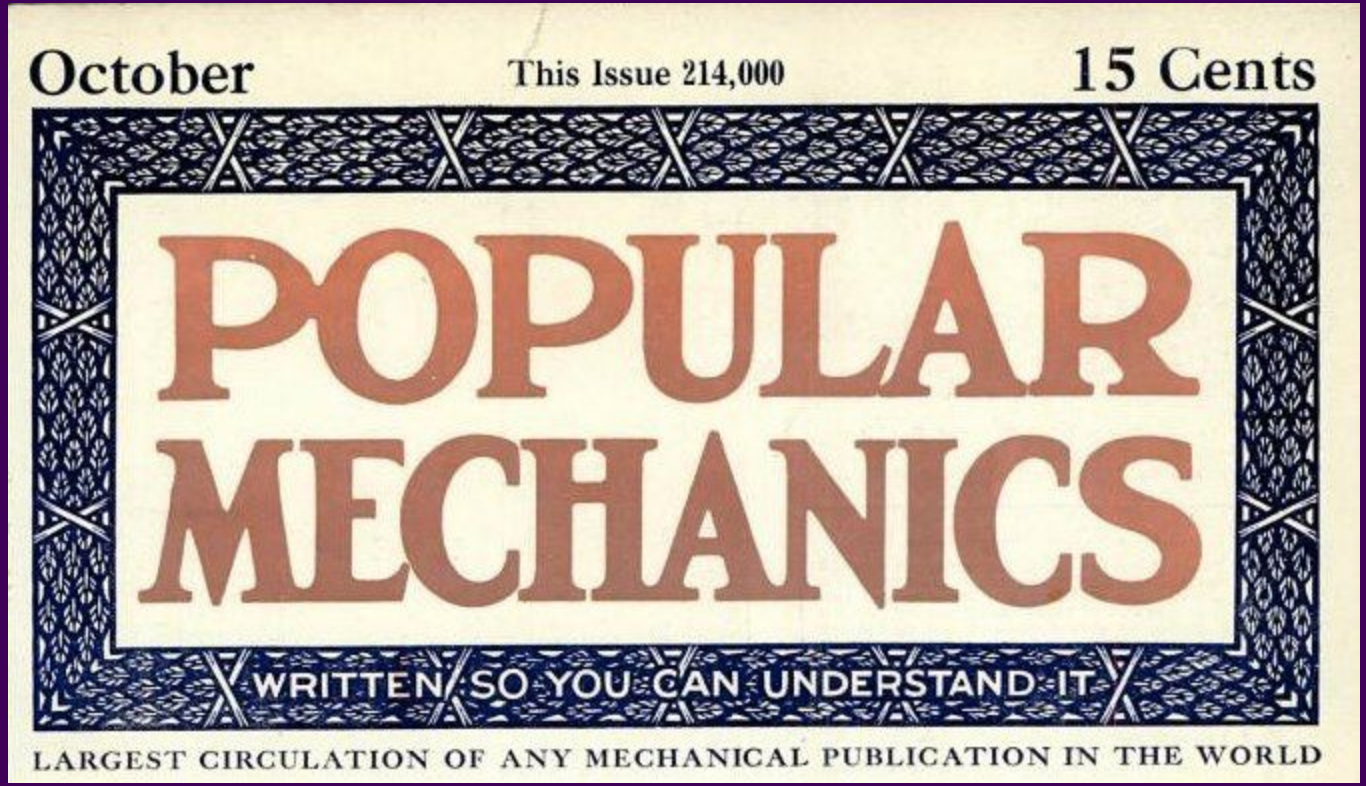


Tesla.



It is paradoxical, yet true, to say, that the more we know, the more ignorant we become in the absolute sense, for it is only through enlightenment that we become conscious of our limitations. Precisely one of the most gratifying results of intellectual evolution is the continuous opening up of new and greater prospects.

Popular Mechanics, October 1909



WIRELESS OF THE FUTURE

(Nikola Tesla in the New York Times)

"The practical applications of the revolutionary principles of the wireless art have only begun. What will be accomplished in the future baffles one's comprehension."

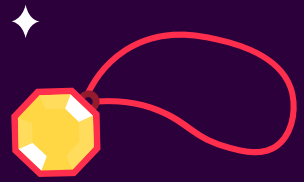
This startling prophecy is made by Mr. Nikola Tesla. In speaking of the utility of wireless transmission in the near future he said: "The attention of the world has been caught and held by the wireless telegraph, and yet this is a very primitive use of the art. So far only electric waves have been used, which have been quickly damped out in their passage through the air. It is possible, however, to transmit electric currents of enormous power for thousands of miles without diminishing their energy. This is not a theory, but a truth established by many practical experiments. It will soon be possible to transmit wireless messages all over the world so simply that any individual can carry and operate his own apparatus. The wireless transmission of power across the ocean, for instance, obviously opens up an entirely new era in mechanical developments.

"It will soon be possible, for instance, for a business man in New York to dictate instructions and have them appear instantly in type in London or elsewhere. He will be able to call up from his desk and talk with any telephone subscriber in the world. It will only be necessary to carry an inexpensive instrument not bigger than a watch, which will enable its bearer to hear anywhere on sea or land for distances of thousands of miles. One may listen or transmit speech or song to the uttermost parts of the world. In the same way any kind of picture, drawing, or print can be transferred from one place to another. It will be possible to operate millions of such instruments from a single station. Thus it will be a simple matter to keep the uttermost parts of the world in instant touch with each other. The song of a great singer, the speech of a political leader, the sermon of a great divine, the lecture of a man of science may thus be delivered to an audience scattered all over the world.

Tim Berners-Lee

The web is more a social creation than a technical one. I designed it for a social effect — to help people work together — and not as a technical toy. The ultimate goal of the Web is to support and improve our weblike existence in the world. We clump into families, associations, and companies. We develop trust across the miles and distrust around the corner.

The Web does not just connect machines, it connects people.



The very nature of these inventions cries out for the goodness in men; cries out for universal brotherhood; for the unity of us all.

Tim Berners-Lee

In 1989, he proposed a global hypertext project, to be known as the World Wide Web. He wrote the first World Wide Web server, "httpd", and the first client, "WorldWideWeb" a what-you-see-is-what-you-get hypertext browser/editor which ran in the NeXTStep environment.

This work was started in October 1990, and the program "WorldWideWeb" first made available within CERN in December, and on the Internet at large in the summer of 1991.

Tim Berners-Lee

The Web as I envisioned it, we have not seen it yet. The future is still so much bigger than the past.

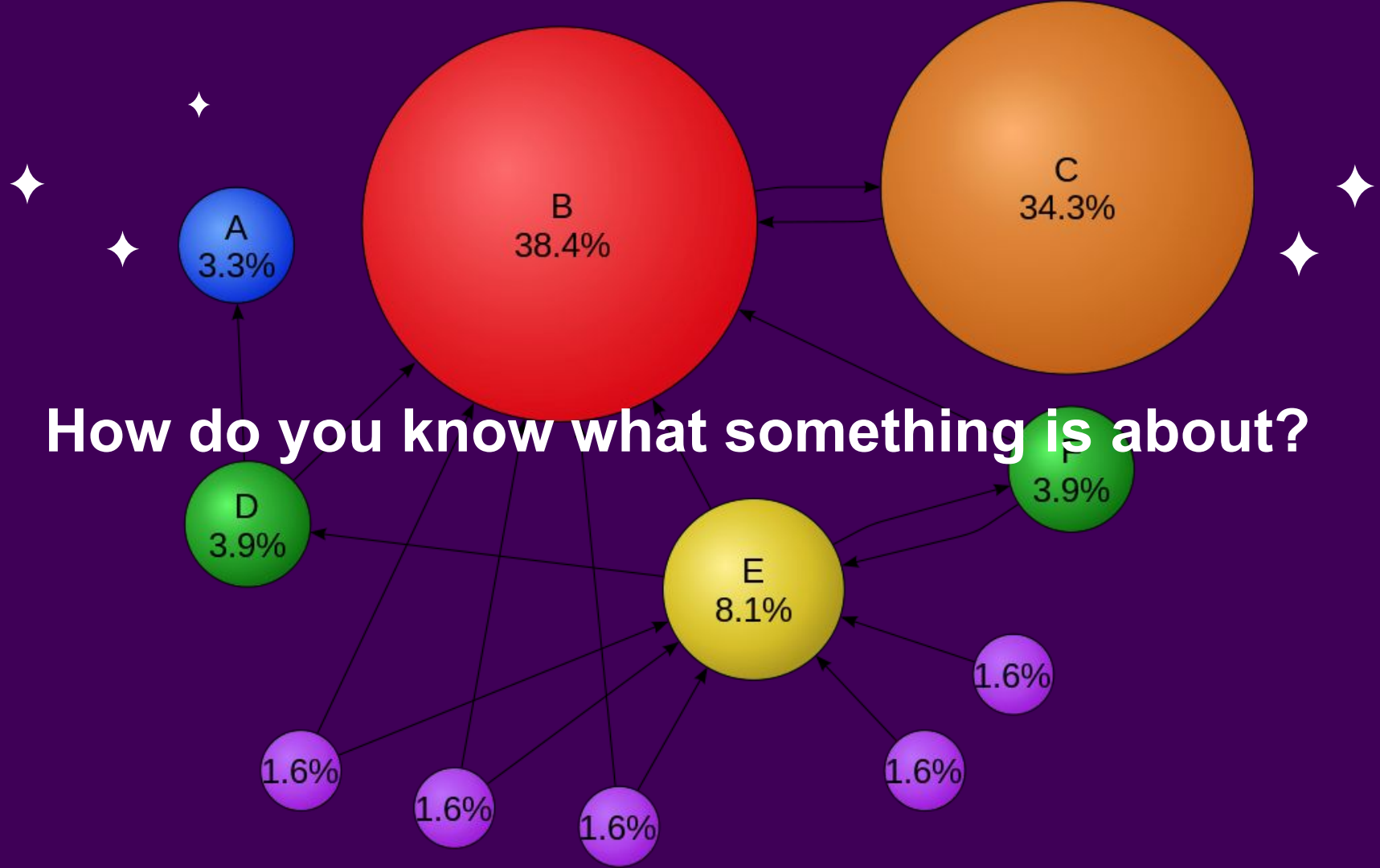
Tim Berners-Lee

In an extreme view, **the world can be seen as only connections**, nothing else. We think of a dictionary as the repository of meaning, but it defines words only in terms of other words. I liked the idea that a piece of information is really defined only by what it's related to, and how it's related. **There really is little else to meaning. The structure is everything.** There are billions of neurons in our brains, but what are neurons? Just cells. The brain has no knowledge until connections are made between neurons. All that we know, all that we are, comes from the way our neurons are connected.


Connections are everything


Connections are everything


Connections are everything



How do you know what something is about?

Google is a measurement of connections.

In the general case, the PageRank value for any page **u** can be expressed as:

$$PR(u) = \sum_{v \in B_u} \frac{PR(v)}{L(v)},$$

i.e. the PageRank value for a page **u** is dependent on the PageRank values for each page **v** contained in the set $\mathbf{B_u}$ (the set containing all pages linking to page **u**), divided by the number $L(v)$ of links from page **v**.

The Internet is Important

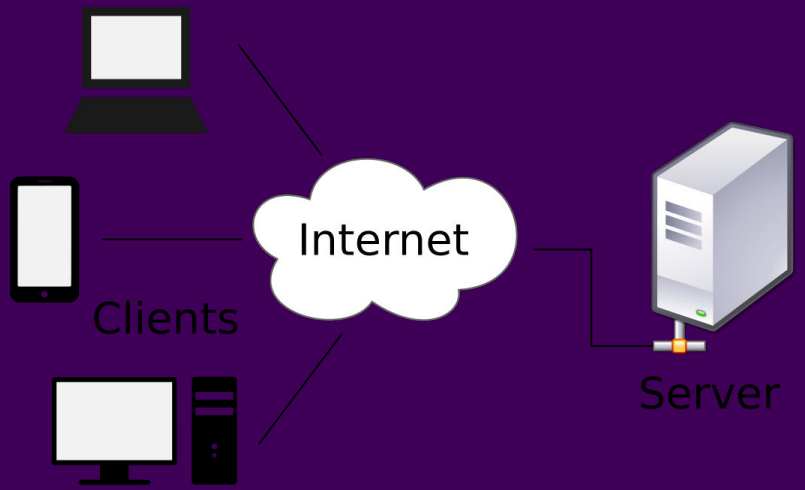
It connects us.

The Web in a Nutshell

The server is always online, sitting and waiting for people to request information from it via the World Wide Web, specifically, via something called an HTTP request, which is just a name for the messages computers pass each other on the internet.

Client Server Model

Clients make requests, servers respond with data from files.



Client / Server Model

Clients make HTTP/S Requests.

Clients are anything that can send and process an HTTP/S Request

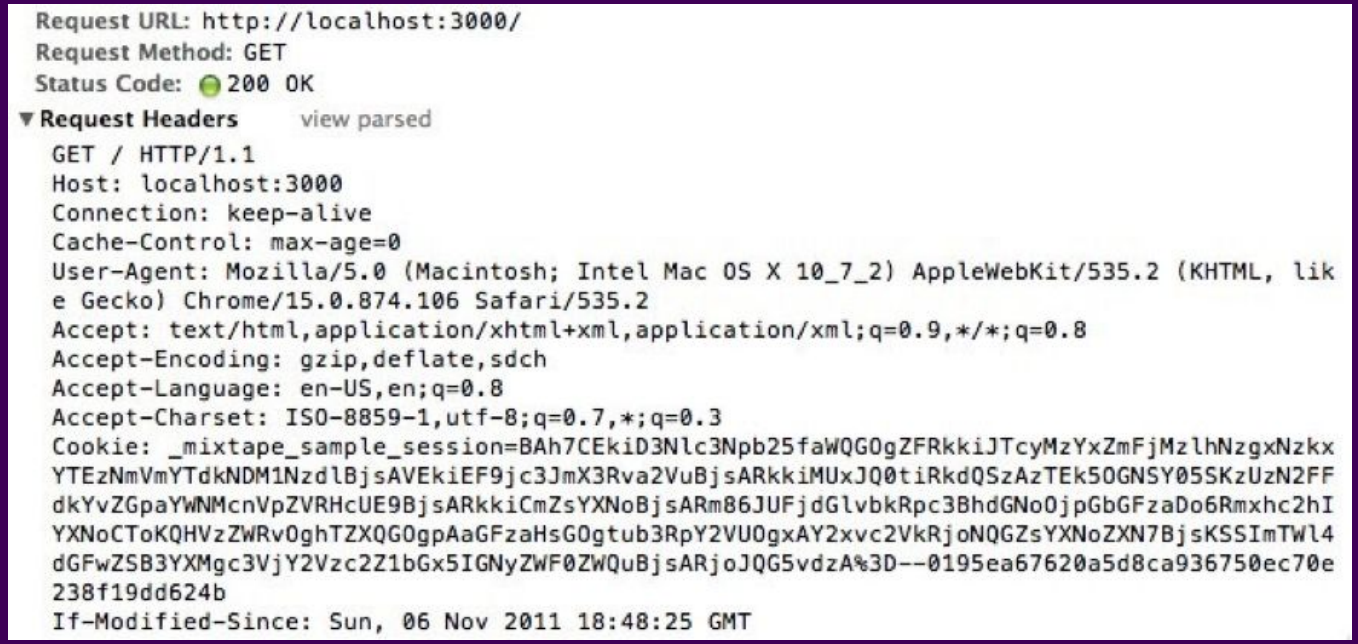
GET http://twitter.com

GET https://instagram.com

GET https://netflix.com

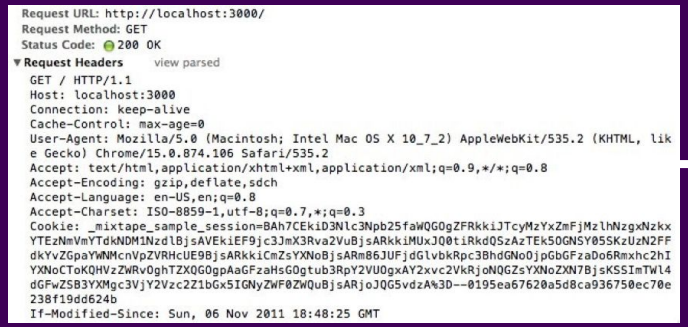
What's an HTTP Request

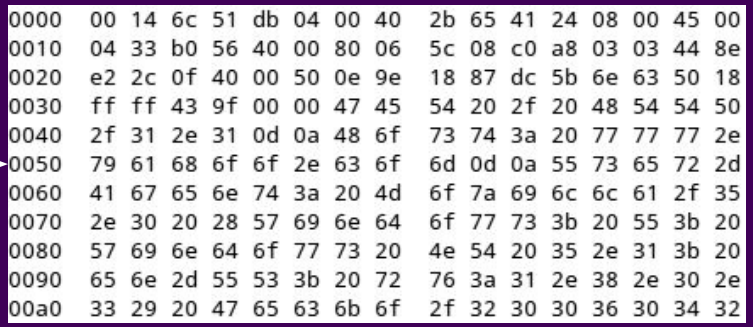
A specifically formatted string sent from one computer to another.



What's an HTTP Request

The string gets converted to TCP/IP packets





Those packets travel across all the computers on the internet until they reach the computer you want. Then the packets are converted back into the HTTP Request string.

What's in HTTP Request

1. Verb: GET
2. Protocol: http (plain text) or https (secured, encrypted)
3. Domain: github.com
4. Resource: /aviflombaum

All together:
GET http://github.com/aviflombaum HTTP/1.1

1. Purpose
2. Transportation
3. Building
4. Apartment

HTTP Verbs

HEAD	Asks for a response like a GET but without the body
GET	Retrieves a representation of a resource
POST	Submits data to be processed in the body of the request
PUT	Uploads a representation of a resource in the body of the request
DELETE	Deletes a specific resource.
TRACE	Echoes back the received request
OPTIONS	Returns the HTTP methods the server supports
CONNECT	Converts the request to a TCP/IP tunnel (generally for SSL)
PATCH	Apply a partial modification of a resource

Client / Server Model

Servers send HTTP responses, still just a giant specifically formatted string.

HTTP Response

```
HTTP/1.1 200 OK
Last-Modified: Sun, 06 Nov 2011 18:48:25 GMT
Content-Type: text/html
Content-Length: 5907
Server: WEBrick/1.3.1 (Ruby/1.9.2/2011-07-09)
Date: Sun, 06 Nov 2011 18:50:01 GMT
Connection: Keep-Alive
```

```
<!DOCTYPE html>
<html>
  <head>
    <title>Ruby on Rails: Welcome aboard</title>
    <style type="text/css" media="screen">
      body {
        margin: 0;
        margin-bottom: 25px;
        padding: 0;
        background-color: #f0f0f0;
        font-family: "Lucida Grande", "Bitstream Vera Sans", "Verdana";
        font-size: 13px;
        color: #333;
      }
```

HTTP Responses

An HTTP Response contains information about the response in the header.

A response comes in a format HTML, JSON, XML, Binary (images,etc)

A response has a status code.

HTTP Status Codes

HTTP Status Codes

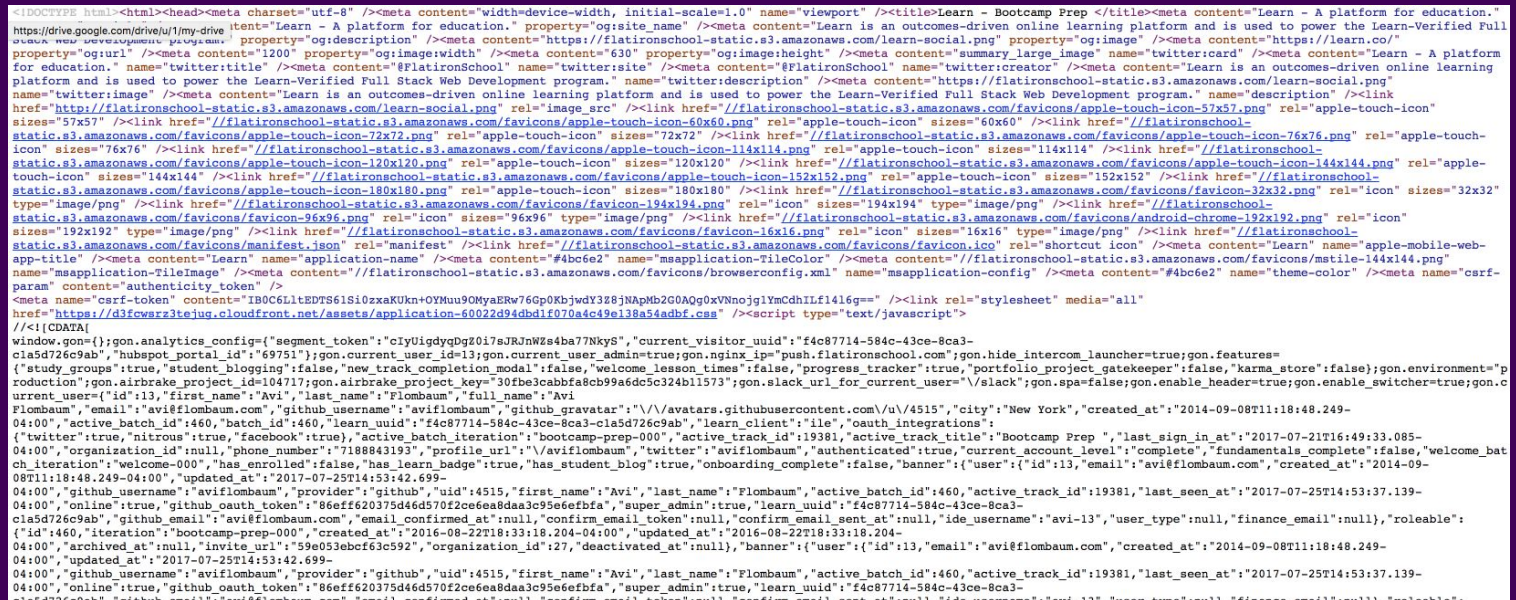
- 1xx - informational
- 2xx - success
- 3xx - redirect
- 4xx - error
- 5xx - server error

Sending Back HTML

The server sends back HTML from a file to your browser, which turns it into a graphical representation.

HTTP Response in the form of HTML

HTML: The Language of the Web



Responding to HTTP

Anything can do it, any language, that's the beauty of the format, it's all about abstraction.

RAILS

node JS

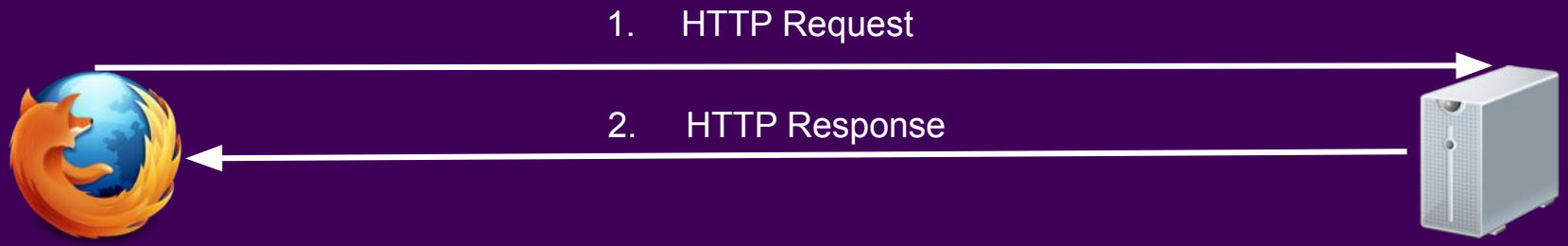
django

spring

Client / Server Model

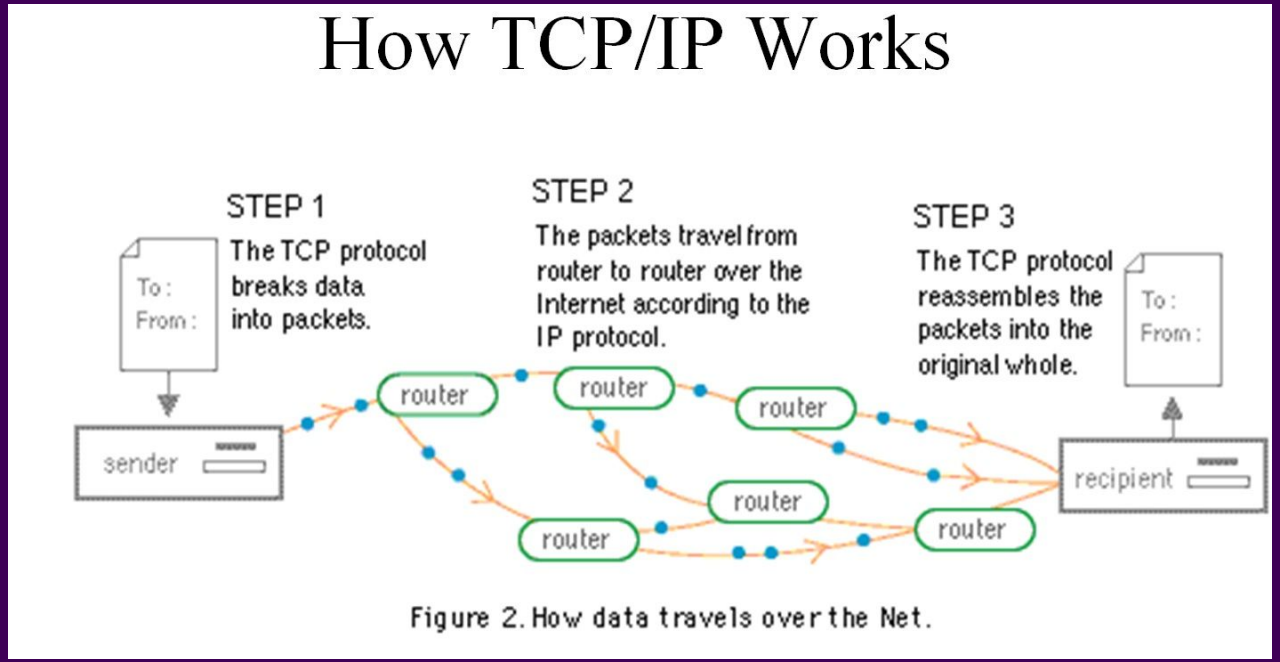
A global game of catch.

1. Clients make requests for information via HTTP.
2. Servers receive requests and then send HTTP responses.
3. Clients processes the response, generally rendering it graphically via the browser.



TCP/IP is the Backend

All these HTTP formatted requests and responses are sent via TCP/IP across the internet.



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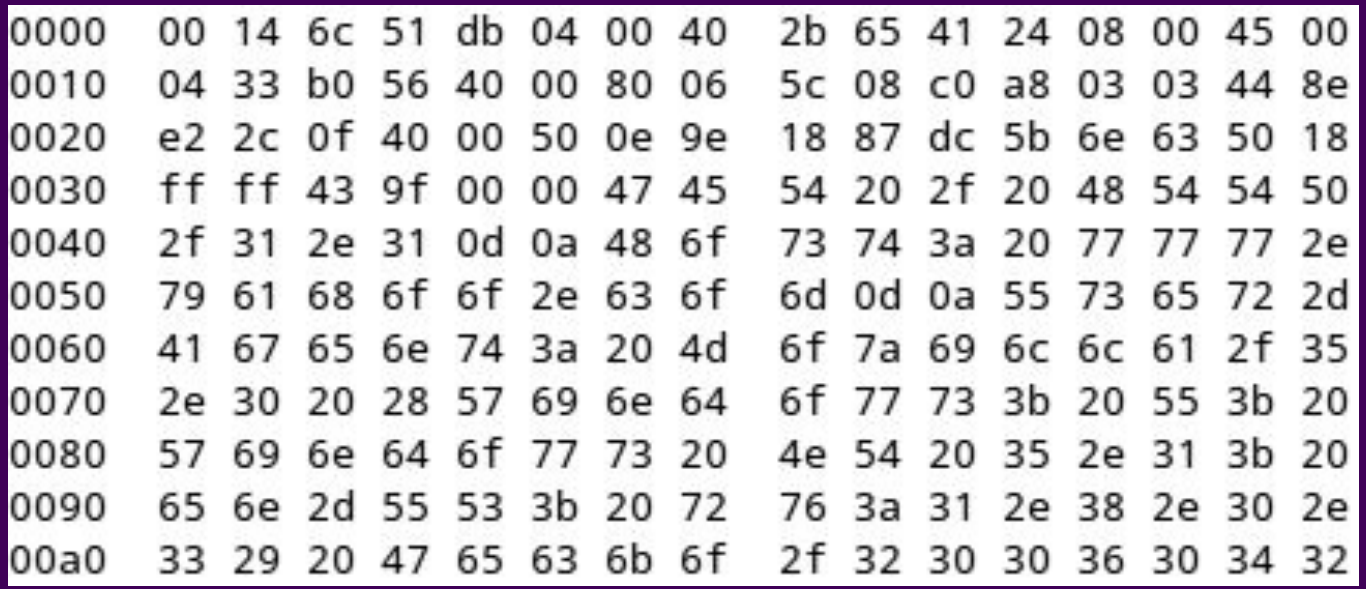


```
0000  00 14 6c 51 db 04 00 40  2b 65 41 24 08 00 45 00
0010  04 33 b0 56 40 00 80 06  5c 08 c0 a8 03 03 44 8e
0020  e2 2c 0f 40 00 50 0e 9e  18 87 dc 5b 6e 63 50 18
0030  ff ff 43 9f 00 00 47 45  54 20 2f 20 48 54 54 50
0040  2f 31 2e 31 0d 0a 48 6f  73 74 3a 20 77 77 77 2e
0050  79 61 68 6f 6f 2e 63 6f  6d 0d 0a 55 73 65 72 2d
0060  41 67 65 6e 74 3a 20 4d  6f 7a 69 6c 6c 61 2f 35
0070  2e 30 20 28 57 69 6e 64  6f 77 73 3b 20 55 3b 20
0080  57 69 6e 64 6f 77 73 20  4e 54 20 35 2e 31 3b 20
0090  65 6e 2d 55 53 3b 20 72  76 3a 31 2e 38 2e 30 2e
00a0  33 29 20 47 65 63 6b 6f  2f 32 30 30 36 30 34 32
```

Domains and DNS

Where do requests go?

GitHub.com

DNS Servers lookup the domain and correspond it to an IP Address

- Local machine
- Home router
- ISP
- Upstream provider
- Root Name Servers
- TLD Name Servers

140.82.112.3

Web Sites vs Web Applications

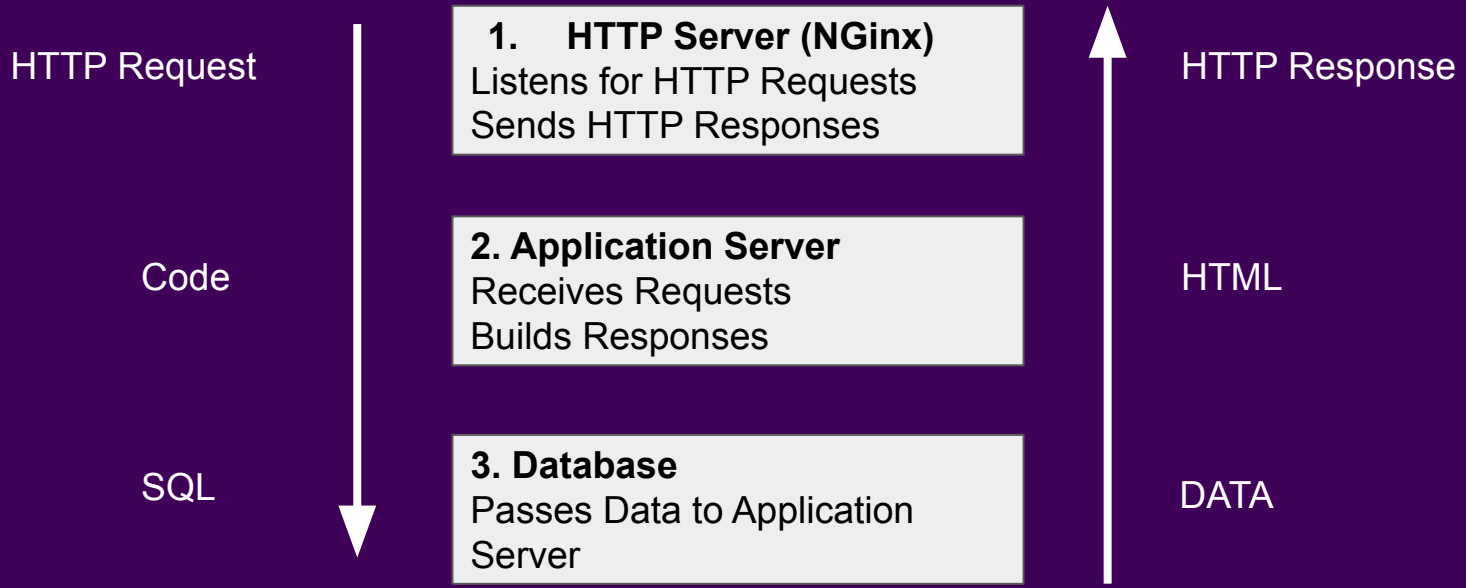
Static Sites

1. Receive a request
2. Naive processing
3. Serve response from filesystem.
4. Rarely any interactivity.
5. No write ability.
6. Doesn’t change often.

Dynamic Sites

1. Receive a request
2. Routing
3. Integrate a data source.
4. Compose a response.
5. Provide write ability.
6. Use programming languages for logic.
7. Change all the time.

Web Application Stack



HTTP Summary

1. Standard Protocol (format) for HTTP Requests/Responses over TCP/IP
2. Clients are anything that makes an HTTP Request and can receive a response.
3. A Web Application is responsible for receiving HTTP requests and sending an HTTP response.
4. HTTP Responses are formatted text with response header and status and a body (generally HTML or JSON).
5. Web Applications provide dynamic responses to HTTP requests.

URLs are Everything

“The most important thing that was new was the idea of URI-or URL, that any piece of information anywhere should have an identifier, which will allow you to get hold of it.”

Tim Berners-Lee

Clients make requests to URLs.

Our applications respond to requests to URLs.

- get ‘/’ - loading the homepage
- get ‘/questions/new’ - clicking on the “New Question” link
- post ‘/questions’ - submitting the “New Question” form
- get ‘/questions’ - redirecting to list all the questions.

Our application code has to respond to all these requests. We map URLs to discrete application logic to process the request and respond with HTML.

An HTTP Request to Response is typically a 200ms roundtrip.

As I said, it’s basically magic.

You can become a magician, a sorcerer, part of this timeless narrative of people leveraging technology to make a better world by helping us connect.

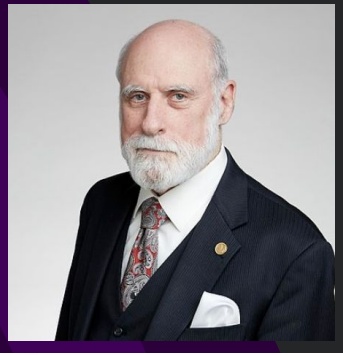
Kilby, Noyce, Faggin and XParc Invent Modern Computing 60-70s

The Integrated Circuit creates reliable and significantly smaller computers and Kilby makes Texas Instruments and Noyce makes Intel.

Faggin invents the CPU and the computational power of computers doubles every year (Moore's Law)

Adele Goldberg and Alan Kay at Xerox Palo Alto Research Center invents everything, the personal computer, object orientation, ethernet, the mouse, the graphic user interface, just everything. Apple steals it all.

Vint Cerf Networks All the Computers Together - 1982



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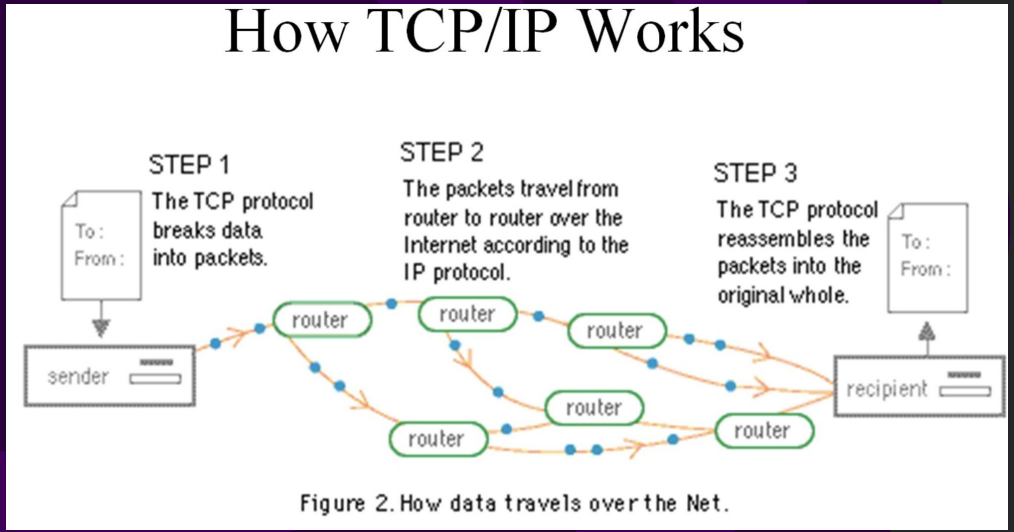
The internet is born but it's mostly used by government and universities for POP, SMTP, FTP, and USENET.



Ben Franklin Discovers Electricity - 1752 CE

1.21 Gigawatts?!?!

Electricity is an important part of this story as it will provide the power for the machines a medium to transfer information.

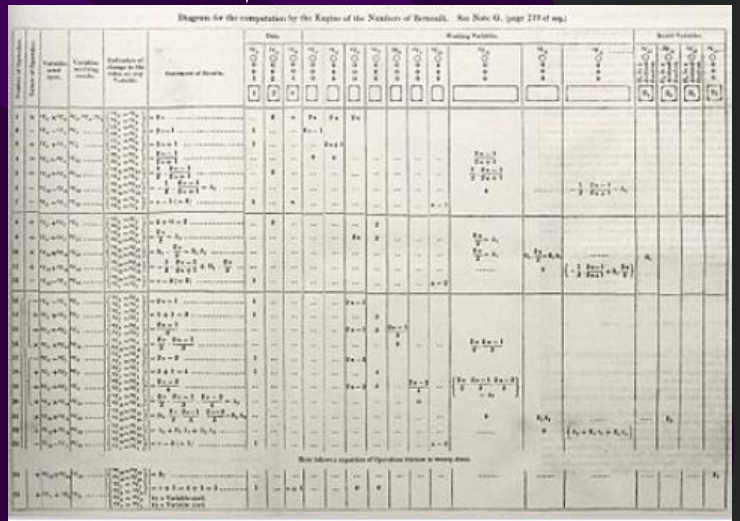
Babbage and Lovelace on Thinking Machines 1819-1840 CE

First the Difference Engine, for solving polynomial equations, and then the theoretical Analytical Engine, which can be “operated” to solve anything.

Ada Lovelace describes the future of Thinking Machines:

"A new, a vast, and a powerful language is developed for the future use of analysis, in which to wield its truths so that these may become of more speedy and accurate practical application for the purposes of mankind."

“The science of operations, as derived from mathematics more especially, is a science of itself, and has its own abstract truth and value.”



Lovelace's diagram from Note G, the first published computer algorithm

Michael Faraday Harness Electricity - 1845 CE

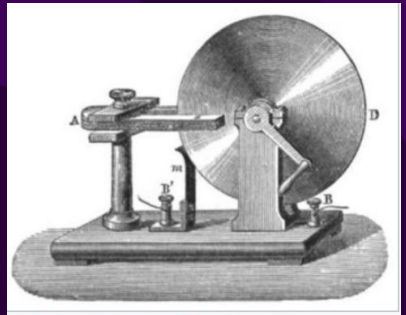
Electricity and Magnetism are not 2 separate forces, but one interconnected force, electromagnetism, each capable of influencing the other.

Spinning a magnetic around a copper coil generates electricity through the movement of electrons in the coil.

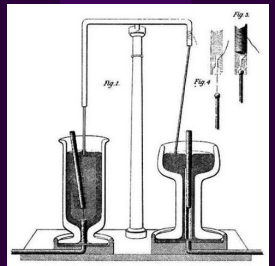
Electrify a magnetic and you can reverse it's polarity, turning negative to positive.

With a magnet and electricity you can create motion, known as a motor.

With motion, say from steam, you can spin a magnet to generate electricity, known as a generator.



Built in 1831, the Faraday disk was the first electric generator. The horseshoe-shaped magnet *(A)* created a magnetic field through the disk *(D)*. When the disk was turned, this induced an electric current radially outward from the center toward the rim. The current flowed out through the sliding spring contact *m*, through the external circuit, and back into the center of the disk through the axle.



Electromagnetic rotation experiment of Faraday, *ca.* 1821[39]

Nikola Tesla Creates a Modern World - 1886/89/93 CE

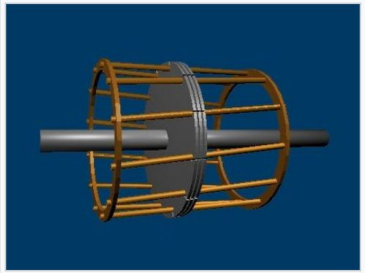
Tesla invents Alternating Current that can transport electricity at great distances.

He creates the modern turbines used for generating huge quantities of electricity, including those used in Niagra Falls and the Hoover Dam.

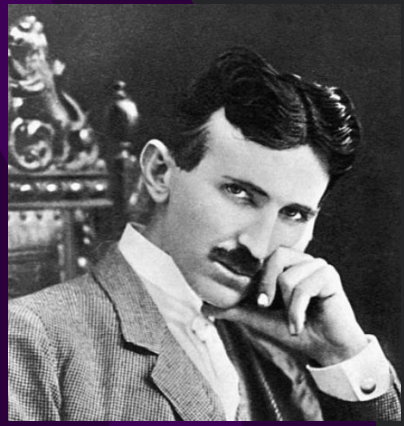
He describes the earth as having “Acoustical Resonance,” capable of amplifying and bouncing waves back and forth, allowing for wireless communication.

The world is now electrified and connected.

A model of Tesla's first induction motor, in Tesla Museum, Belgrade



Squirrel cage rotor construction, showing only the center three laminations



Okay, let’s move a little faster. Nothing super important happens from 1900-1940.

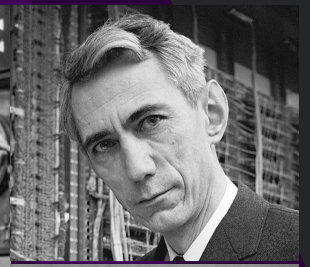
Want to try to guess why?

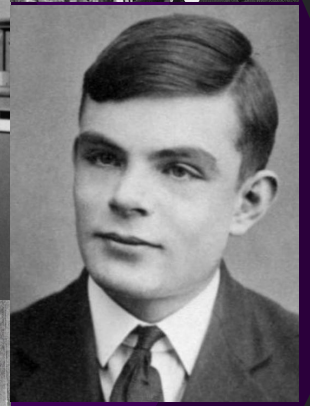
Turing, Shannon, and Hopper Invent Computing 40-50s

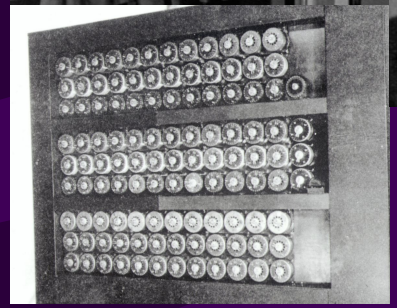
Alan Turing invents the first “universal machine” - the Manchester Mark 1 (watch Imitation Game it’s great).

Grace Hopper also works on one of the first computers in WW2 to solve imploding sphere problem and then after the war invents the idea of a “Compiler” and “Human Readable” code - COBAL. She was 39 when she started in computing.

Shannon coins the unit of measurement of a bit, creates information theory, a mathematical way of unifying all data into a singular notion.







A Mathematical Theory of Communication

“Information is the resolution of uncertainty, the negative reciprocal value of probability. One bit is typically defined as the uncertainty of a binary random variable that is 0 or 1 with equal probability, or the information that is gained when the value of such a variable becomes known.” Claude Shannon

“What lies at the heart of every living thing is not a fire, not warm breath, not a ‘spark of life’. It is information, words, instructions. If you want to understand life don’t think about vibrant, throbbing gels and oozes, think about information technology.” Richard Dawkins, Biologist

“It from Bit, every it, every particle, every field of force, even the space-time continuum itself. What we call reality, arises in the last analysis of posing of yes or no questions. All things physical are information-theoretic in origin, and this is a participatory universe. The whole universe is a thus seen as a computer - a cosmic information processing machine.” Archibald Wheeler, Physicist

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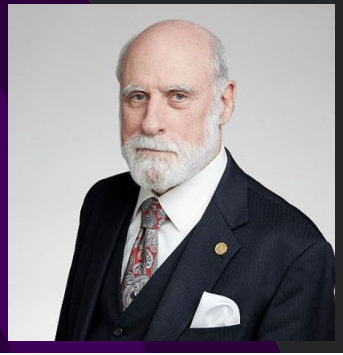

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