CS50T

By Eng. Rasha Abdeen

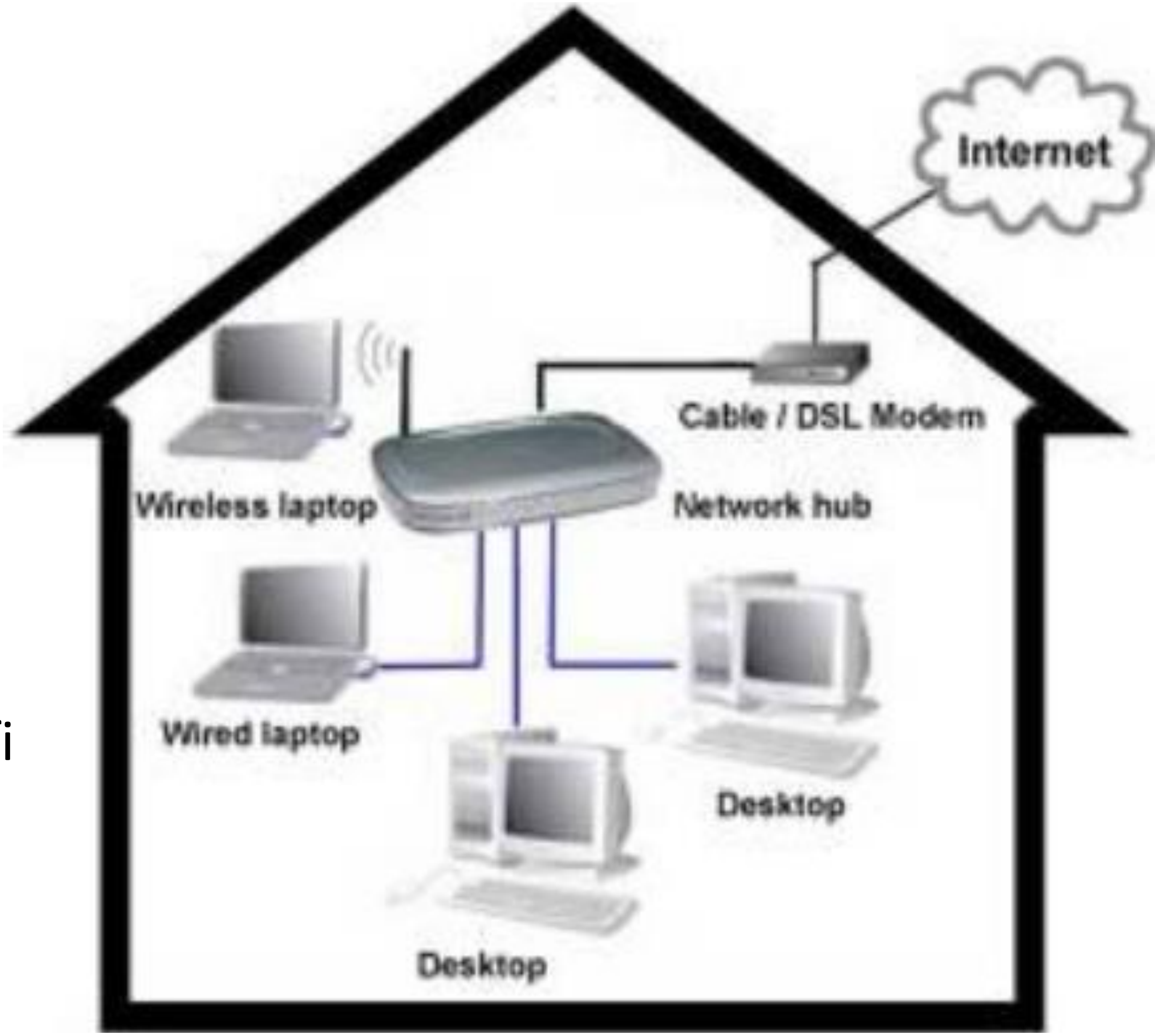
Youtube: Coders Camp
https://youtube.com/playlist?list=PLnrlZUDQofUvLtIMvVxZRYYju7ni0Xsxq

Lecture 2 : Internet

- IP
- DNS
- Packets
- TCP/IP
- Ports
- Protocols
- UDP
- Routers
- Traceroute
- Undersea Cabling
- Cable Modem Demo

What is the Internet?

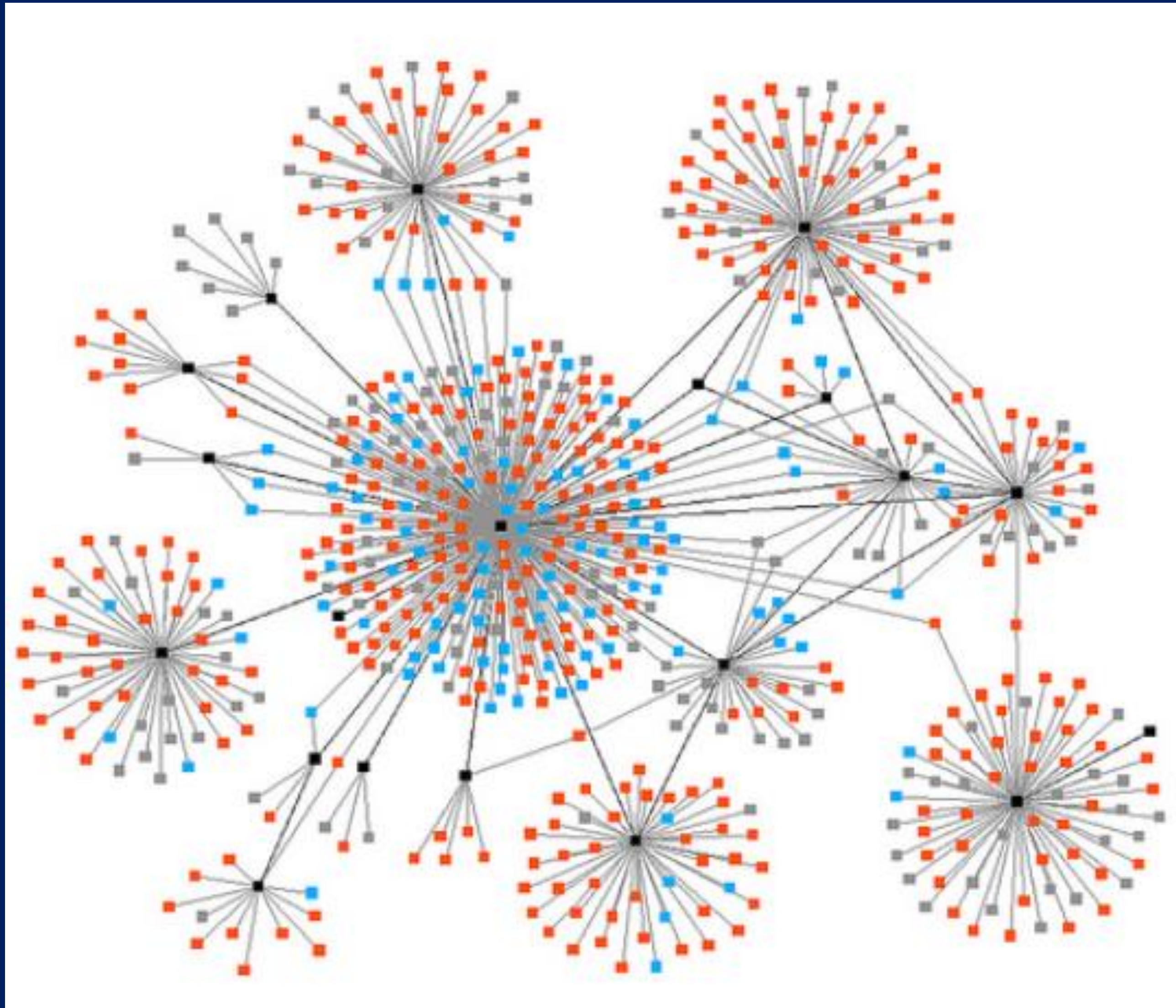
- Cable modem, DSL modem, or FIOS device
  Connects to the internet
  - Pay monthly for an ISP (Internet Service Provider)
- Devices connect to a router via cables or wifi

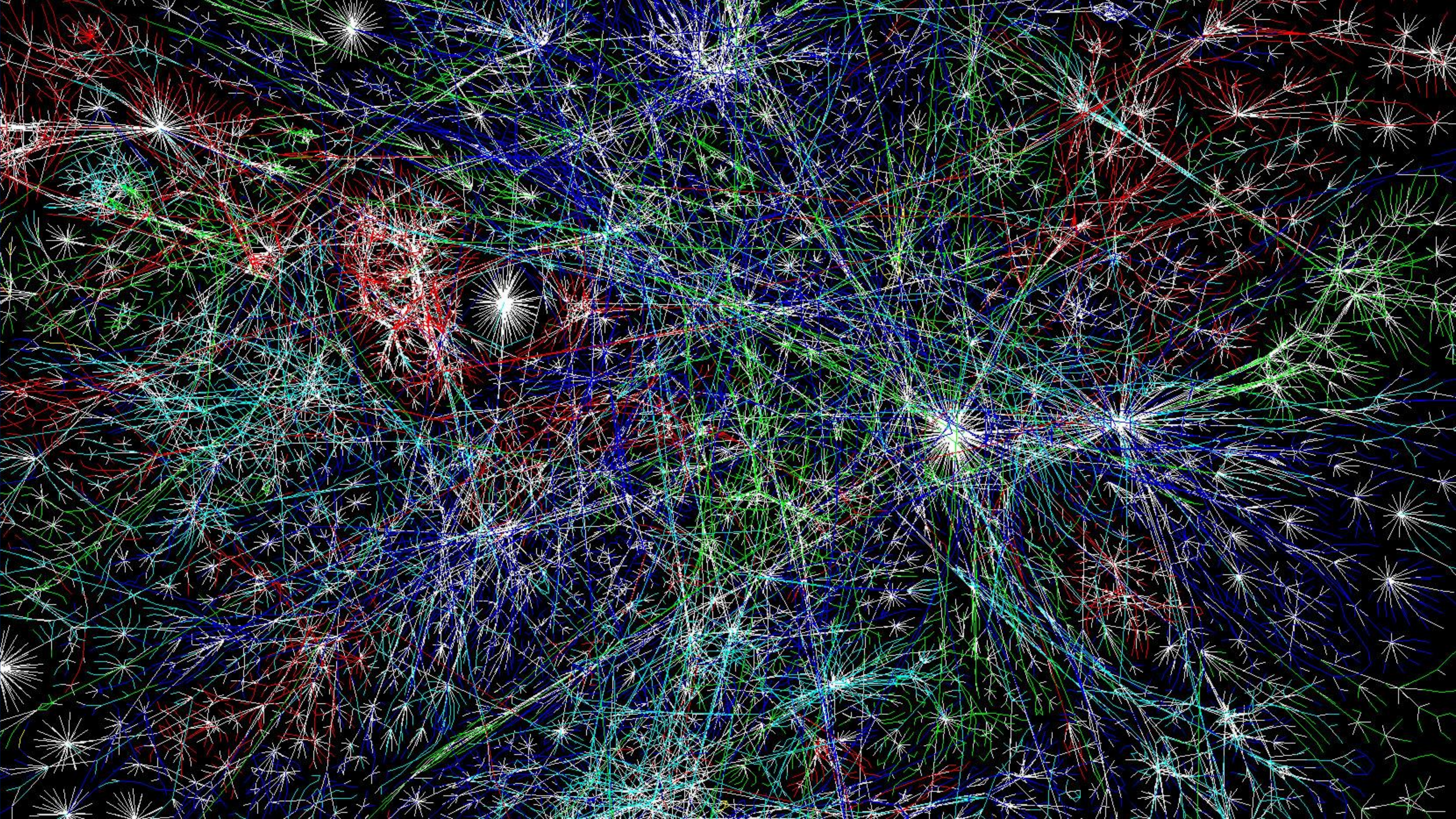


What is the Internet?

Infrastructure:

Network of Networks.





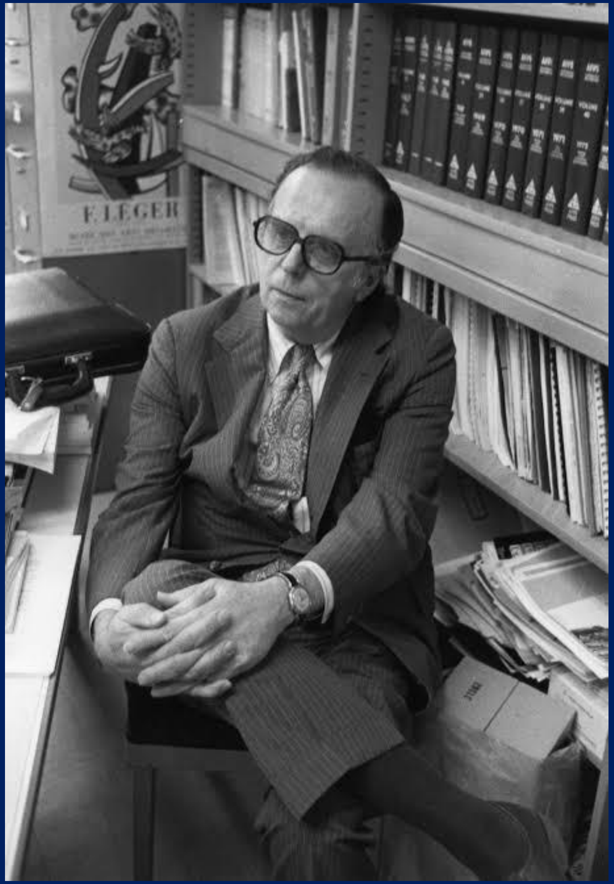
What is the Internet?

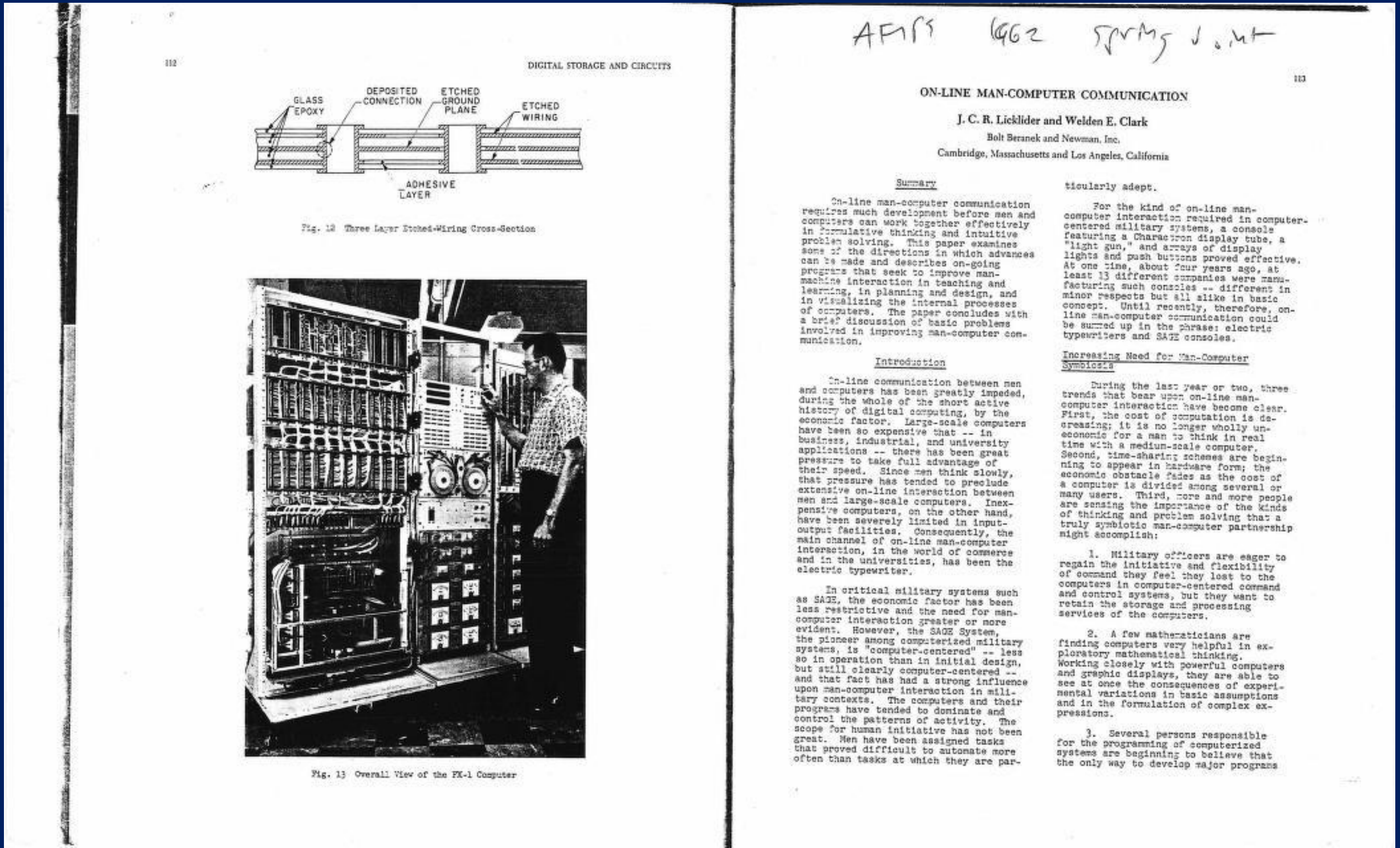
Infrastructure:

Network of Networks.

What is the Internet?

History:





GLASS EPOXY
DEPOSITED CONNECTION
ETCHED GROUND PLANE
ETCHED WIRING
ADHESIVE LAYER

Fig. 12 Three Layer Etched-Wiring Cross-Section

Fig. 13 Overall View of the FX-1 Computer

AFIPS 1962 Spring Joint

ON-LINE MAN-COMPUTER COMMUNICATION

J. C. R. Licklider and Welden E. Clark

Bolt Beranek and Newman, Inc.

Cambridge, Massachusetts and Los Angeles, California

Summary

On-line man-computer communication requires much development before men and computers can work together effectively in formulative thinking and intuitive problem solving. This paper examines some of the directions in which advances can be made and describes on-going programs that seek to improve man-machine interaction in teaching and learning, in planning and design, and in visualizing the internal processes of computers. The paper concludes with a brief discussion of basic problems involved in improving man-computer communication.

Introduction

On-line communication between men and computers has been greatly impeded, during the whole of the short active history of digital computing, by the economic factor. Large-scale computers have been so expensive that -- in business, industrial, and university applications -- there has been great pressure to take full advantage of their speed. Since men think slowly, that pressure has tended to preclude extensive on-line interaction between men and large-scale computers. Inexpensive computers, on the other hand, have been severely limited in input-output facilities. Consequently, the main channel of on-line man-computer interaction, in the world of commerce and in the universities, has been the electric typewriter.

In critical military systems such as SAGE, the economic factor has been less restrictive and the need for man-computer interaction greater or more evident. However, the SAGE System, the pioneer among computerized military systems, is "computer-centered" -- less so in operation than in initial design, but still clearly computer-centered -- and that fact has had a strong influence upon man-computer interaction in military contexts. The computers and their programs have tended to dominate and control the patterns of activity. The scope for human initiative has not been great. Men have been assigned tasks that proved difficult to automate more often than tasks at which they are particularly adept.

For the kind of on-line man-computer interaction required in computer-centered military systems, a console featuring a Charactron display tube, a "light gun," and arrays of display lights and push buttons proved effective. At one time, about four years ago, at least 13 different companies were manufacturing such consoles -- different in minor respects but all alike in basic concept. Until recently, therefore, on-line man-computer communication could be summed up in the phrase: electric typewriters and SAGE consoles.

Increasing Need for Man-Computer Symbiosis

During the last year or two, three trends that bear upon on-line man-computer interaction have become clear. First, the cost of computation is decreasing; it is no longer wholly uneconomic for a man to think in real time with a medium-scale computer. Second, time-sharing schemes are beginning to appear in hardware form; the economic obstacle fades as the cost of a computer is divided among several or many users. Third, more and more people are sensing the importance of the kinds of thinking and problem solving that a truly symbiotic man-computer partnership might accomplish:

1. Military officers are eager to regain the initiative and flexibility of command they feel they lost to the computers in computer-centered command and control systems, but they want to retain the storage and processing services of the computers.

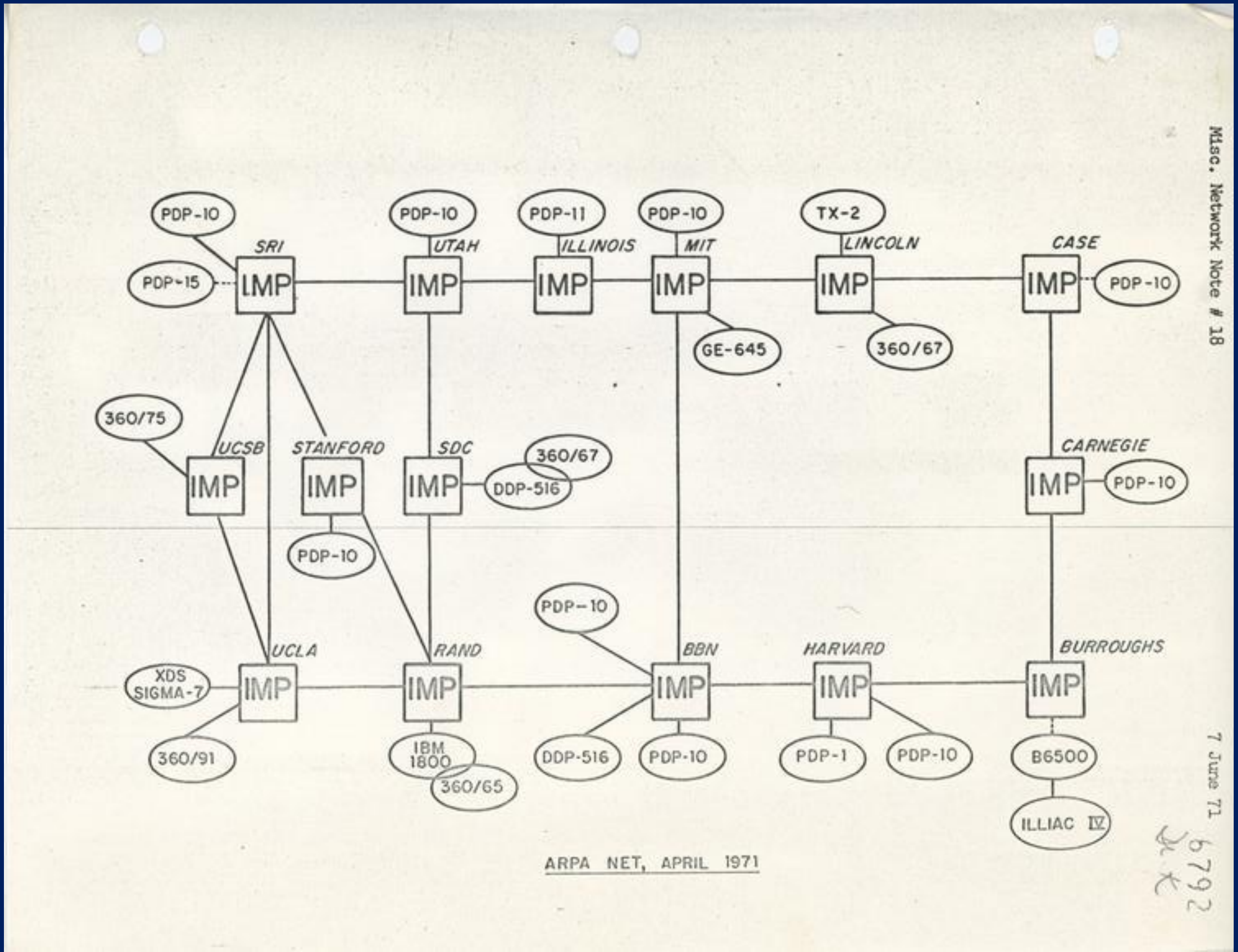
2. A few mathematicians are finding computers very helpful in exploratory mathematical thinking. Working closely with powerful computers and graphic displays, they are able to see at once the consequences of experimental variations in basic assumptions and in the formulation of complex expressions.

3. Several persons responsible for the programming of computerized systems are beginning to believe that the only way to develop major programs

What is the Internet?

History:

ARPANET (Advanced Research Projects Agency Network)



Internet

Internet

Protocols:

- A way of communicating - more specifically, a protocol is a set of rules or conventions that computers or computer programs use while communicating with each other

Internet

IP Address
(Internet Protocol Address)

- Every computer on the internet has an IP (Internet Protocol) address
  - Like postal addresses, they uniquely identify computers on the internet
    - Any device connected to the internet has an IP address
  - Of the form #.#.#.#
    - Four numbers separated by dots of the values 0-255.
    - Other IP address formats exist today as well.
- ISPs assign a IP address to your computer (router)
  - Used to be physically configured

#.#.#.#

Internet

IP Address

(Internet Protocol Address)

#.#.#.#

8 bits. 8 bits. 8 bits. 8 bits

0-255.0-255.0-255.0-255

32 bits

11111111111111111111111111111111

version of addresses is IPv4

2^{32} = 4294967296

4 billion possible addresses

Internet

IP Address

(Internet Protocol Address)

IPv4	IPv6
32 bits	128 bits
2^{32} Possible addresses	2^{128} Possible addresses
192.168.10.150	3002:0bd6:0000:0000:0000:ee00:0033:6778

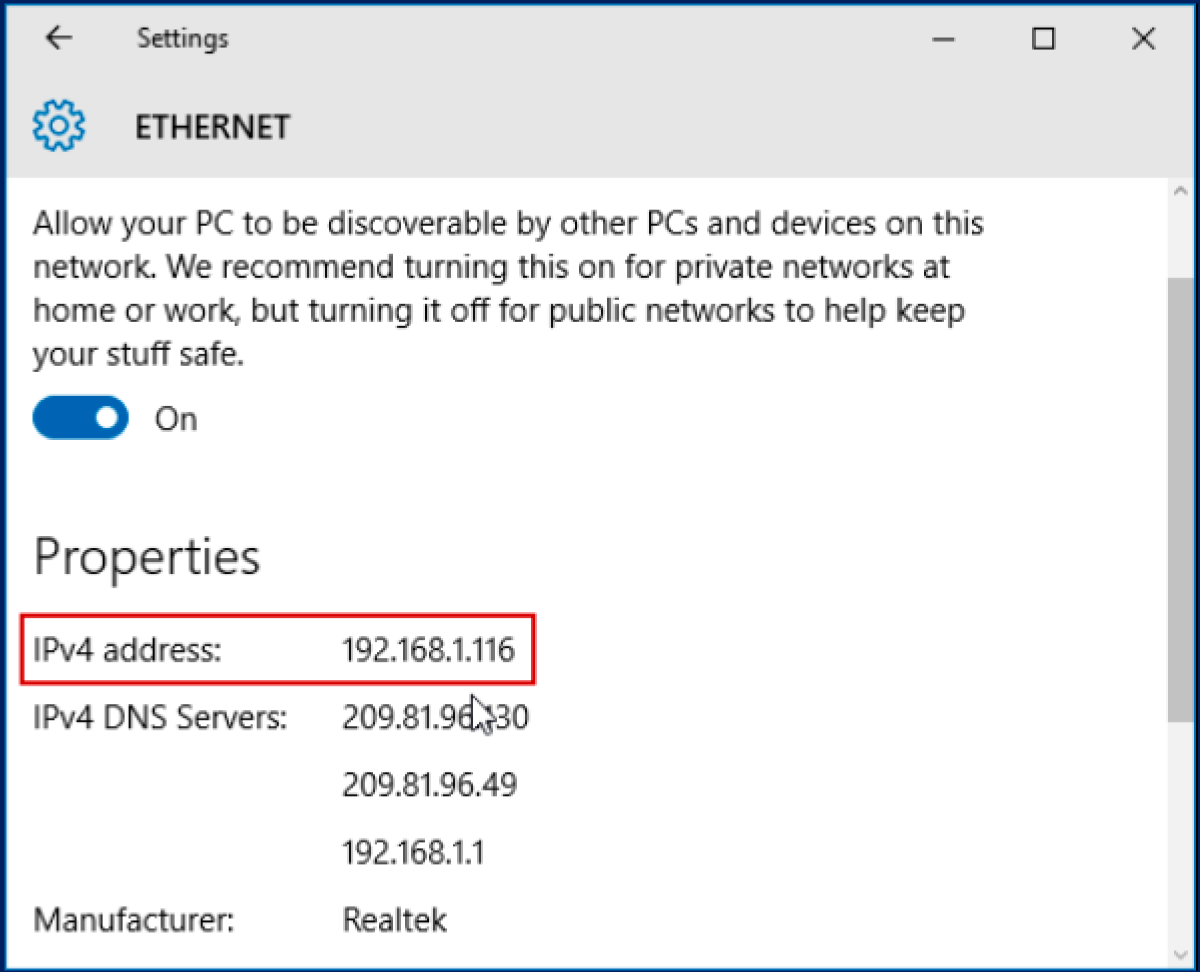
How do you find your IP address?

Internet

How do you find your IP address?

On windows:

- Private addresses exist
- 10.#.#.#, 192.168.#.#, or 172.16.#.#



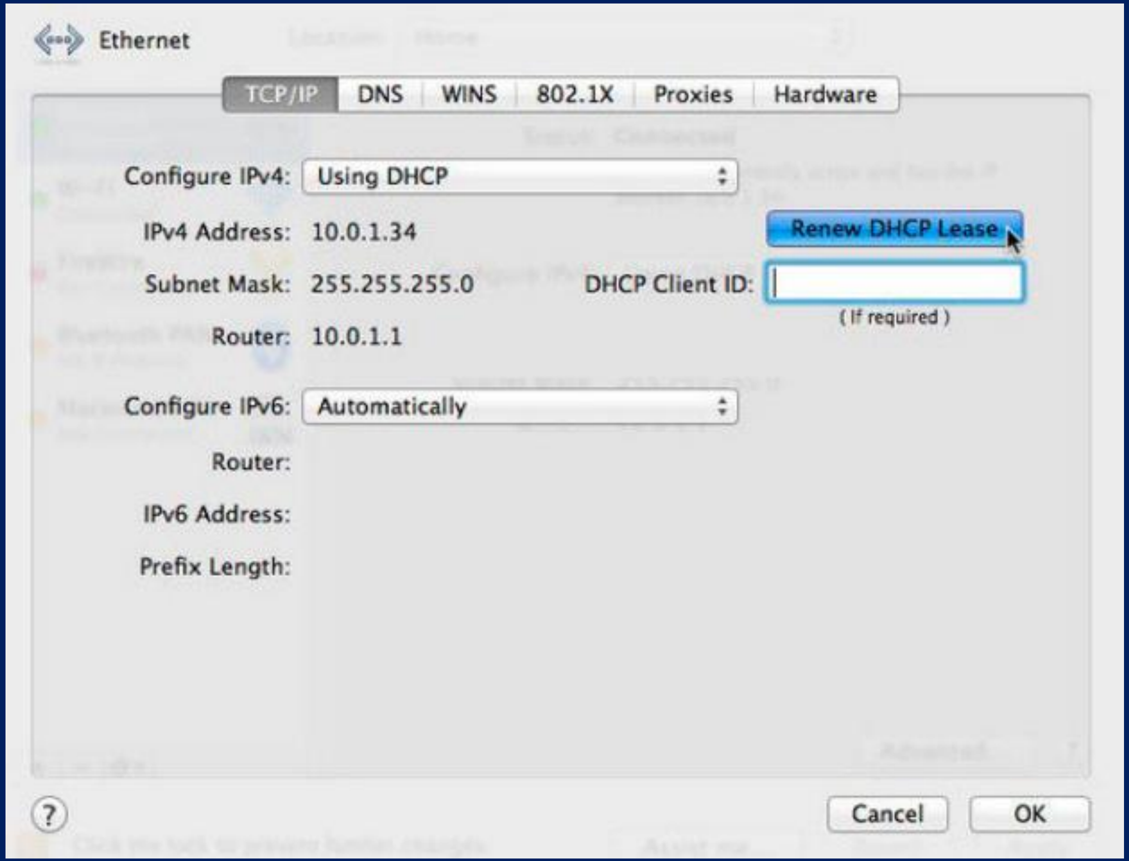
Internet

How do you find your IP address?

On a Mac, go to system preferences:

- Private addresses exist
- 10.#.#.#, 192.168.#.#, or 172.16.#.#

- Subnet mask is used to decide if another computer is on the same network
- Router (Gateway) has its own address
  Routs data in different directions



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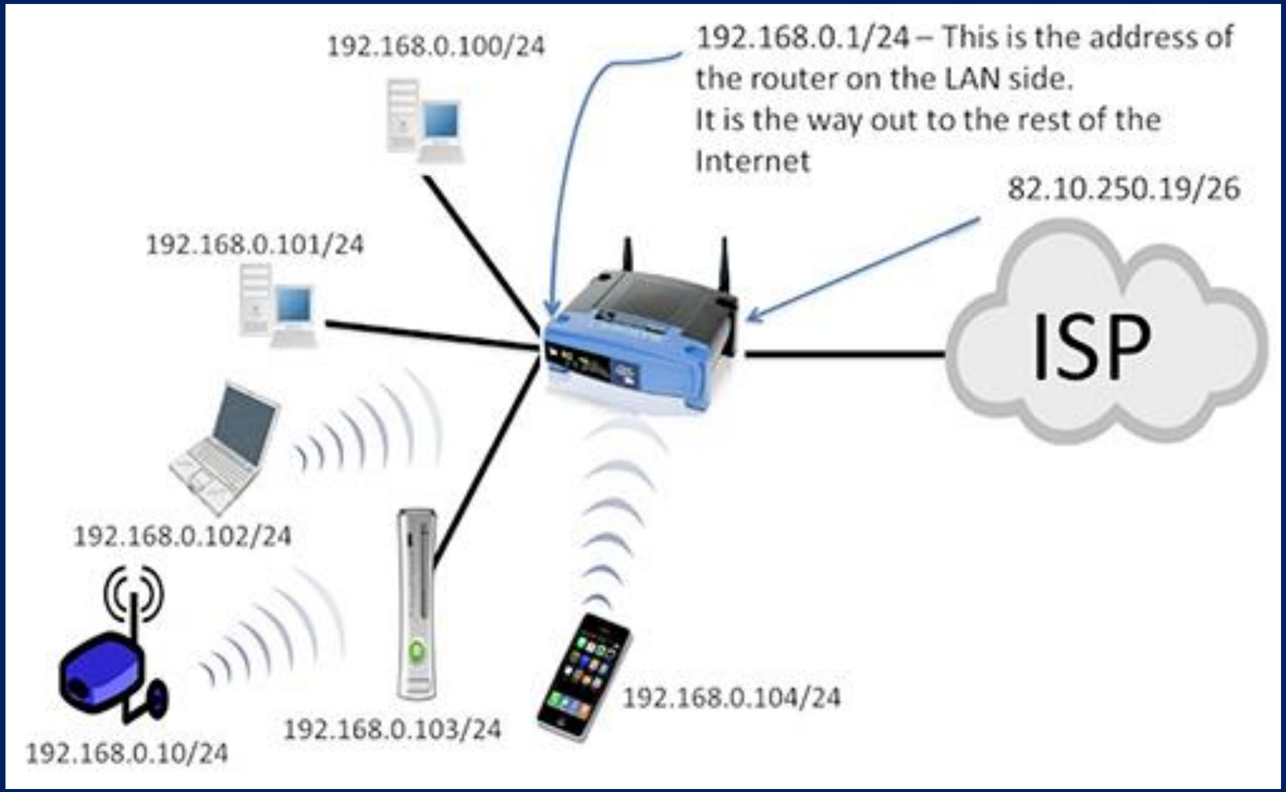


Internet

DHCP (Dynamic Host Configuration Protocol):

- Software that ISPs provides to allow your computer to request an IP address
- DHCP servers respond with a specific IP address for your Home
- Multiple devices can connect to your home network
- The home router supports DHCP and assigns IP addresses to your devices

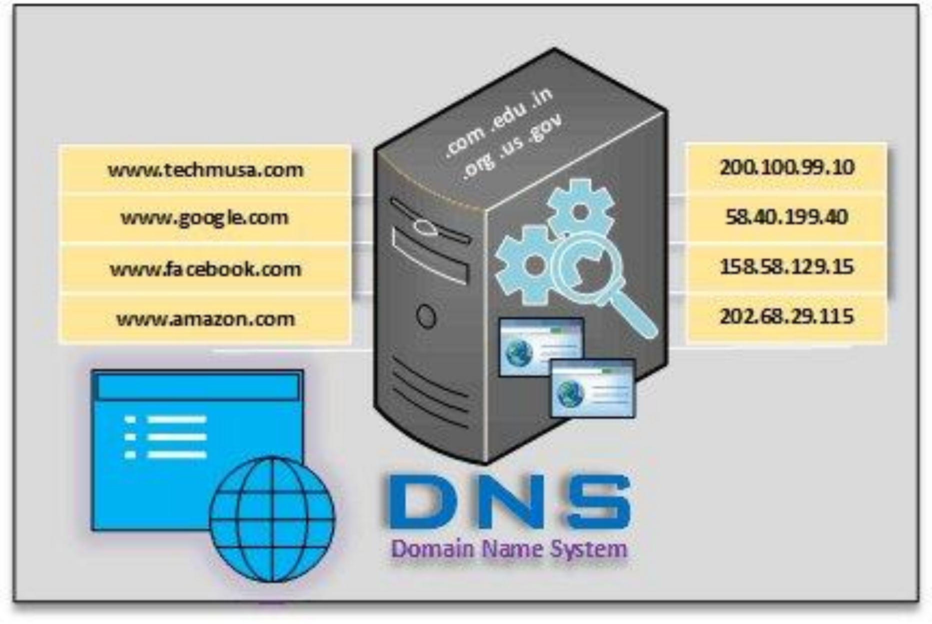
Internet

- Your personal device is not a server, so people should not need to access them directly
- Your device needs to request data from servers
- Even email is stored on a server such as Gmail and your device makes a request to that server to access that email

Internet

DNS (Domain Name System):

- We access websites using domain names (Facebook.com, Google.com, etc.), but it turns out that these sites too have IP addresses
- DNS (Domain Name System) servers convert domain names into IP addresses



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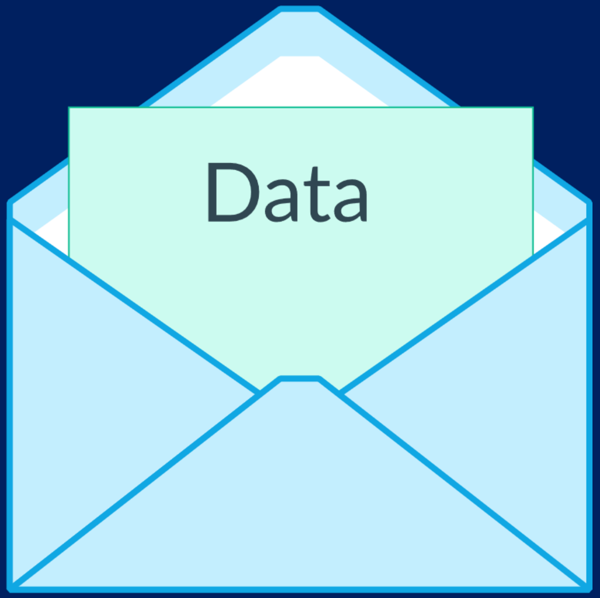

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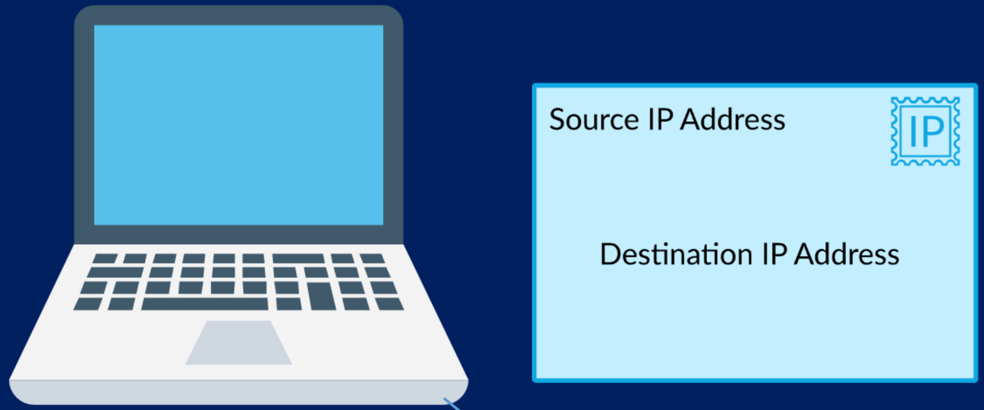


Send a request to our ISPs DNS server for Google’s IP address

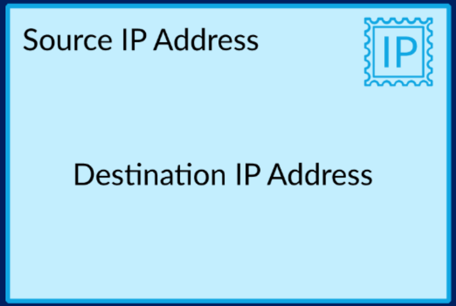
Internet

Source IP Address IP

Destination IP Address

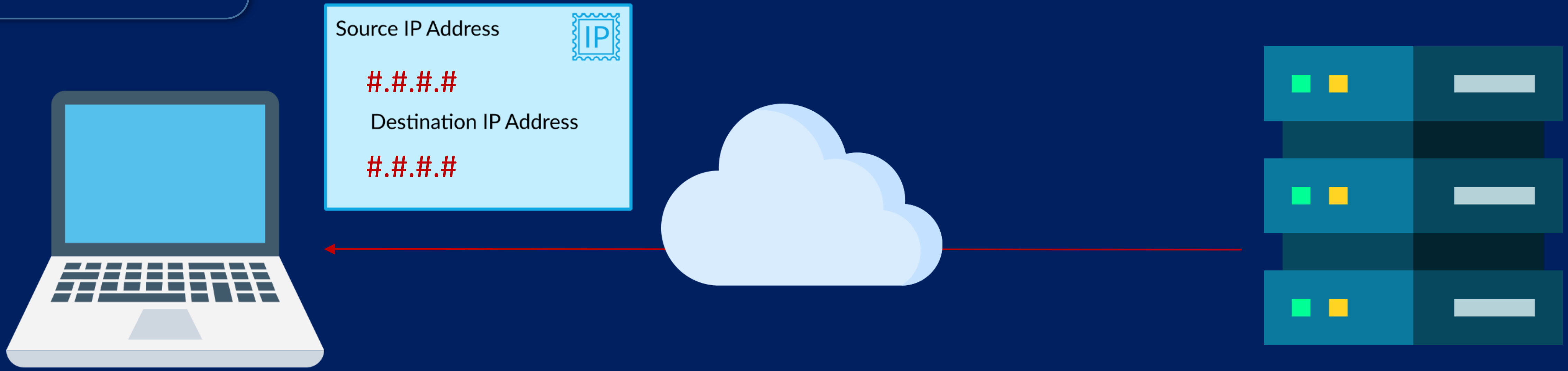
IP address for
Facebook.com

Internet

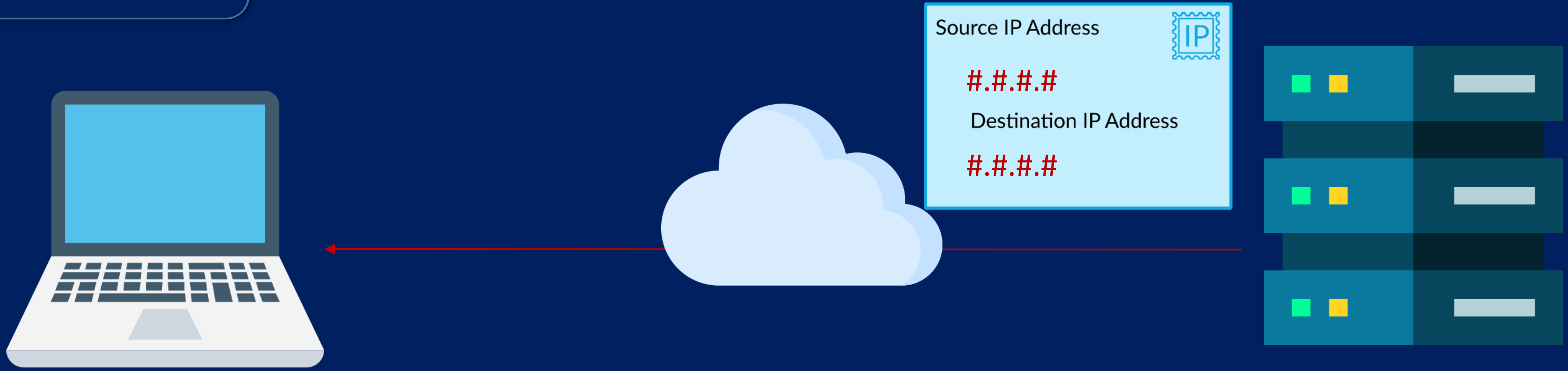


If the ISP's DNS server doesn't know a website's IP address, it has been configured to ask another DNS server

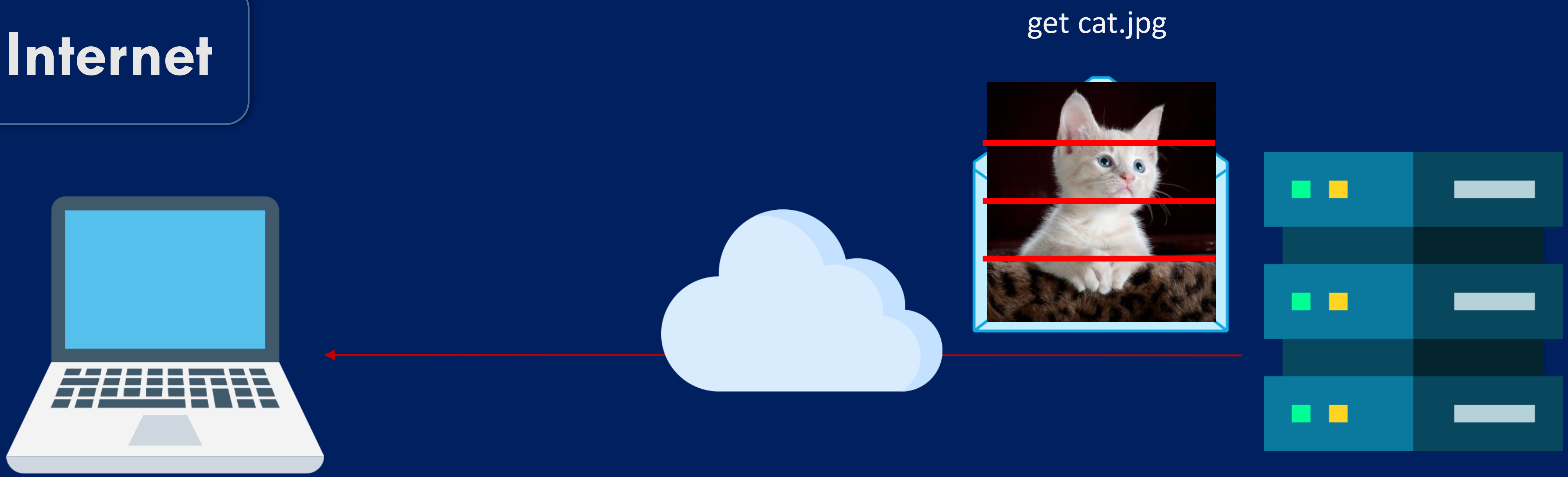
Internet



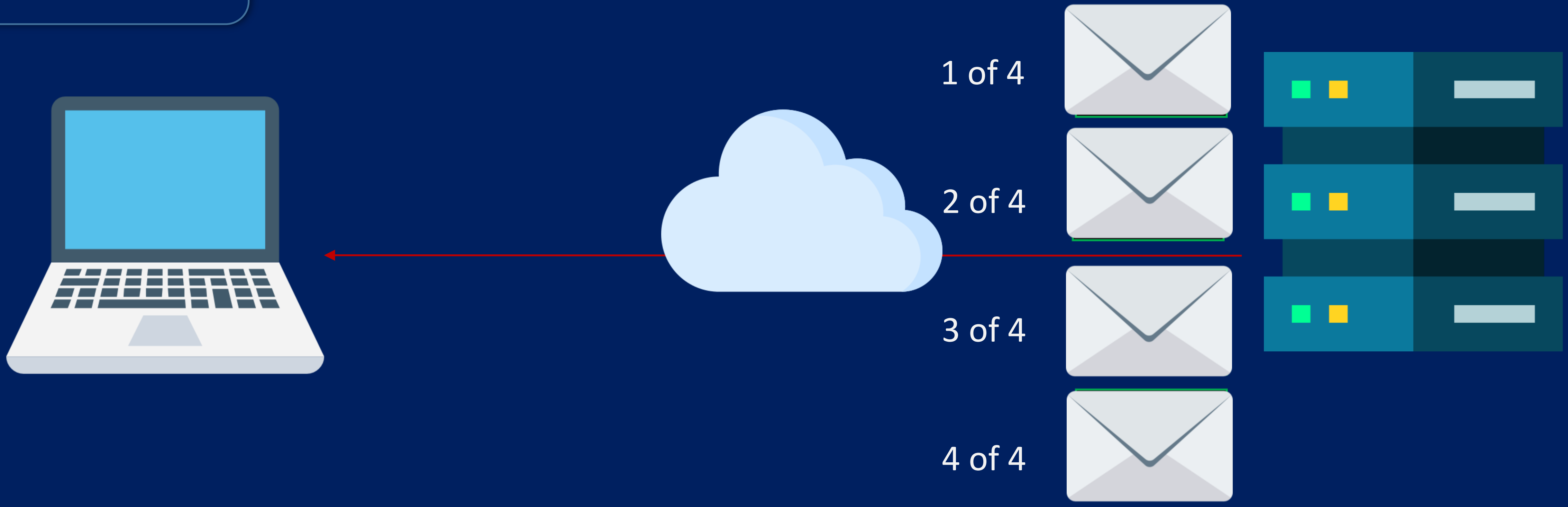
Internet



Internet



Internet



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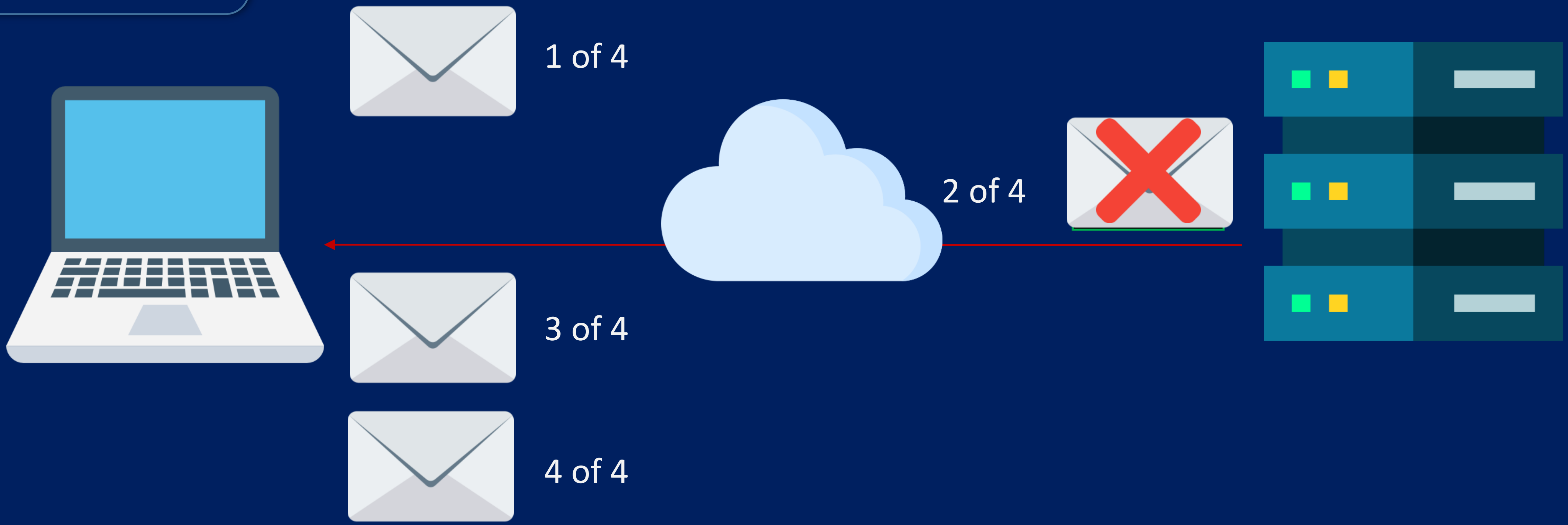

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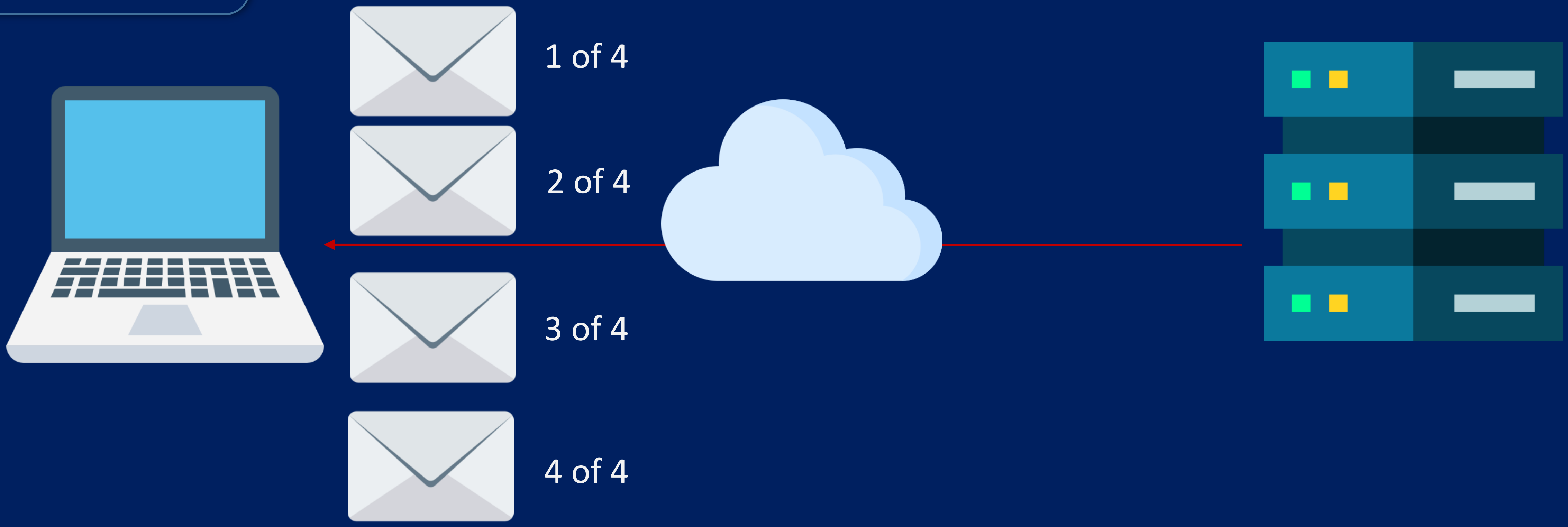

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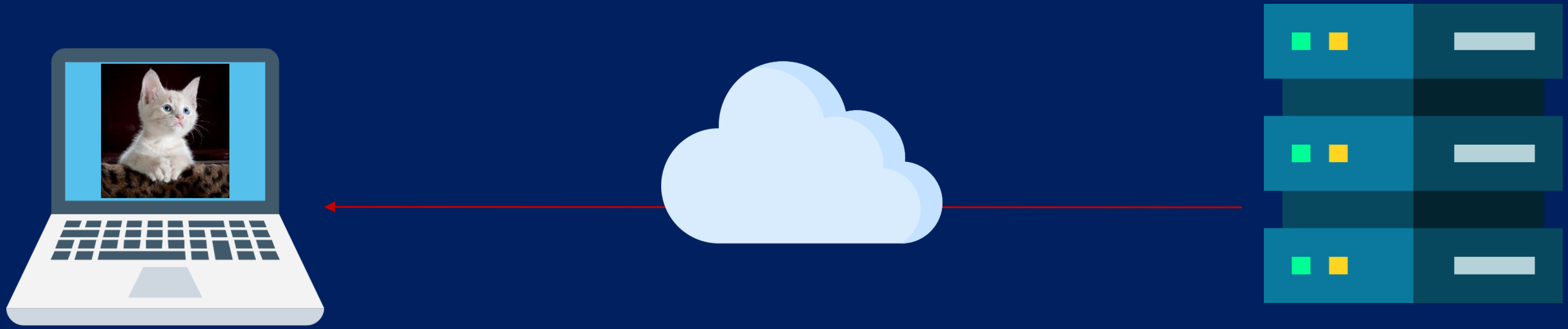


Internet

TCP/IP (Transmission Control Protocol):

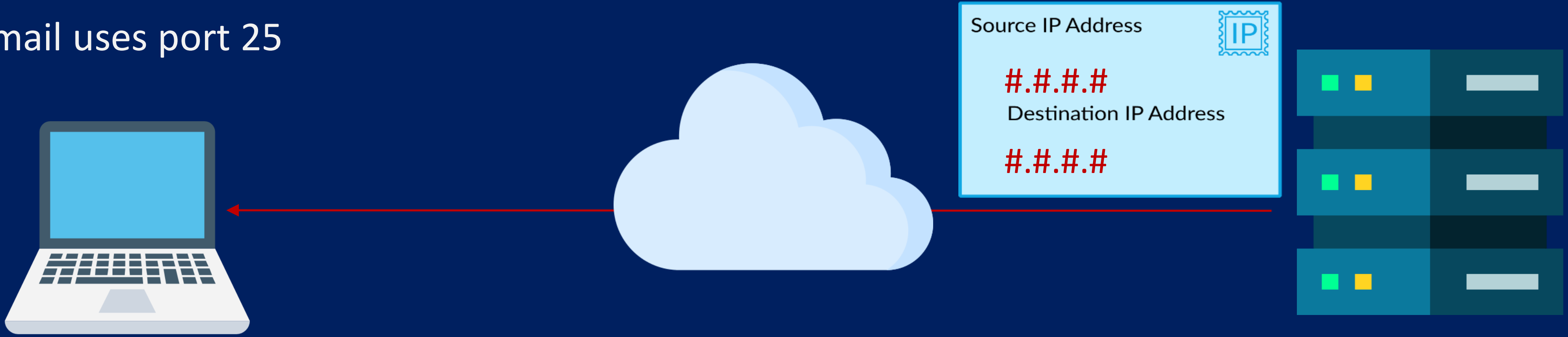
- TCP (Transmission Control Protocol) ensures packets can get to their destination
- Supports sequence numbers that help data get to its destination
- When missing a packet, a computer can make a request for the missing packet
- The computer will put packets together to get a whole file

Internet

TCP/IP (Transmission Control Protocol):

Ports Identifiers:

- Per TCP, the world has standardized numbers that represent different services
- 80 means http (hypertext transfer protocol)
- Many websites use secure connections with SSL or HTTPS, which uses the port 443
- Email uses port 25

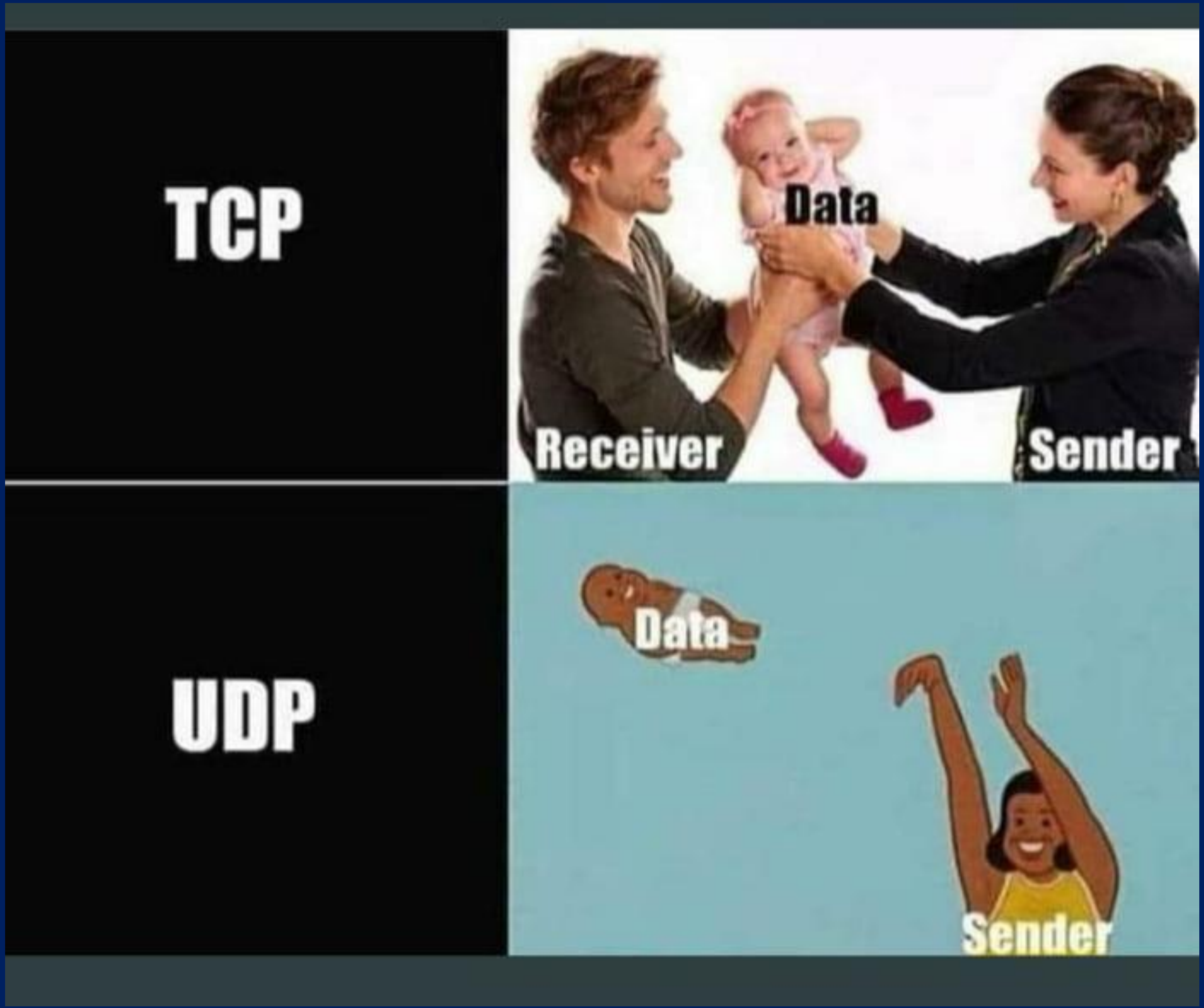


Internet

UDP (User Datagram Protocol)

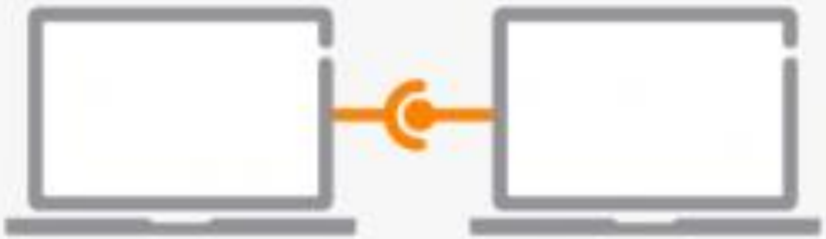
- Doesn’t guarantee delivery
- Packets can be dropped for the sake of keeping the conversation flowing
- Used anytime you want to keep data coming without waiting for a buffer to fill
- Used for video conferencing such as FaceTime

Internet



Internet

TCP



- Slower but more reliable transfers
- Typical Applications:
  - File Transfer Protocol (FTP)
  - Web Browsing
  - Email

UDP

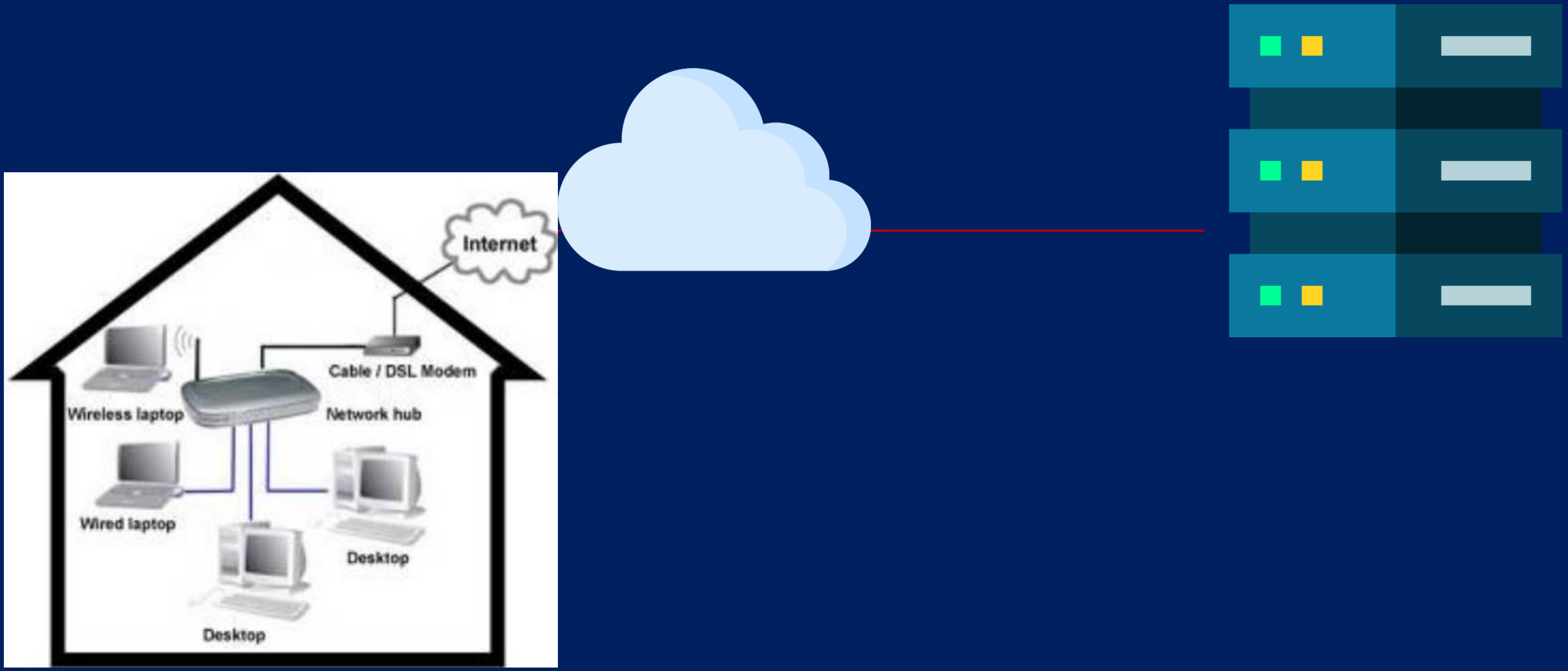
- Faster but not guaranteed transfers ("best effort")
- Typical Applications:
  - Live Streaming
  - Online Games
  - VoIP

Internet

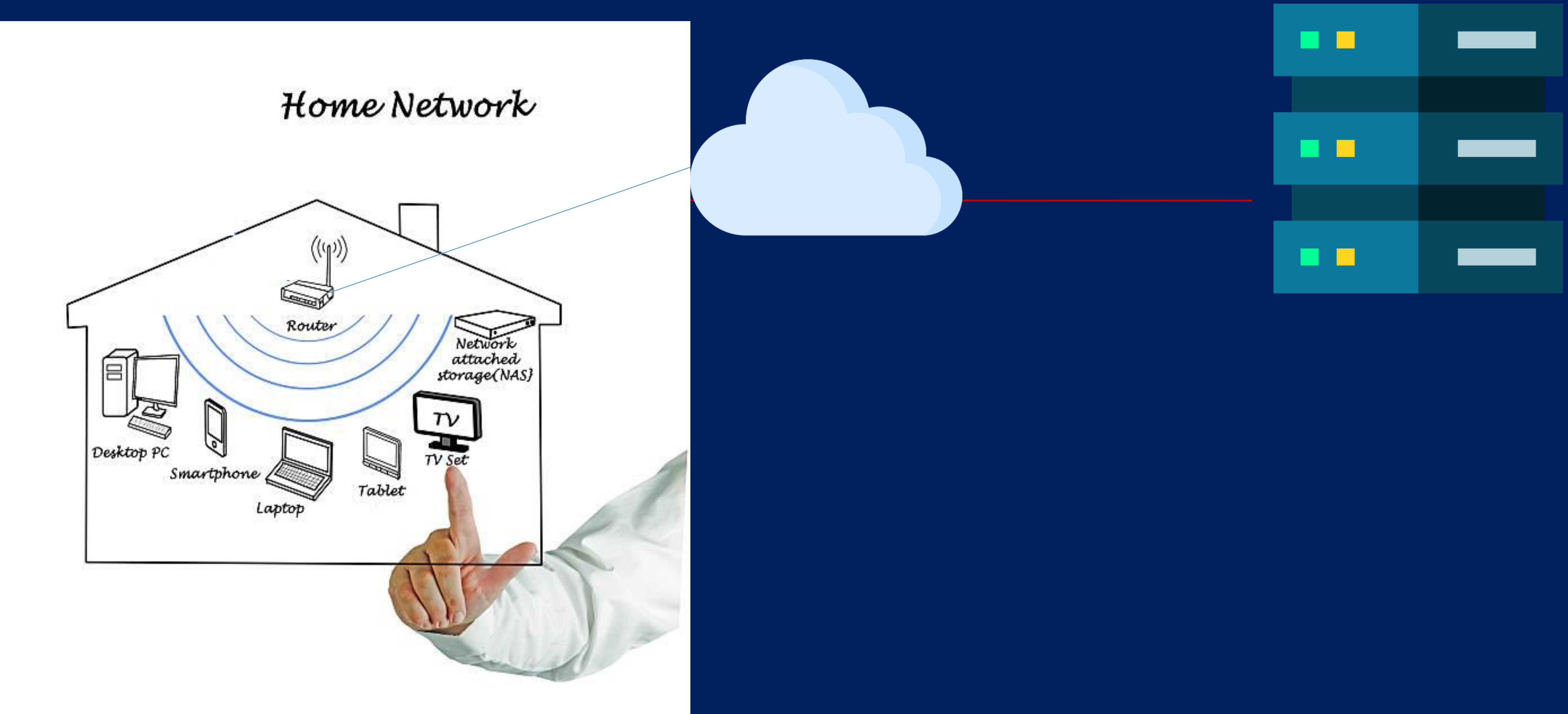
Routers:

- Routers have bunches if wires coming and going out of them
- They have a big table with IP addresses and where data should be routed to get to that destination
- Routers purpose is to send data in the direction of a destination
- The next router will send it to another until it reaches a destination
- Data will reach destination within 30 hops.
- Data can route across continents across countries across oceans in order to get from one place to another.

Internet


Internet
Cable / DSL Modem
Wireless laptop
Network hub
Wired laptop
Desktop
Desktop

Internet



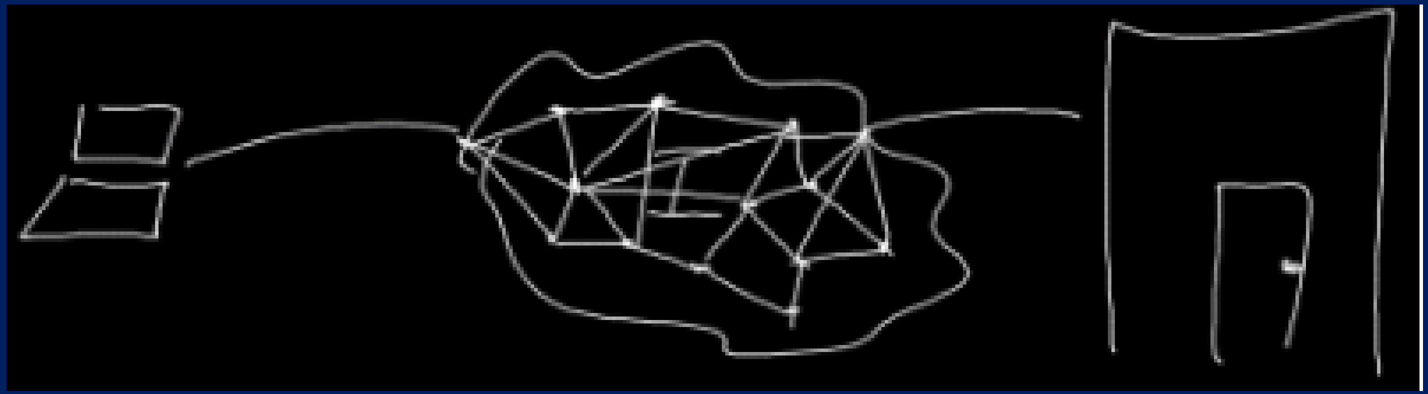
Home Network
Router
Network attached storage(NAS)
TV
Desktop PC
Smartphone
Laptop
Tablet
TV Set

Internet

Network Diagram-Typical Simple Home Network

Internet

Routers:



- The internet is a network of networks (with their own routers)
- Often multiple ways to go from A to B
- Based in US Military logic to prevent downtime if a particular router goes down
- When multiple packets are sent, like cat.jpg from Google, they can each take a different path, still getting to their destination eventually
- Sometimes the internet is busy and the quickest path changes

How long does it take for this process of data transfer to take on the internet?

Internet

Traceroute:

- Traceroute is a program that sends packets to each router on a path to a destination, reporting the time it takes to reach that router

- From Sanders Theatre to Google.com:

```
$ traceroute www.google.com
traceroute to www.google.com (4.53.56.109), 30 hops max, 40 byte packets
 1  10.243.16.161 (10.243.16.161)  0.572 ms
 2  10.240.144.33 (10.240.144.33)  0.890 ms
 3  coregw1-vl-415-fas.net.harvard.edu (140.247.2.61)  0.813 ms
 4  coregw1-te-3-6-core.net.harvard.edu (128.103.0.77)  1.463 ms
 5  5-1-20.bear2.Boston1.Level3.net (4.53.56.9)  3.607 ms
 6  5-1-20.bear2.Boston1.Level3.net (4.53.56.9)  3.722 ms
 7  *
 8  *
 9  *
10  *
11  *
12  *
13  *
14  *
```

1-2: A few unnamed routers at Harvard
3-4: More Harvard routers
5-6: Level3 is a ISP
7+: The routers are denying the request

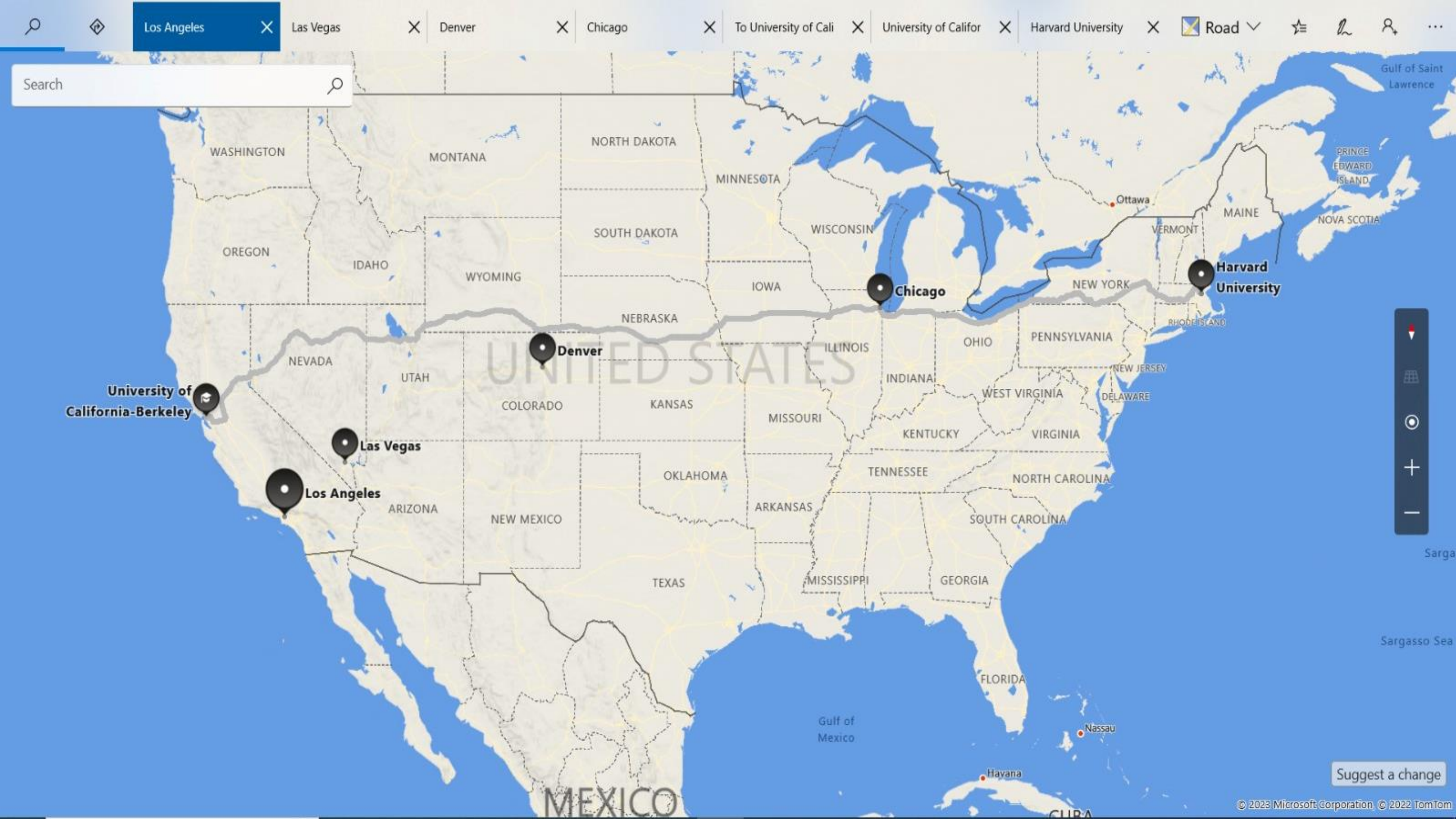
Internet

Traceroute:

- From Sanders Theatre to Berkeley.edu:

6: Northern Crossroads
7-14: A fast connection
8-9: Chicago
10-11: Denver
12-13: Las Vegas
14: Los Angeles
19 is where it arrives at Berkeley in 80 ms!

```
traceroute to www.berkeley.edu (128.32.203.137), 30 hops max, 40 byte packets
 1  10.243.16.161 (10.243.16.161)  0.333 ms
 2  10.240.144.33 (10.240.144.33)  0.517 ms
 3  core-ne-gw-vl408.fas.harvard.edu (140.247.2.33)  0.676 ms
 4  bdrgw1-te-4-7-core.net.harvard.edu (128.103.0.146)  1.314 ms
 5  18.254.32.5 (18.254.32.5)  1.637 ms
 6  i2-re-nox1sumgw1.nox.org (192.5.89.18)  14.017 ms
 7  et-3-0-0.4079.sdn-sw.eqch.net.internet2.edu (162.252.70.113)  22.988 ms
 8  et-5-3-0.4079.rtsw.chic.net.internet2.edu (162.252.70.114)  23.451 ms
 9  et-5-3-0.4079.rtsw.chic.net.internet2.edu (162.252.70.114)  23.217 ms
10  et-8-0-0.4079.sdn-sw.denv.net.internet2.edu (162.252.70.10)  44.928 ms
11  et-8-0-0.4079.sdn-sw.denv.net.internet2.edu (162.252.70.10)  44.836 ms
12  et-7-0-0.4079.sdn-sw.lasv.net.internet2.edu (162.252.70.30)  61.950 ms
13  et-7-0-0.4079.sdn-sw.lasv.net.internet2.edu (162.252.70.30)  61.859 ms
14  et-4-1-0.4079.rtsw.losa.net.internet2.edu (162.252.70.29)  66.695 ms
15  hpr-svl-hpr3--lax-hpr3-100ge.cenic.net (137.164.25.74)  78.135 ms
16  hpr-ucb--svl-hpr-10g.cenic.net (137.164.27.133)  80.391 ms
17  t1-3.inr-201-sut.berkeley.edu (128.32.0.65)  79.948 ms
18  e3-48.inr-310-ewdc.berkeley.edu (128.32.0.97)  80.265 ms
19  calweb-farm-prod.ist.berkeley.edu (128.32.203.137)  80.162 ms
```


Los Angeles
Las Vegas
Denver
Chicago
To University of Cali
University of Califor
Harvard University
Road
Search
Gulf of Saint Lawrence
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
PRINCE EDWARD ISLAND
Ottawa
MAINE
NOVA SCOTIA
OREGON
IDAHO
SOUTH DAKOTA
WISCONSIN
VERMONT
WYOMING
Harvard University
IOWA
Chicago
NEW YORK
NEBRASKA
RHODE ISLAND
NEVADA
Denver
ILLINOIS
OHIO
PENNSYLVANIA
UNITED STATES
NEW JERSEY
UTAH
INDIANA
University of California-Berkeley
WEST VIRGINIA
DELAWARE
COLORADO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
Las Vegas
TENNESSEE
OKLAHOMA
NORTH CAROLINA
Los Angeles
ARKANSAS
ARIZONA
NEW MEXICO
SOUTH CAROLINA
Sarga
TEXAS
MISSISSIPPI
GEORGIA
Sargasso Sea
FLORIDA
Gulf of Mexico
Nassau
Havana
Suggest a change
MEXICO
CUBA
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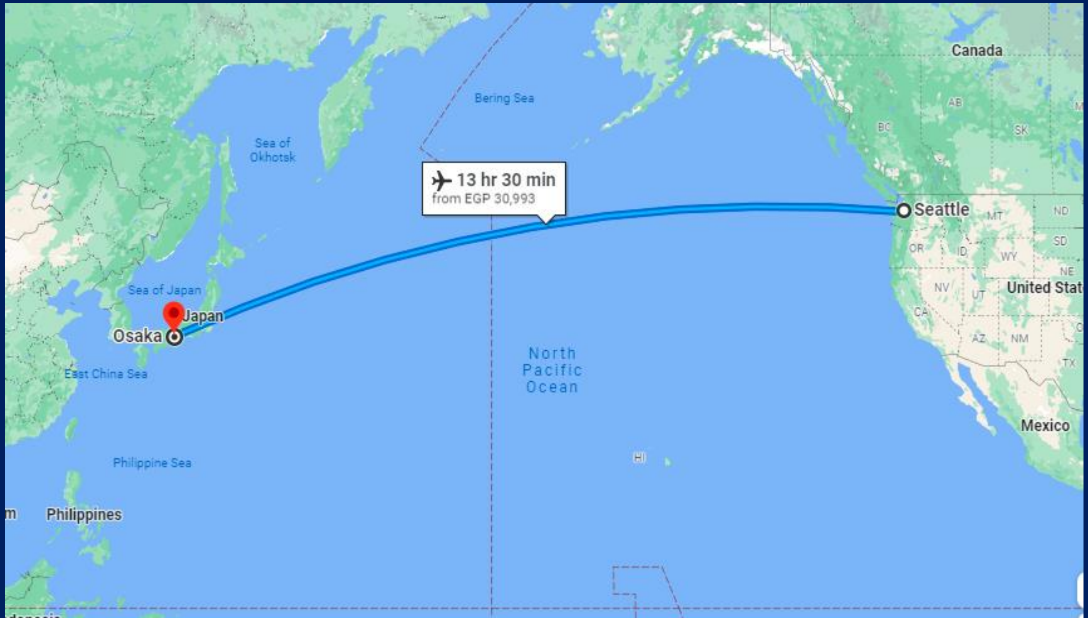
Internet

Traceroute:

- From Sanders Theatre to CNN.jp:

9-10 jumps from Seattle to Osaka past an ocean!

Using undersea cabling



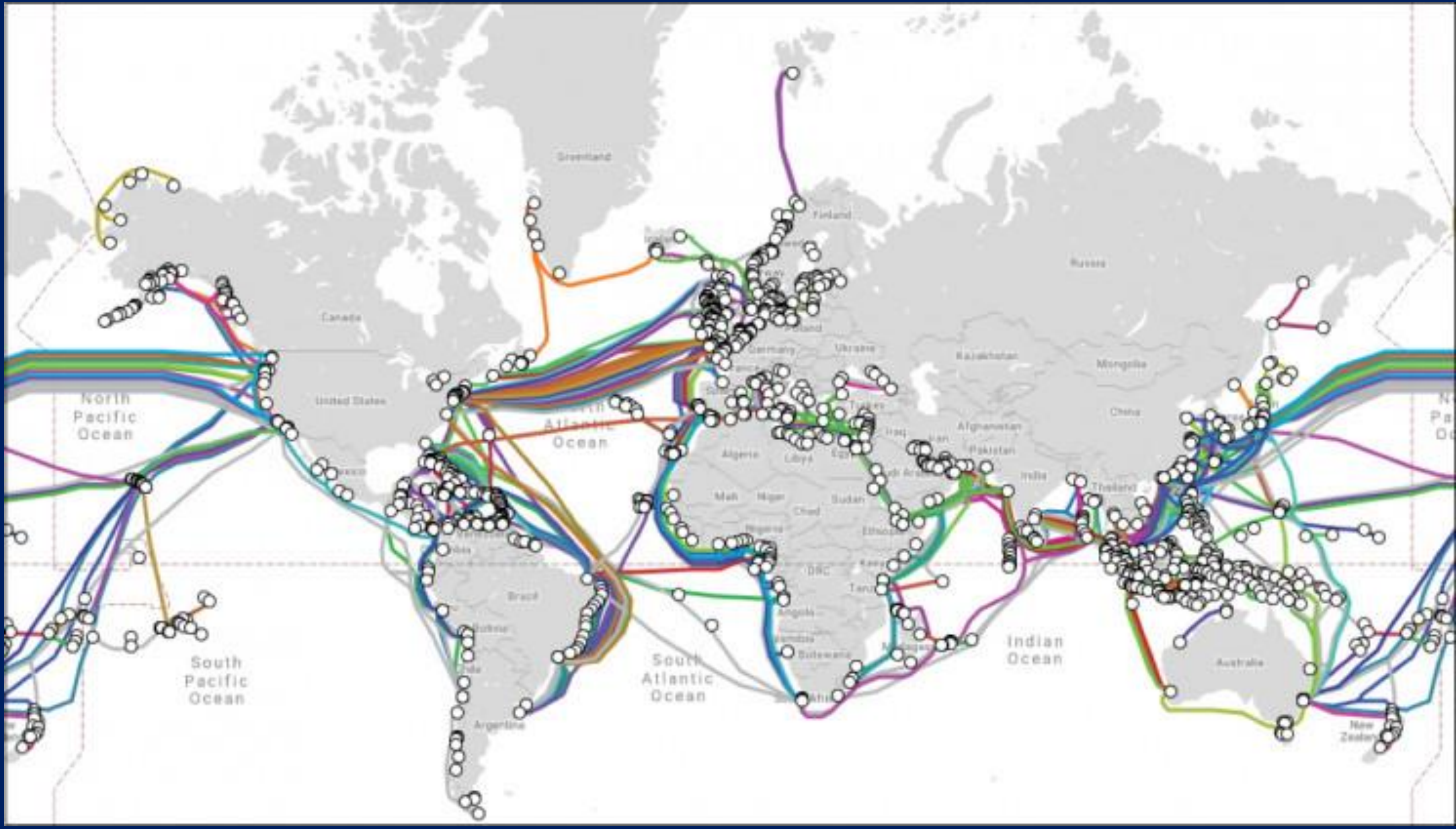

```
$ traceroute www.cnn.co.jp
traceroute to www.cnn.co.jp (27.121.48.200), 30 hops max, 40 byte packets
 1  10.243.16.161 (10.243.16.161)  0.504 ms
 2  10.240.144.33 (10.240.144.33)  0.806 ms
 3  coregw1-vl-415-fas.net.harvard.edu (140.247.2.61)  0.978 ms
 4  bdrgw2-te-4-2-core.net.harvard.edu (128.103.0.2)  1.376 ms
 5  18.254.48.5 (18.254.48.5)  1.798 ms
 6  et-10-0-0.122.rtr.eqch.net.internet2.edu (198.71.47.61)  23.029 ms
 7  *
 8  sea001bb00.IIJ.Net (58.138.81.210)  85.044 ms
 9  sea001bb00.IIJ.Net (58.138.81.210)  106.799 ms
10  osk004bb00.IIJ.Net (58.138.88.193)  193.943 ms
11  osk004ip57.IIJ.Net (58.138.107.206)  213.306 ms
12  p078.net061211176.broadline.ne.jp (61.211.176.78)  191.566 ms
13  p070.net061211176.broadline.ne.jp (61.211.176.70)  194.730 ms
14  p246.net061200097.broadline.ne.jp (61.200.97.246)  193.614 ms
15  27.121.48.200 (27.121.48.200)  213.724 ms
16  *
```

Internet

Undersea cabling:

https://youtu.be/IlAJJI-qG2k

- There are now over 300 Undersea cables stretching 550,000 Miles.
- The longest cable hits 39 landing Points from Germany to Korea spanning 24,000 Miles.
- Some are laid over 25,000 FT below the ocean’s surface.
- They transmit 99% of all international data.

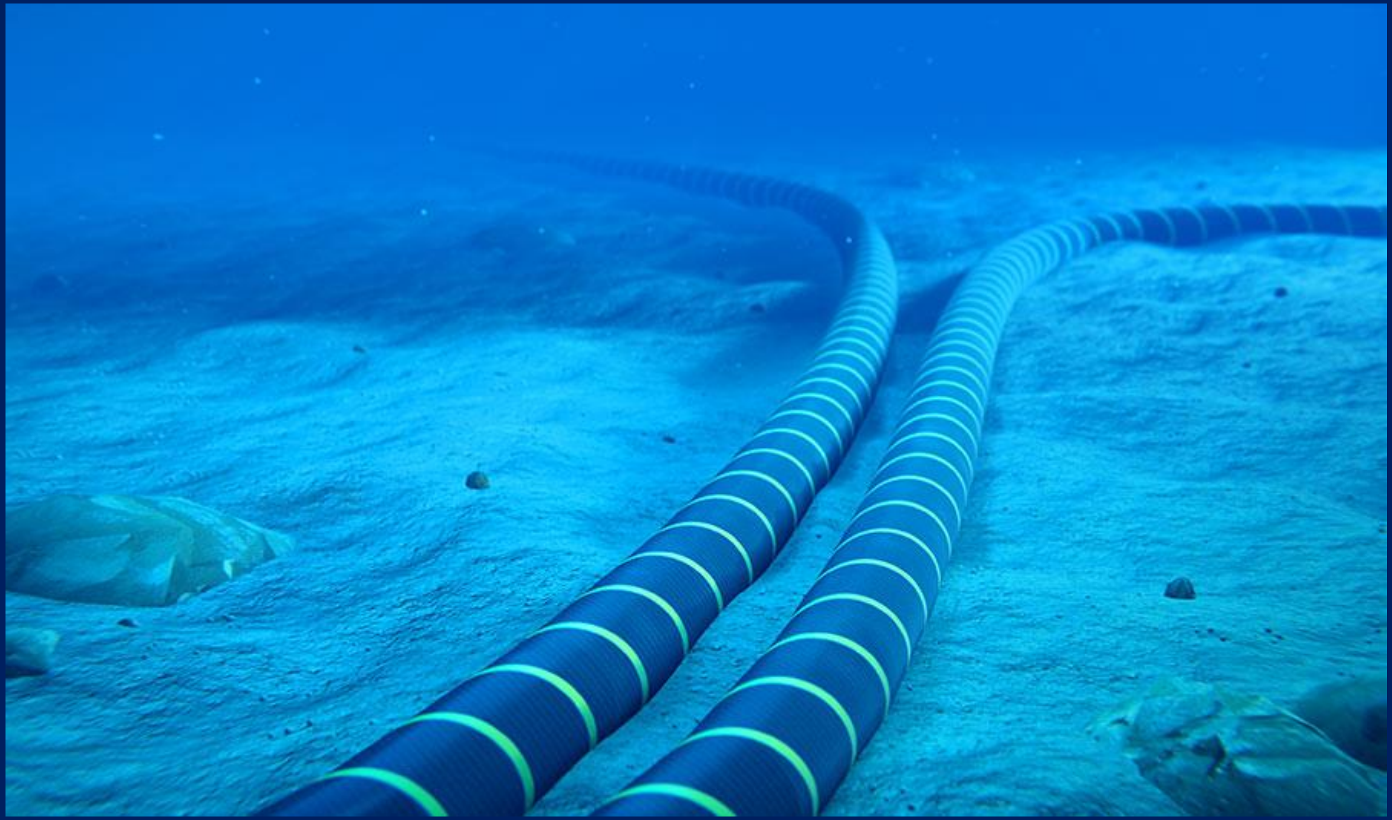


Internet

Undersea cabling:

https://youtu.be/IlAJJl-qG2k

- Laying one cable across an ocean takes several months & costs hundreds of MILLIONS of Dollars



Let's try

Internet

Traceroute:

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traceroute to www.berkeley.edu (128.32.203.137), 30 hops max, 40 byte packets
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 2  10.240.144.33 (10.240.144.33)  0.517 ms
 3  core-ne-gw-vl408.fas.harvard.edu (140.247.2.33)  0.676 ms
 4  bdrgw1-te-4-7-core.net.harvard.edu (128.103.0.146)  1.314 ms
 5  18.254.32.5 (18.254.32.5)  1.637 ms
 6  i2-re-nox1sumgw1.nox.org (192.5.89.18)  14.017 ms
 7  et-3-0-0.4079.sdn-sw.eqch.net.internet2.edu (162.252.70.113)  22.988 ms
 8  et-5-3-0.4079.rtsw.chic.net.internet2.edu (162.252.70.114)  23.451 ms
 9  et-5-3-0.4079.rtsw.chic.net.internet2.edu (162.252.70.114)  23.217 ms
10  et-8-0-0.4079.sdn-sw.denv.net.internet2.edu (162.252.70.10)  44.928 ms
11  et-8-0-0.4079.sdn-sw.denv.net.internet2.edu (162.252.70.10)  44.836 ms
12  et-7-0-0.4079.sdn-sw.lasv.net.internet2.edu (162.252.70.30)  61.950 ms
13  et-7-0-0.4079.sdn-sw.lasv.net.internet2.edu (162.252.70.30)  61.859 ms
14  et-4-1-0.4079.rtsw.losa.net.internet2.edu (162.252.70.29)  66.695 ms
15  hpr-svl-hpr3--lax-hpr3-100ge.cenic.net (137.164.25.74)  78.135 ms
16  hpr-ucb--svl-hpr-10g.cenic.net (137.164.27.133)  80.391 ms
17  t1-3.inr-201-sut.berkeley.edu (128.32.0.65)  79.948 ms
18  e3-48.inr-310-ewdc.berkeley.edu (128.32.0.97)  80.265 ms
19  calweb-farm-prod.ist.berkeley.edu (128.32.203.137)  80.162 ms
```

6: Northern Crossroads
7-14: A fast connection
8-9: Chicago
10-11: Denver
12-13: Las Vegas
14: Los Angeles
19 is where it arrives at Berkeley in 80 ms!

Internet

Traceroute:

Take the following steps to run a traceroute in Microsoft® Windows®:

- Press Windows key + R to open the Run window.
- Enter cmd and press Enter to open a Command Prompt.
- Enter tracert, a space, then the IP address or web address for the destination site (for example: tracert www.lexis.com).
- Press Enter.

THANK YOU
Rasha Abdeen