Software Engineering

A Faculty of Engineering Course: CSEN 303

1

Introduction to Software Engineering (SE), HTTP, DNS, TCP/IP

Dr. Iman Awaad

iman.awaad@giu-uni.de

GIU GERMAN INTERNATIONAL UNIVERSITY
الجامعة الألمانية الدولية

Acknowledgments

The slides are **heavily** based on the **slides** by **Prof. Dr. John Zaki**.

They are also **heavily** based on the slides and textbook by **Ian Somerville**.

Their contribution is gratefully acknowledged.

Any additional sources are referenced.

Intro to SE, HTTP, DNS, TCP/IP

- Software engineering (SE)
- Software development (SD)

- Client-server architecture
- HTTP
- DNS
- TCP/IP

What is software?

What are characteristics of **good** software?

What is
software engineering?

Why study it?

What is a
client-server architecture?

What is Software?

…Computer **programs** and **associated documentation**. Software products may be developed for a *particular* customer or for a *general market*.

— Ian Somerville

What are characteristics of **good** software?

…Good software should deliver the **required** functionality and performance to the user and should be maintainable, dependable, and usable.

— Ian Somerville

What is software engineering?

…Software engineering is an **engineering** discipline that is concerned with **all aspects** of software production.

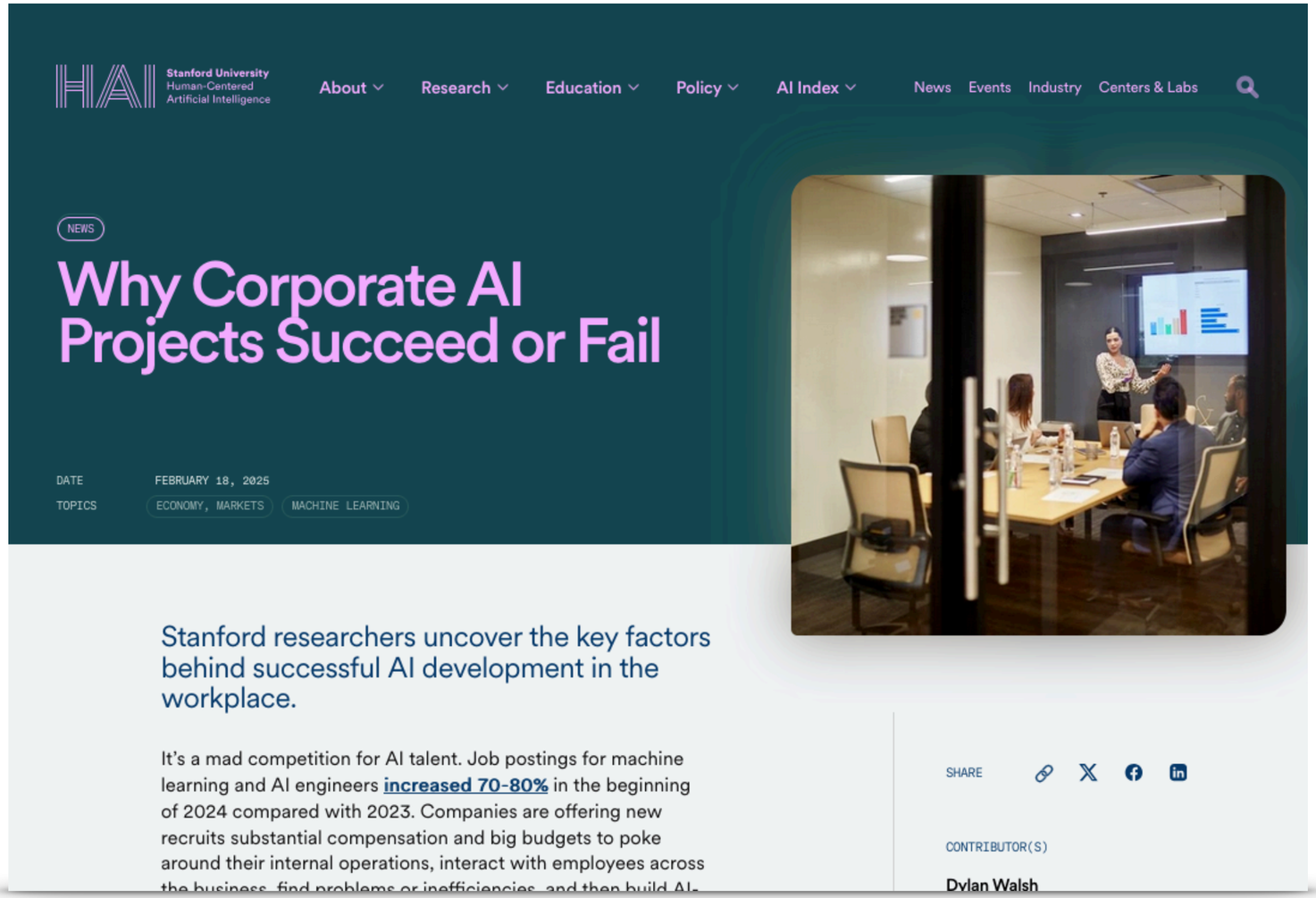
— Ian Somerville

Why study it?


Vibe Coding 101
Adam [redacted]
Middle Mile Engineering Programs | Optimization & Simulation | 7/08/2025
1

Why study it?

“**But in-house developments don’t seem to be working well: Even as companies invest a lot of money, a lot of projects are failing or not delivering their promised value**,” says Arvind Karunakaran, an assistant professor of engineering at Stanford and a faculty affiliate at the Stanford Institute for Human-Centered Artificial Intelligence (HAI). **“Something is going on in these very early stages of interaction between developers and other employees across the business that’s leading to these shortcomings**.”



https://hai.stanford.edu/news/why-corporate-ai-projects-succeed-or-fail

Why does software development sometimes fail?

scope creep

lack of user involvement

unclear requirements

poor project management

inadequate testing

communication breakdowns

unrealistic expectations

Are all software development (SD) processes the same?

Game software development

Flight control software development

No

What is the difference between SE & SD? **Scope!**

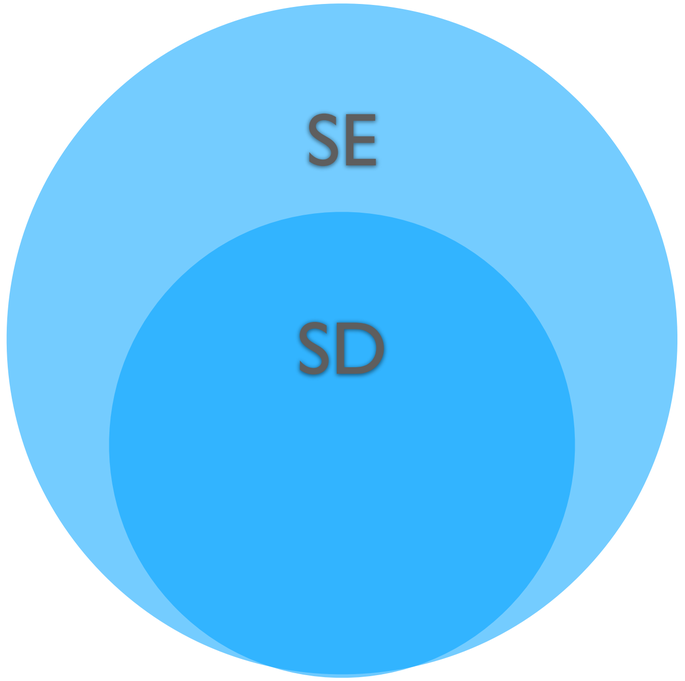
coursera Explore What do you want to learn? Online Degrees Find your New Career John Zaki

Learn the skills of a software developer

- Proficiency in popular programming languages like Python, Java, C++, and Scala
- Ability to write and test code
- Creativity
- Ability to look at the big picture and small steps along the way
- Presentation skills
- Familiarity with cross-browser compatibility
- Proficient in developing responsive web designs
- Ability to work on front-end application development
- Knowledge of algorithms and data structures
- Time management skills

Learn the skills of a software engineer

- Extensive knowledge of a wide range of programming languages
- Proficient in software development and computer operating systems
- Proficient in advanced mathematics
- Ability to apply engineering principles to software creation
- Leadership skills
- Ability to debug software and systems
- Ability to create scalable domain-specific pipelines and languages
- Ability to create the tools needed to develop software
- Project management skills



Generic software versus custom software

Software Engineering

Learn the skills of a software engineer

- Extensive knowledge of a wide range of programming languages
- Proficient in software development and computer operating systems
- Proficient in advanced mathematics
- Ability to apply engineering principles to software creation
- Leadership skills
- Ability to debug software and systems
- Ability to create scalable domain-specific pipelines and languages
- Ability to create the tools needed to develop software
- Project management skills

Software Development

Learn the skills of a software developer

- Proficiency in popular programming languages like Python, Java, C++, and Scala
- Ability to write and test code
- Creativity
- Ability to look at the big picture and small steps along the way
- Presentation skills
- Familiarity with cross-browser compatibility
- Proficient in developing responsive web designs
- Ability to work on front-end application development
- Knowledge of algorithms and data structures
- Time management skills

Development fault or engineering fault?

"…a navigation error caused by a **unit mismatch**; the ground software used imperial units (**pounds-force per second**) while the spacecraft's onboard software used metric units (**newtons per second**), leading to a trajectory error that brought the spacecraft too close to the surface"…

https://unionrayo.com/en/nasa-mars-climate-orbiter-mistake/

Generic software versus custom software

Generic software

Software products are generic software systems that provide functionality that is useful to a range of customers.

e.g. MS Excel, Sudoku…

Custom software

Still important for large businesses, governments, and public bodies

Developed in dedicated software projects

What is software engineering?

…Software engineering is an **engineering** discipline that is concerned with **all aspects** of software production.

— Ian Somerville

What is software engineering?

- Software is not just code. It is:
  - collection of executable programming code
  - associated libraries
  - documentation
  - support
- Software, when **made for a specific requirement** is called a software product.

- Engineering: developing products using well-defined, scientific principles and methods.

— Prof. Dr. John Zaki

Again, what is software engineering?

…The application of a **systematic**, **disciplined**, **quantifiable** approach to the **development**, **operation**, and **maintenance** of software… *i.e. the application of engineering to software*

— IEEE

Again, what is software engineering?

…The application of a **systematic**, **disciplined**, **quantifiable** approach to the **development**, **operation**, and **maintenance** of software…

— IEEE

Again, what is software engineering?

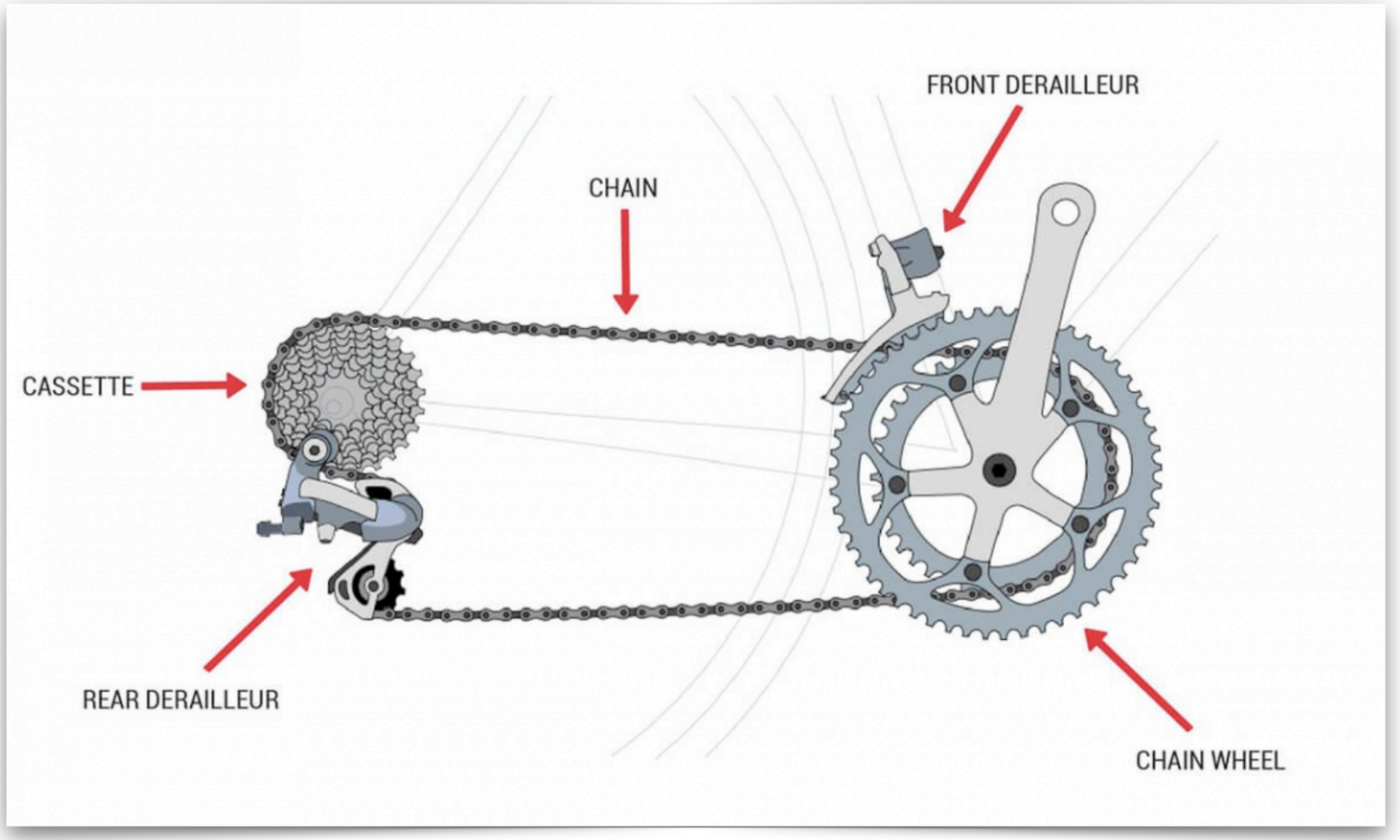
…The application of a **systematic**, **disciplined**, **quantifiable** approach to the **development**, **operation**, and **maintenance** of software…

— IEEE

i.e.
a process…

…composed of activities

1. **Specification**
2. **Development**
3. **Validation**
4. **Evolution**


FRONT DERAILLEUR
CHAIN
CASSETTE
REAR DERAILLEUR
CHAIN WHEEL

Intro to SE, **HTTP**, **DNS**, **TCP/IP**

- Software engineering (SE)
- Software development (SD)

- **Client-server architecture**
- **HTTP**
- **DNS**
- **TCP/IP**

What is software?

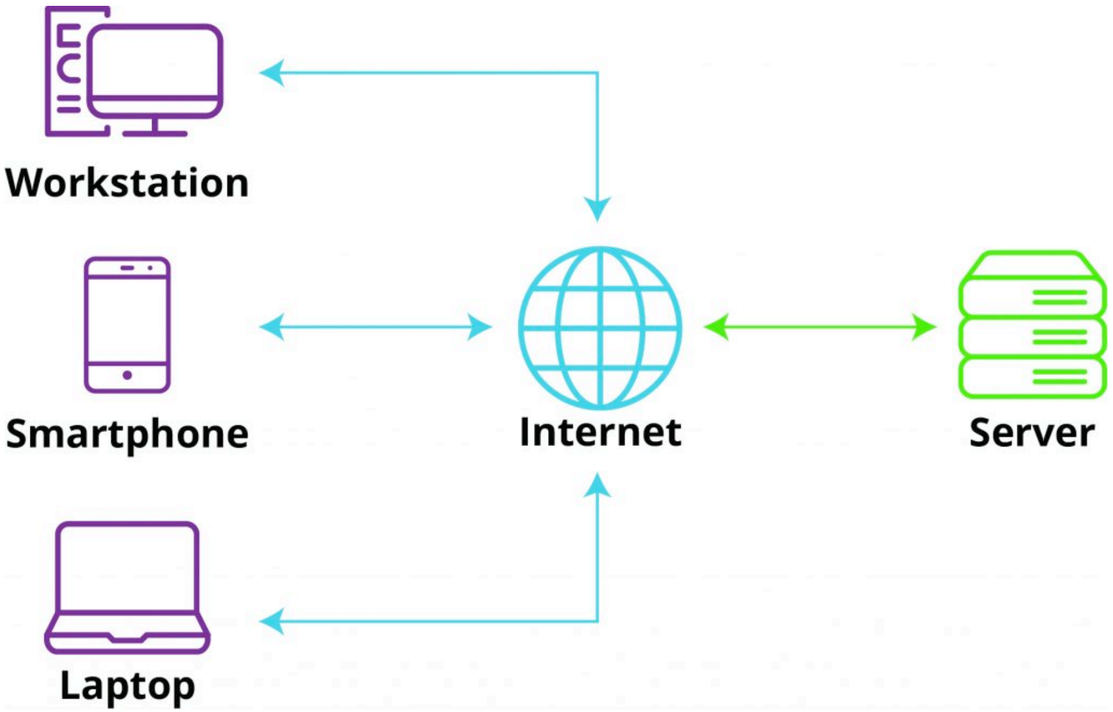
What are characteristics of **good** software?

What is software engineering?

Why study it?

What is a client-server architecture?

Big picture: What is the Internet and how does it work?



The biggest computer network…

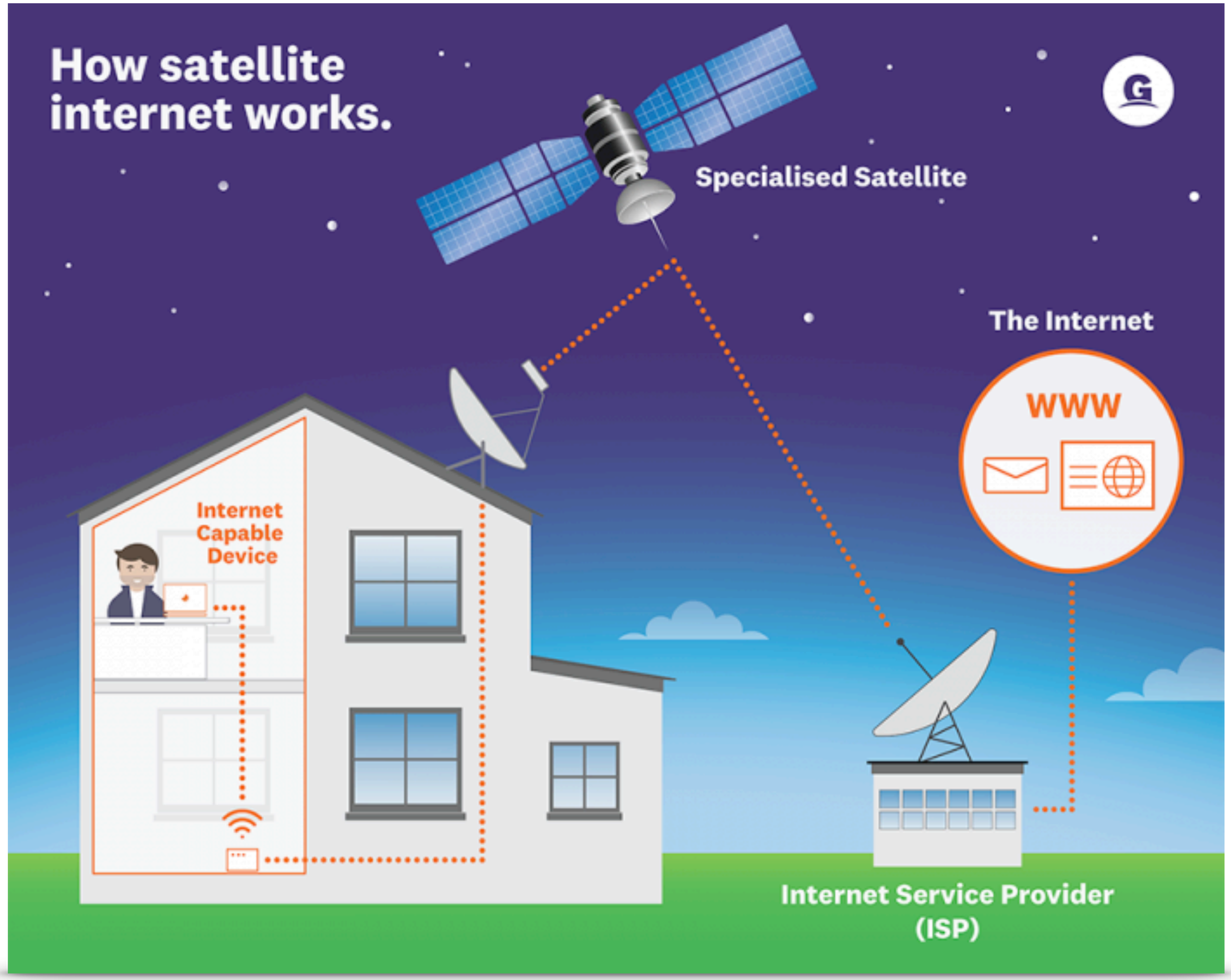
Billions of connected computers and other devices

https://www.liquidweb.com/wp-content/uploads/2024/03/client-server-network-1024x653-1.jpg

Connectivity

Satellite

1. User request: computer sends signal to router, then to modem, then up to a specialised internet satellite dish on your roof. Dish sends signal to a satellite.
2. Satellite relay: Satellite sends request to your internet service provider (ISP).
3. Return trip: Provider sends a signal back via satellite to your dish, then to your computer at home.



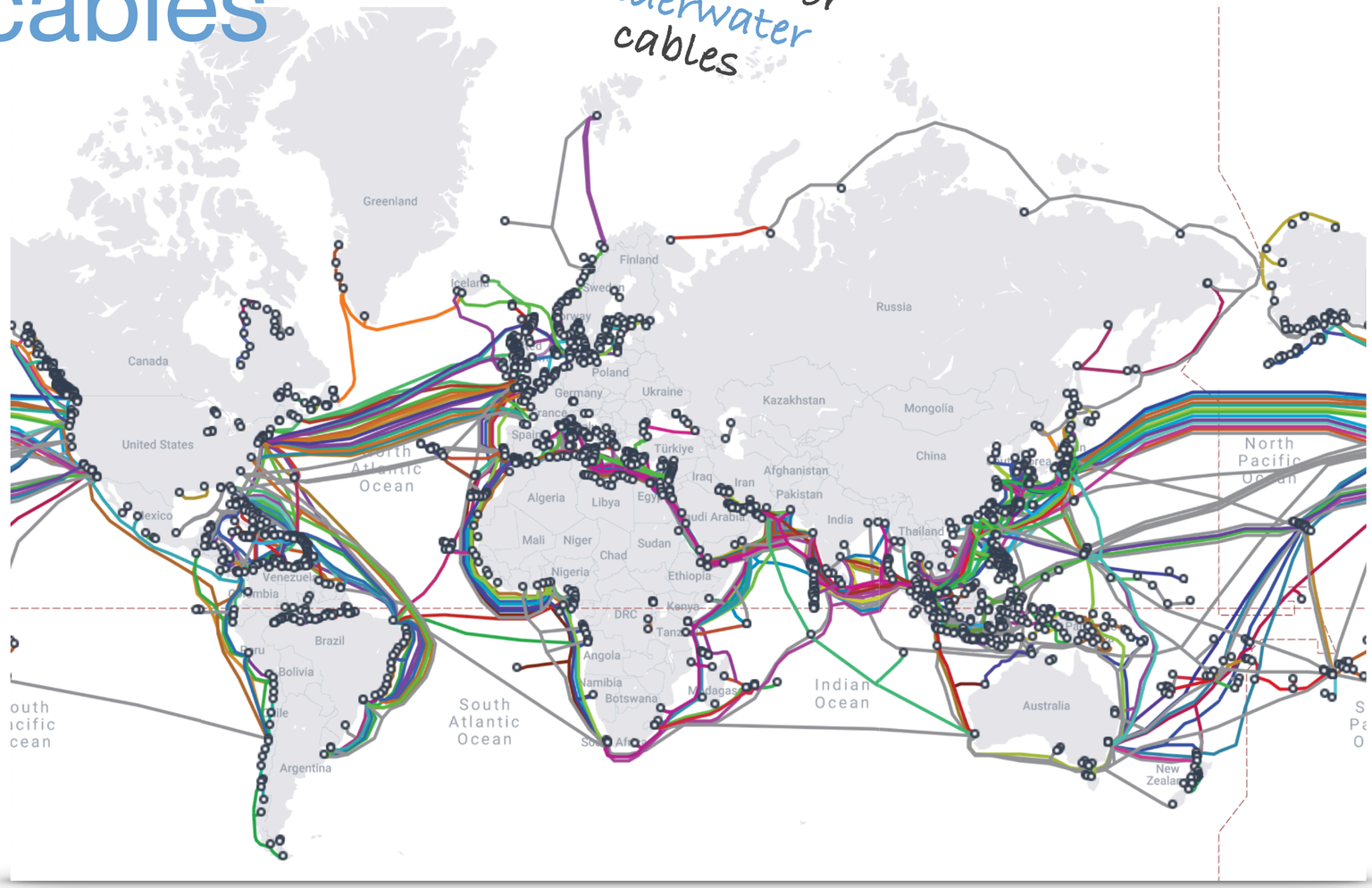
https://getgravity.nz/satellite-internet/how-it-works

Connectivity Submarine cables

aka subsea or underwater cables

Backbone
of the internet
carrying
99%
of **all** traffic!

Wireless world depends on submarine internet cables: physical links lying on ocean floors



https://dgtlinfra.com/submarine-cables-fiber-link-internet/

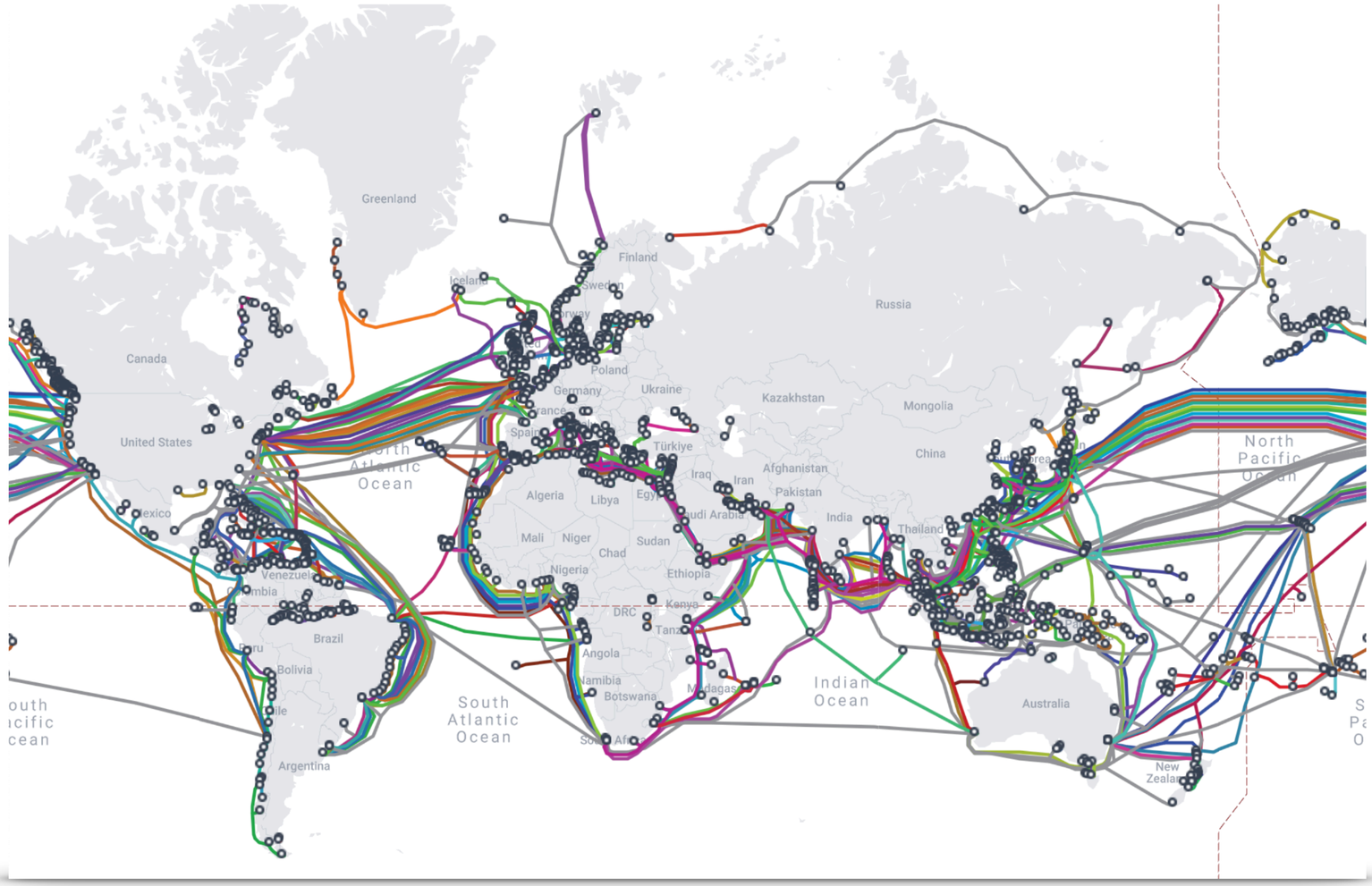
https://www.submarinecablemap.com/

Connectivity

~$**25,000**/km

~**450** submarine cable systems in-service around the world

1.35 million km



https://dgtlinfra.com/submarine-cables-fiber-link-internet/

https://www.submarinecablemap.com/

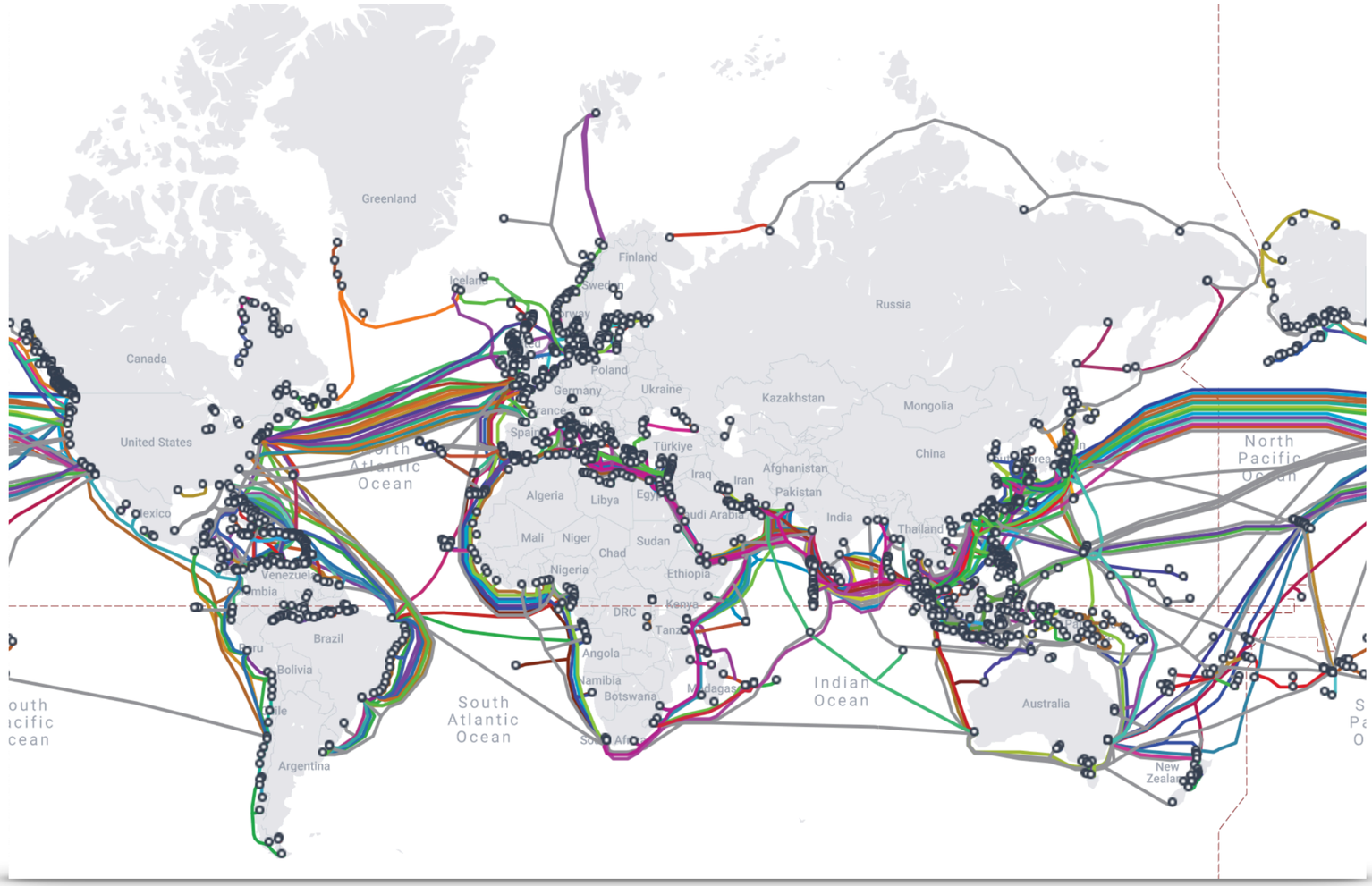
Connectivity

Demand for data continues to grow:

…mobile devices, cloud computing, 5G

…

So, demand for submarine cables continues to grow

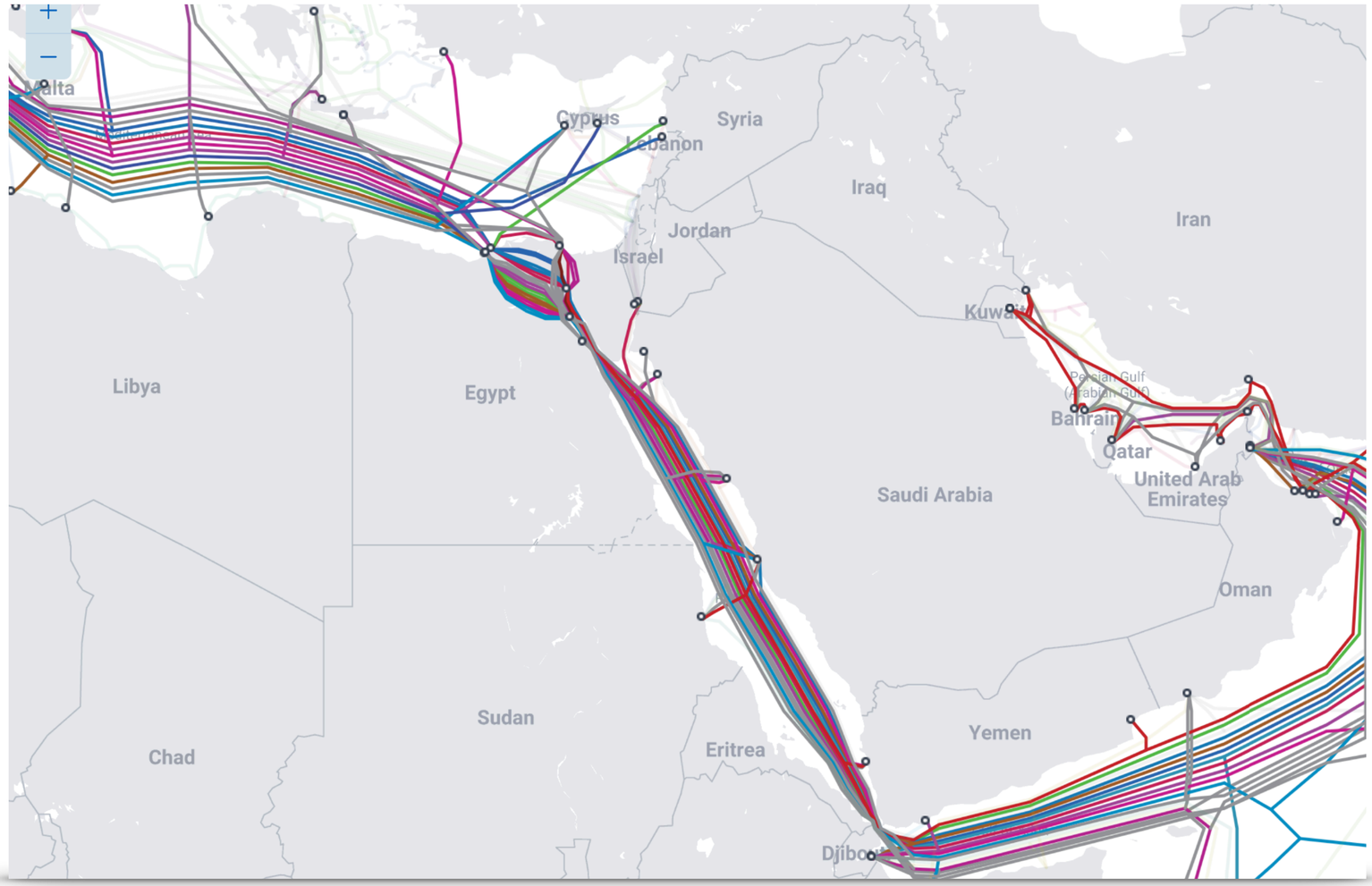


https://dgtlinfra.com/submarine-cables-fiber-link-internet/

https://www.submarinecablemap.com/

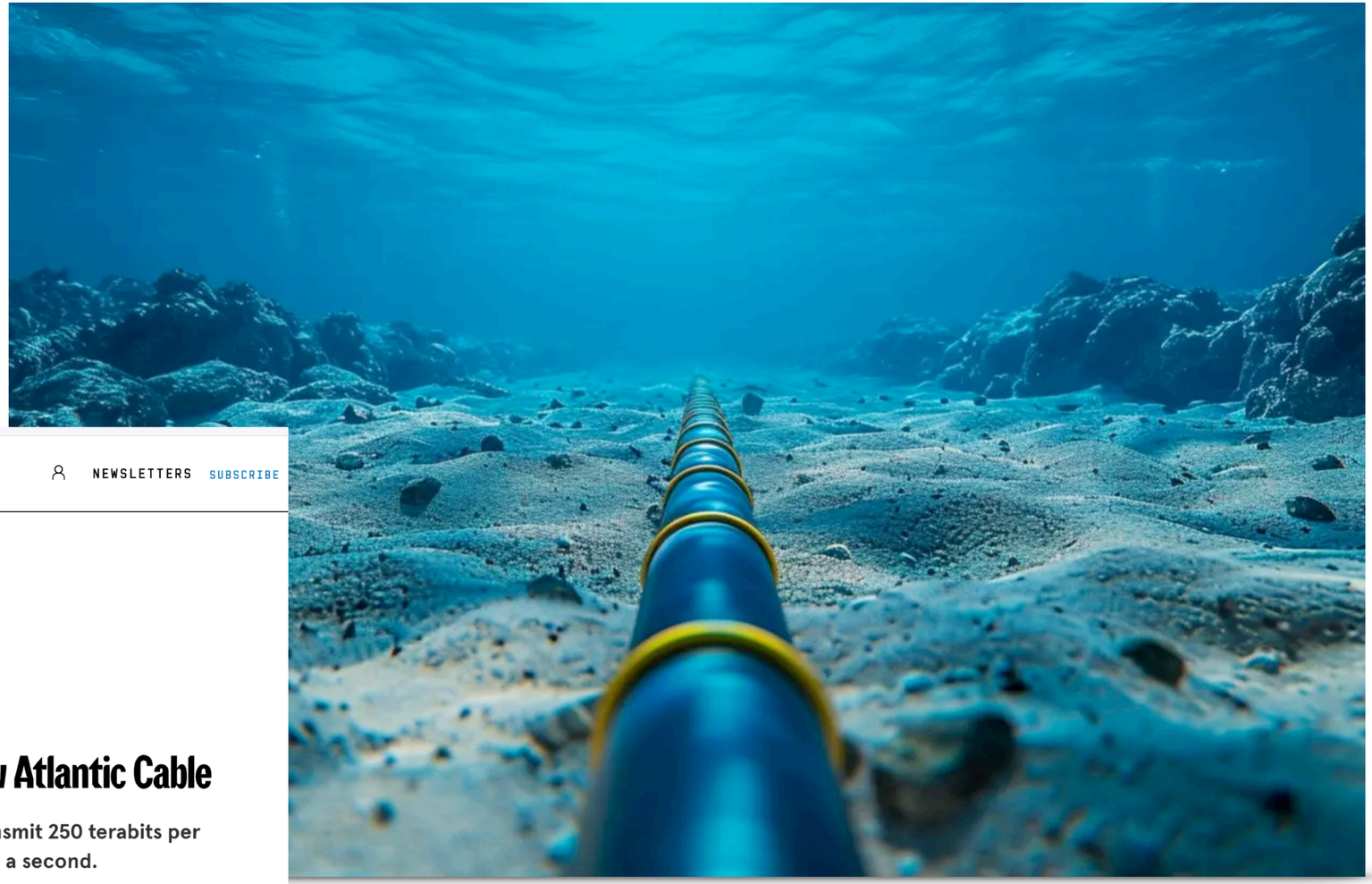
Connectivity

- Abu Talat, Egypt
- Alexandria, Egypt
- Port Said, Egypt
- Ras Ghareb, Egypt
- Sidi Kerir, Egypt
- Suez, Egypt
- Taba, Egypt
- Zafarana, Egypt



https://www.submarinecablemap.com/

Connectivity



WIRED

NEWSLETTERS SUBSCRIBE

KLINT FINLEY BUSINESS APR 5, 2019 9:00 AM

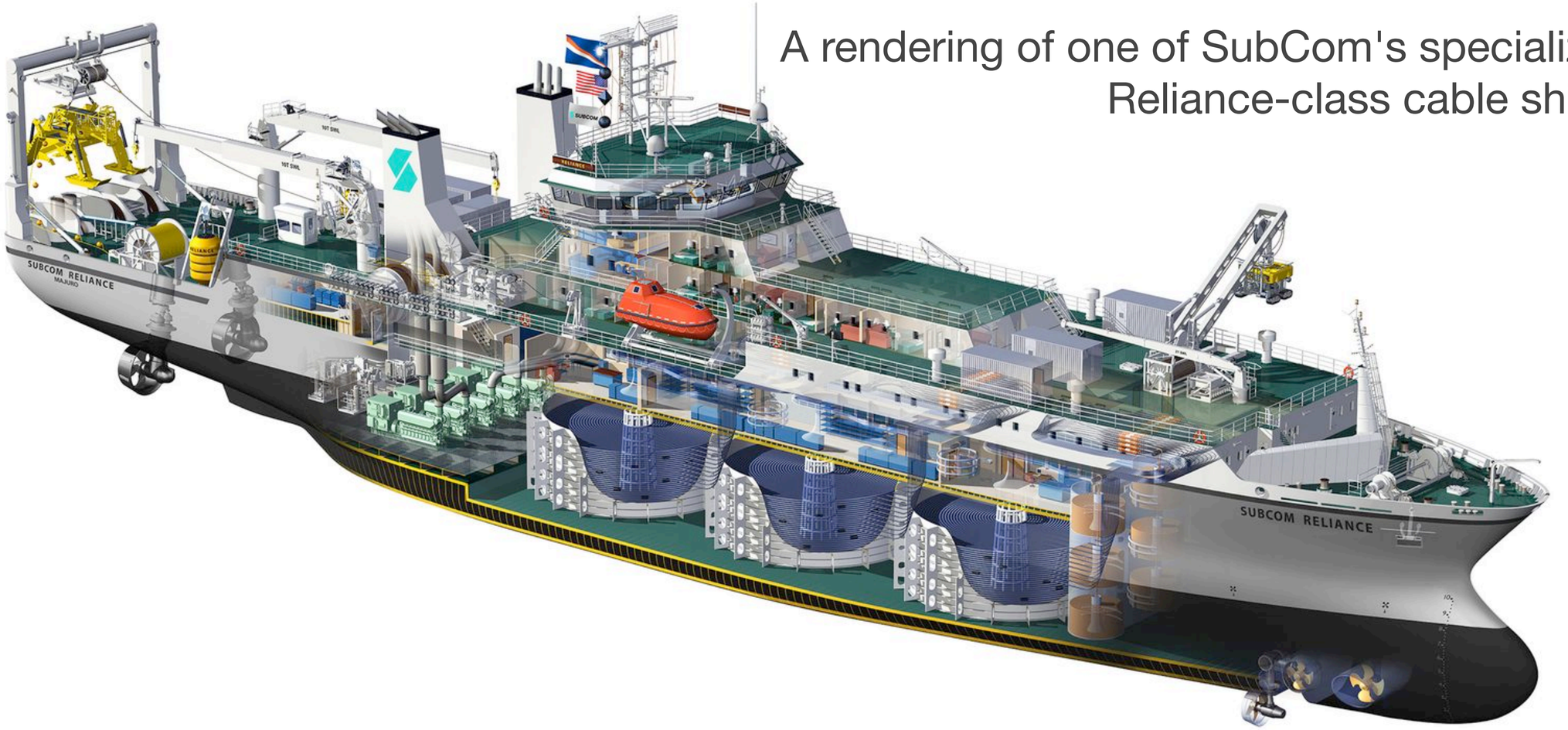
How Google Is Cramming More Data Into Its New Atlantic Cable

Google says its planned Dunant cable from Virginia to France will transmit 250 terabits per second, enough to zap the Library of Congress through it three times a second.

https://dgtlinfra.com/submarine-cables-fiber-link-internet/

https://media.wired.com/photos/5ca6987ea0d9e3567d432be3/master/w_1600%2Cc_limit/SubCom-Reliance-Class-Rendering-Up-Open-Inline1.jpg

Connectivity



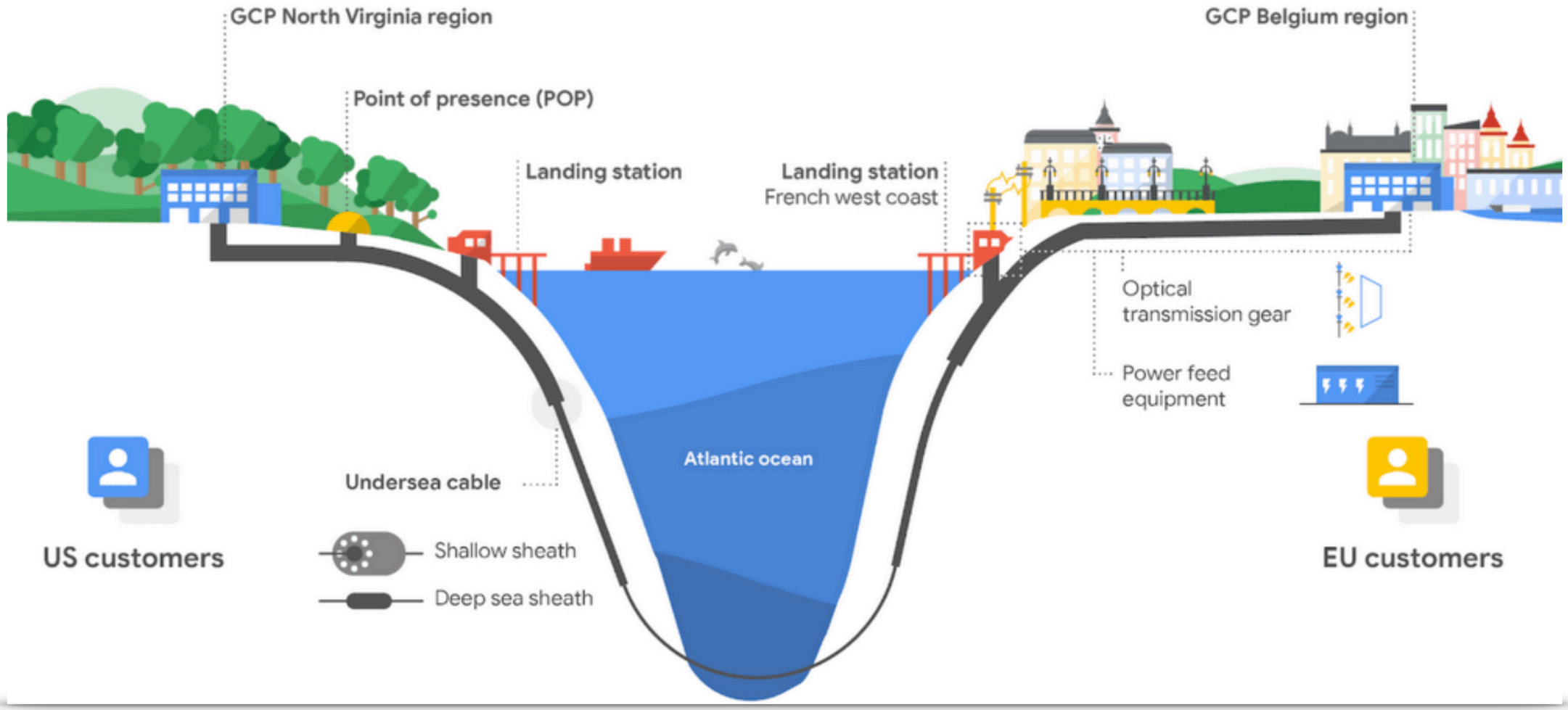
A rendering of one of SubCom's specialized Reliance-class cable ships.

https://media.wired.com/photos/5ca6987ea0d9e3567d432be3/master/w_1600%2Cc_limit/SubCom-Reliance-Class-Rendering-Up-Open-Inline1.jpg

Connectivity

https://media.wired.com/photos/5ca6987ea0d9e3567d432be3/master/w_1600%2Cc_limit/SubCom-Reliance-Class-Rendering-Up-Open-Inline1.jpg

Connectivity



https://dgtlinfra.com/submarine-cables-fiber-link-internet/

Big picture: How does the WWW work?

1. Query initiation

"Youtube picard speech drumhead"

2. DNS Lookup

Browser asks the Domain Name System (DNS) server (*aka the internet's phonebook*) for the IP address (*i.e. specific location*) of the search engine's server

e.g. Google DNS = 142.250.180.174

3. HTTP Request

Your browser sends an Hypertext Transfer Protocol (HTTP) request to the search engine's server, asking for the information you want

4. Data Transmission

The server sends back the search results, which are broken into small pieces called data packets, using protocols like Transmission Control Protocol/Internet Protocol (TCP/IP)

5. Display

Your browser receives these packets and assembles them, displaying the search results as a list of links and summaries for you to see.

https://aws.amazon.com/blogs/mobile/what-happens-when-you-type-a-url-into-your-browser/

WWW work?

3.
HTTP Request

Your browser sends an Hypertext Transfer Protocol (HTTP) request to the search engine's server, asking for the information you want

Built with HTTP v 0.9!!!

4.
Data Transmission

he server sends back the search sults, which are broken into small ieces called data packets, using rotocols like Transmission Control rotocol/Internet Protocol (TCP/IP)

ame
che
e IP
) of
er

https://aws.amazon.com/blogs/mobile/what-happens-when-you-type-a-url-into-your-browser/

Big picture: How does the WWW work?

1. Query initiation

"Youtube picard speech drumhead"

2. DNS Lookup

Browser asks the Domain Name System (DNS) server (*aka the internet's phonebook*) for the IP address (*i.e. specific location*) of the search engine's server

e.g. Google Public DNS = 8.8.8.8

3. HTTP Request

Your browser sends an Hypertext Transfer Protocol (HTTP) request to the search engine's server, asking for the information you want

4. Data Transmission

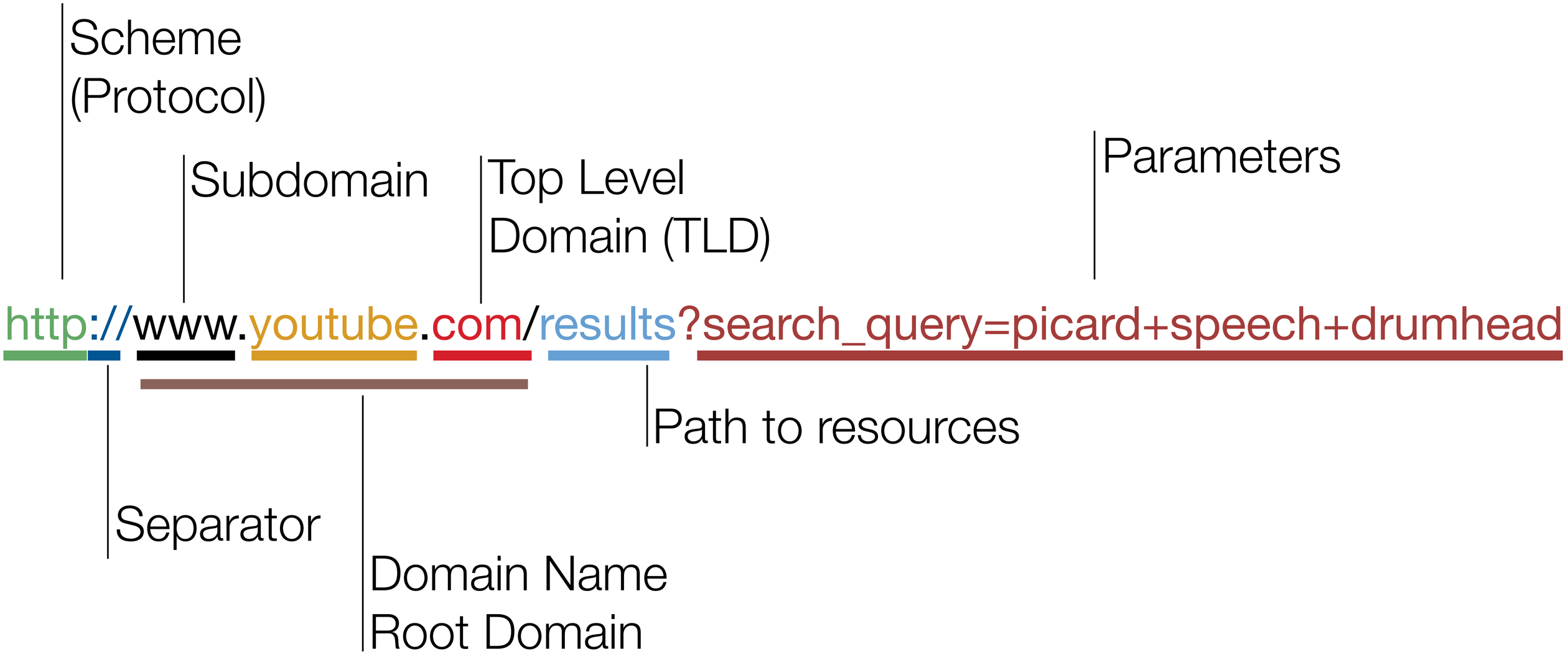
The server sends back the search results, which are broken into small pieces called data packets, using protocols like Transmission Control Protocol/Internet Protocol (TCP/IP)

5. Display

Your browser receives these packets and assembles them, displaying the search results as a list of links and summaries for you to see.

https://aws.amazon.com/blogs/mobile/what-happens-when-you-type-a-url-into-your-browser/

URLs


Scheme
(Protocol)
Subdomain
Top Level
Domain (TLD)
Parameters
http://www.youtube.com/results?search_query=picard+speech+drumhead
Path to resources
Separator
Domain Name
Root Domain

Take a minute…

Find out what the following are and provide examples

Anchor

Authority

& Multilevel subdomains

Port

(HTTP, HTTPS, FTP)

Remember this?

1. Query initiation

"Youtube picard speech drumhead"

2. DNS Lookup

Browser asks the Domain Name System (DNS) server (*aka the internet's phonebook*) for the IP address (*i.e. specific location*) of the search engine's server

e.g. Google Public DNS = 8.8.8.8

3. HTTP Request

Your browser sends an Hypertext Transfer Protocol (HTTP) request to the search engine's server, asking for the information you want

4. Data Transmission

The server sends back the search results, which are broken into small pieces called data packets, using protocols like Transmission Control Protocol/Internet Protocol (TCP/IP)

5. Display

Your browser receives these packets and assembles them, displaying the search results as a list of links and summaries for you to see.

https://aws.amazon.com/blogs/mobile/what-happens-when-you-type-a-url-into-your-browser/

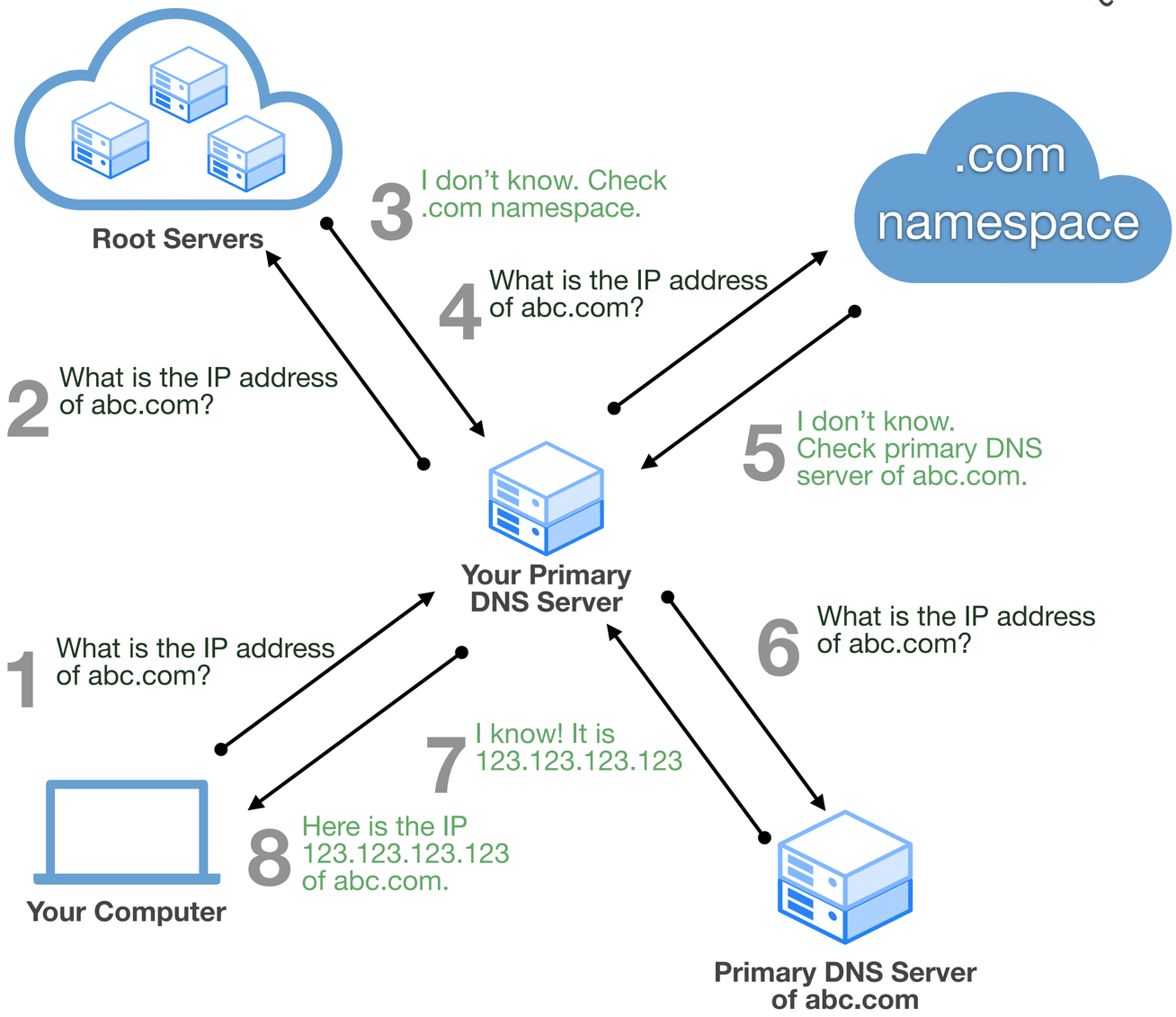
Domain Name System (DNS)

aka the internet's phonebook

…maps human-readable "domain names" to a unique network address (IP)

Various types of DNS Servers:

- **Recursive resolver**
  [Cached or requested]
- **Root Nameserver**
  [13 available, mirrored]
- **TLD Nameserver**
  [Generic TLD, country TLD]
- **Authoritative Nameserver**
  [IP, DNS "A record", CNAME record]



Domain Name System (DNS)

…maps human-readable “domain names” to a unique network address (IP)

Various types of DNS Servers:

- **Recursive resolvers…**
  [Cached or requested]
- Root Nameserver
  [13 available, mirrored]
- TLD Nameserver
  [Generic TLD, country TLD]
- Authoritative Nameserver
  [IP, DNS “A record”, CNAME record]

…act as intermediaries, querying the DNS hierarchy to find IP addresses for clients.

- …**receive DNS queries** from client devices, *e.g.* your computer
- …**query the other types of nameservers** (root, TLD, and authoritative) until they find the IP address for the requested domain name
- …also **cache** (store) **DNS lookup results** to speed up future requests

Domain Name System (DNS)

…maps human-readable “domain names” to a unique network address (IP)

Various types of DNS Servers:

- Recursive resolver
  [Cached or requested]
- **Root Nameservers…**
  [13 available, mirrored]
- TLD Nameserver
  [Generic TLD, country TLD]
- Authoritative Nameserver
  [IP, DNS “A record”, CNAME record]

…direct queries to the correct TLD servers, which themselves point to authoritative servers, where the definitive DNS records for a domain are stored.

- …are the top of the DNS hierarchy
- When a recursive resolver needs to find an IP address for a domain it doesn't have in its cache, it first contacts a root nameserver
- …directs the resolver to the correct TLD server for that domain

Domain Name System (DNS)

…maps human-readable “domain names” to a unique network address (IP)

Various types of DNS Servers:

- Recursive resolver
  [Cached or requested]
- Root Nameserver
  [13 available, mirrored]
- **TLD Nameservers…**
  [Generic TLD, country TLD]
- Authoritative Nameserver
  [IP, DNS “A record”, CNAME record]

…receive queries from recursive resolvers and direct them to the specific authoritative nameserver responsible for the domain in question.

There's a TLD server for each top-level domain, like .com, .org, or .net

Domain Name System (DNS)

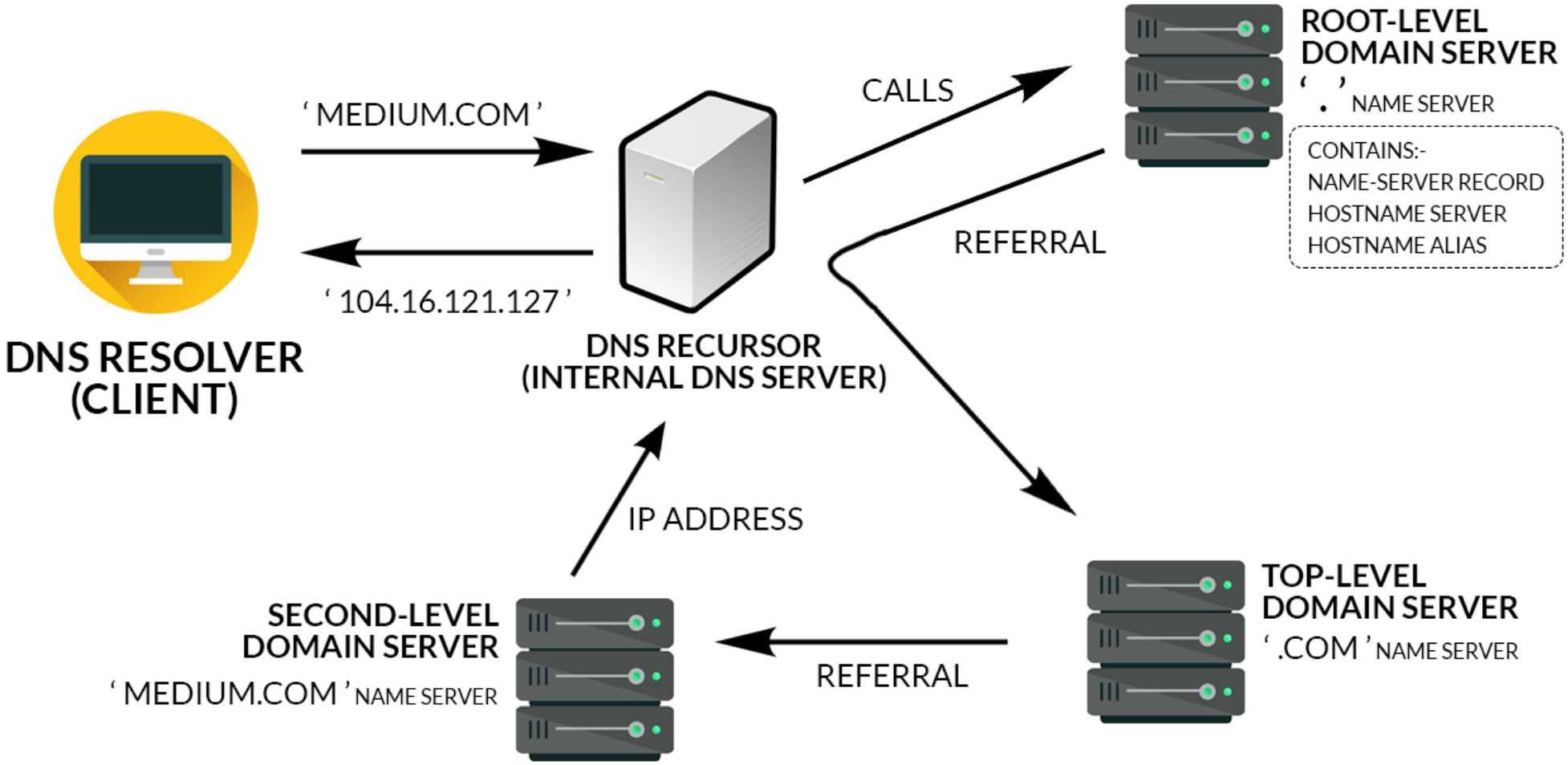
…maps human-readable “domain names” to a unique network address (IP)

Various types of DNS Servers:

- Recursive resolver
  [Cached or requested]
- Root Nameserver
  [13 available, mirrored]
- TLD Nameserver
  [Generic TLD, country TLD]
- **Authoritative Nameservers…**
  [IP, DNS “A record”, CNAME record]

- …hold the actual DNS records (like IP addresses) for specific domains
- When a recursive resolver finally reaches the correct authoritative nameserver, it gets the definitive IP address for the website or service it's looking for
- Authoritative nameservers can be further categorized into **primary** (**read/write**) and **secondary** (**read-only**) servers to increase reliability and performance

Types of DNS Servers



https://narodev.com/index.php/2019/04/11/understanding-the-dns-process-how-website-is-found/

On a Linux machine

Recursor

```
~ ❯ host giu-uni.de
giu-uni.de has address 195.37.15.170
giu-uni.de mail is handled by 60 giuuni-de0i.mail.protection.outlook.com.
```

TLD

```
~ ❯ host -t ns giu-uni.de
giu-uni.de name server ns.checkdomain.de.
giu-uni.de name server ns2.checkdomain.de.
```

Authoritative

```
~ ❯ host giu-uni.de ns2.checkdomain.de
Using domain server:
Name: ns2.checkdomain.de
Address: 5.9.190.98#53
Aliases:

giu-uni.de has address 195.37.15.170
giu-uni.de mail is handled by 60 giuuni-de0i.mail.protection.outlook.com.
```

Courtesy: Dr. A.F Desouky Slides

On a Windows machine

Recursor

```
C:\WINDOWS\system32>nslookup giu-uni.de
Server:  UnKnown
Address:  192.168.158.107

Non-authoritative answer:
Name:    giu-uni.de
Address:  195.37.15.170
```

TLD

```
C:\WINDOWS\system32>nslookup -type=ns giu-uni.de
Server:  UnKnown
Address:  192.168.158.107

Non-authoritative answer:
giu-uni.de      nameserver = ns2.checkdomain.de
giu-uni.de      nameserver = ns.checkdomain.de
```

Authoritative

```
C:\WINDOWS\system32>nslookup ns2.checkdomain.de
Server:  UnKnown
Address:  192.168.158.107

Non-authoritative answer:
Name:    ns2.checkdomain.de
Addresses:  2a01:4f8:201:22cc::106
          5.9.190.98
```

Courtesy: Dr. John Zaki slides

Take a minute…

What is Time to Live (TTL)?

Why do we need it?

Remember this??

1. Query initiation

"Youtube picard speech drumhead"

2. DNS Lookup

Browser asks the Domain Name System (DNS) server (*aka the internet's phonebook*) for the IP address (*i.e. specific location*) of the search engine's server

e.g. Google Public DNS = 8.8.8.8

3. HTTP Request

Your browser sends an Hypertext Transfer Protocol (HTTP) request to the search engine's server, asking for the information you want

4. Data Transmission

The server sends back the search results, which are broken into small pieces called data packets, using protocols like Transmission Control Protocol/Internet Protocol (TCP/IP)

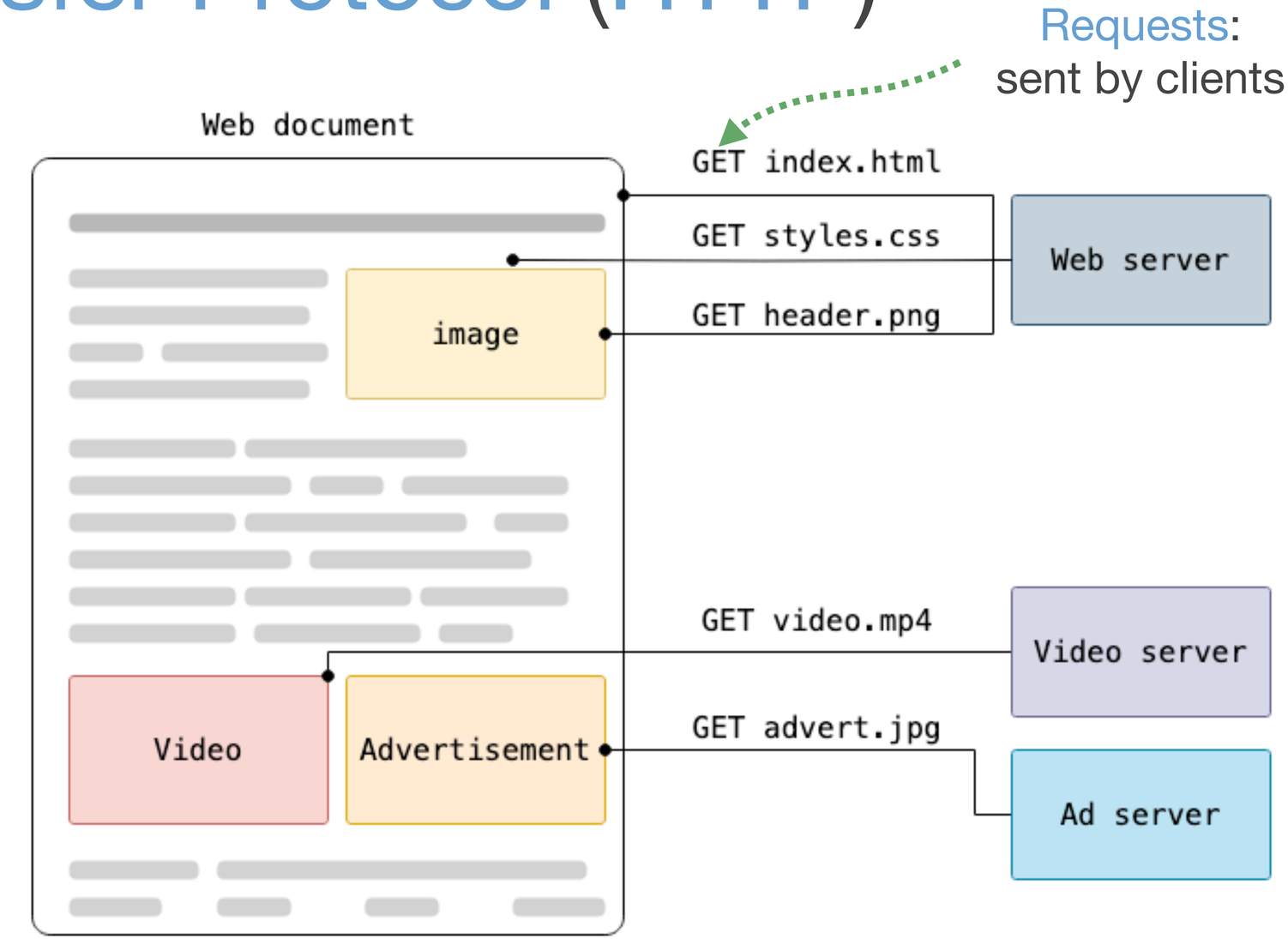
5. Display

Your browser receives these packets and assembles them, displaying the search results as a list of links and summaries for you to see.

https://aws.amazon.com/blogs/mobile/what-happens-when-you-type-a-url-into-your-browser/

Hypertext Transfer Protocol (HTTP)

- A protocol for fetching resources such as HTML documents
- Foundation of any data exchange on the Web
- Client-server protocol, *i.e.* **requests** are initiated by the recipient, usually the Web browser
- Clients & servers communicate by exchanging individual messages



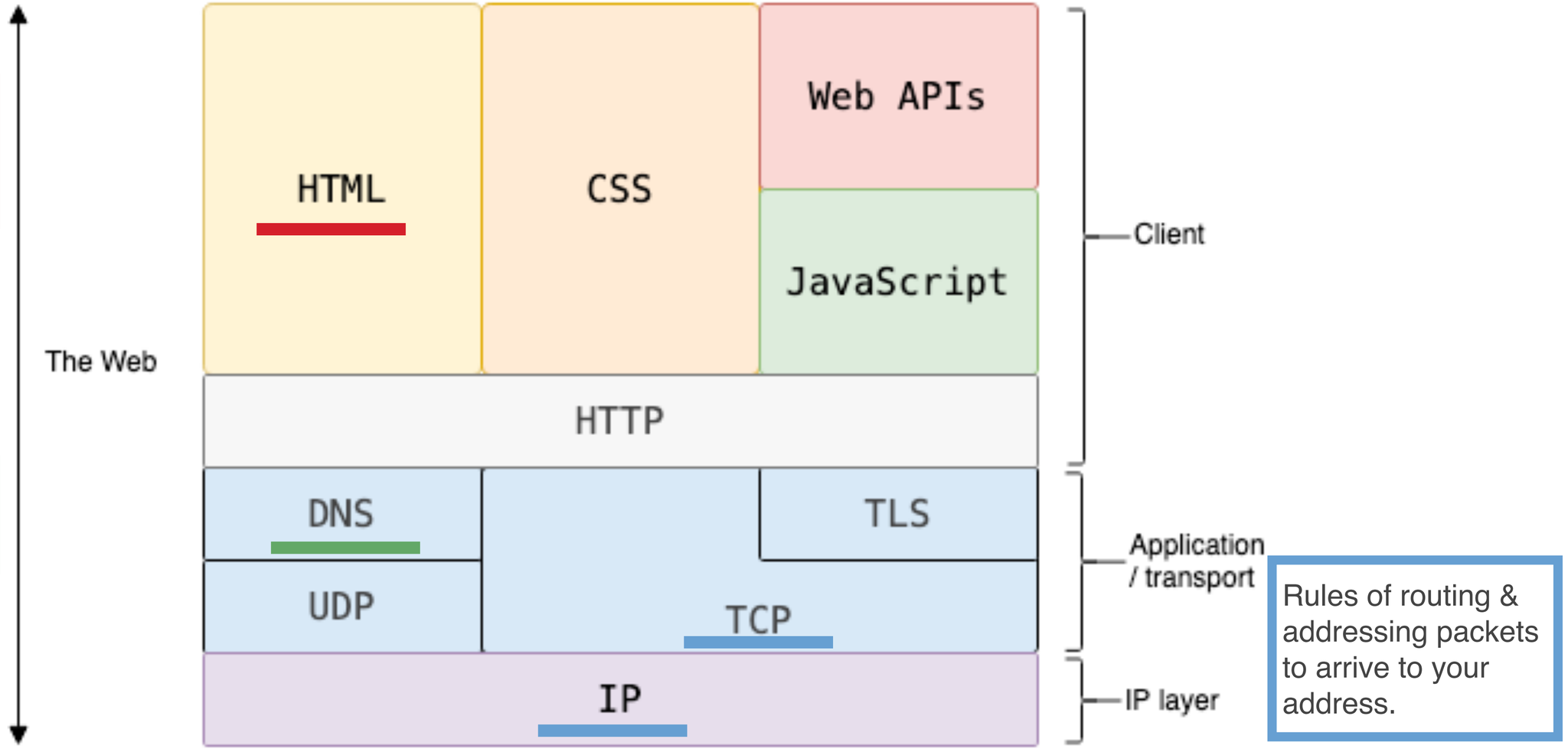
(**Responses:** messages sent by servers)

https://developer.mozilla.org/en-US/docs/Web/HTTP/Guides/Overview

HTTP

An application layer Protocol for fetching resources.

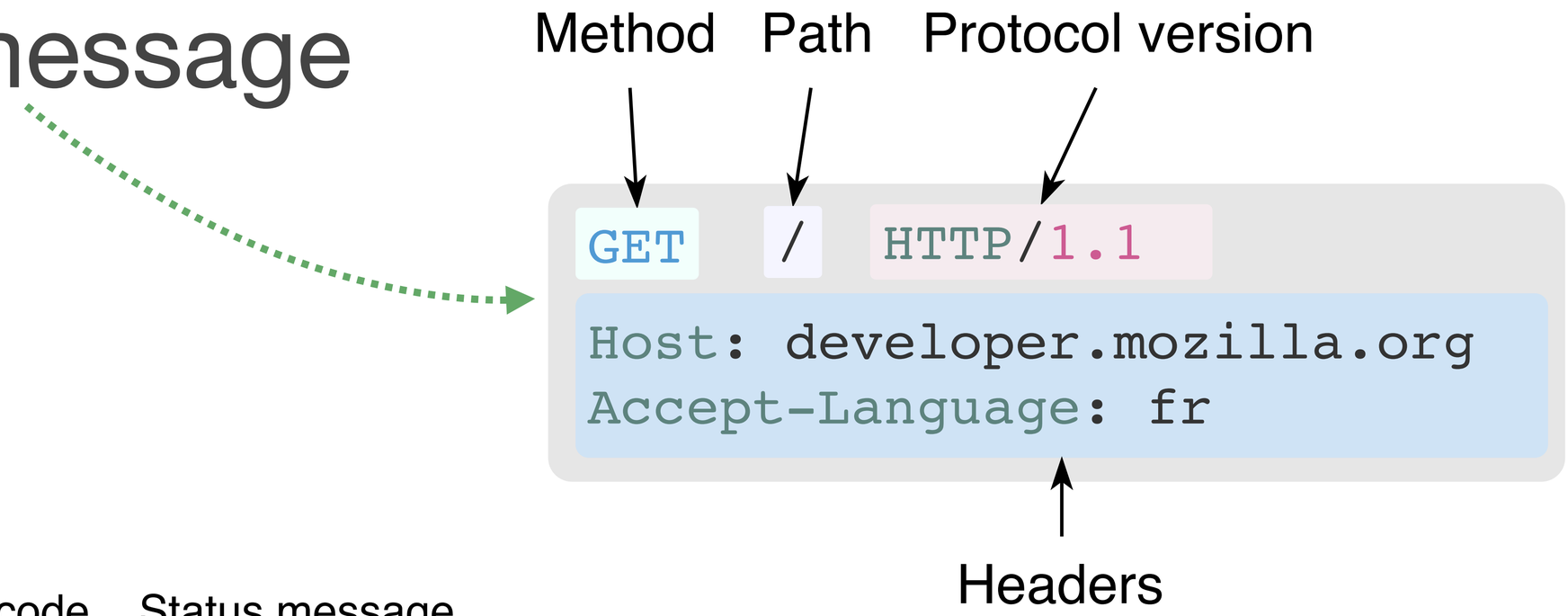
The internet phonebook

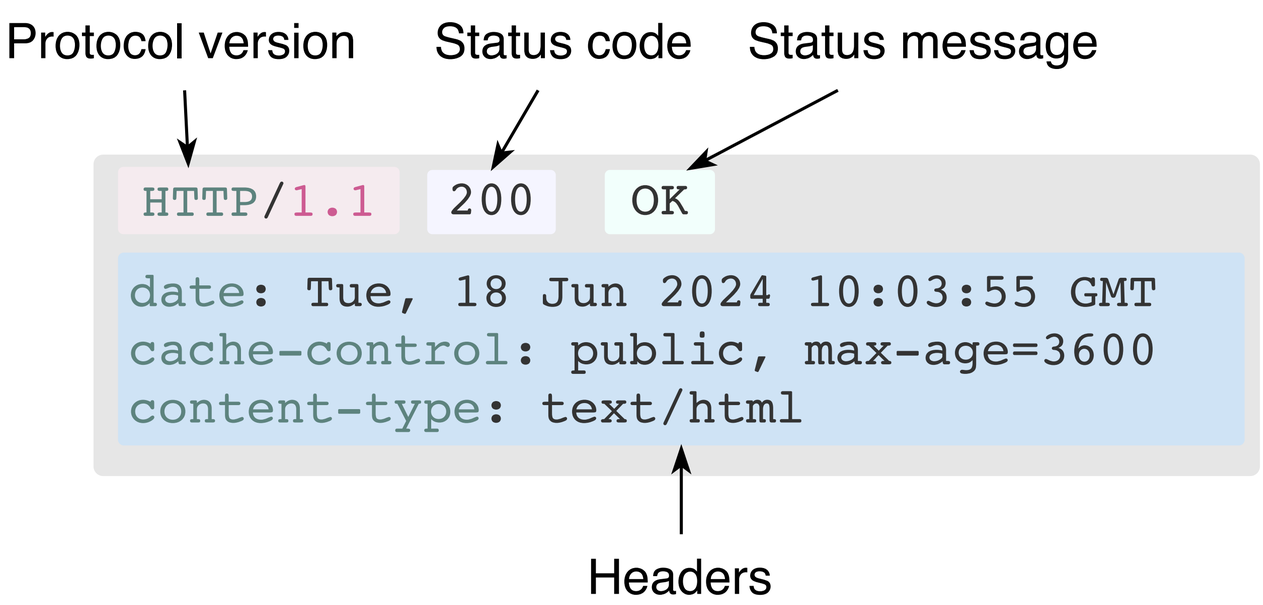


Rules of routing & addressing packets to arrive to your address.

https://developer.mozilla.org/en-US/docs/Web/HTTP/Guides/Overview

Sends a message





Receives a response

Take a minute…

What other methods
does HTTP have?

What other HTTP
status codes are there?

Remember this???

1. Query initiation

"Youtube picard speech drumhead"

2. DNS Lookup

Browser asks the Domain Name System (DNS) server (*aka the internet's phonebook*) for the IP address (*i.e. specific location*) of the search engine's server

e.g. Google Public DNS = 8.8.8.8

3. HTTP Request

Your browser sends an Hypertext Transfer Protocol (HTTP) request to the search engine's server, asking for the information you want

4. Data Transmission

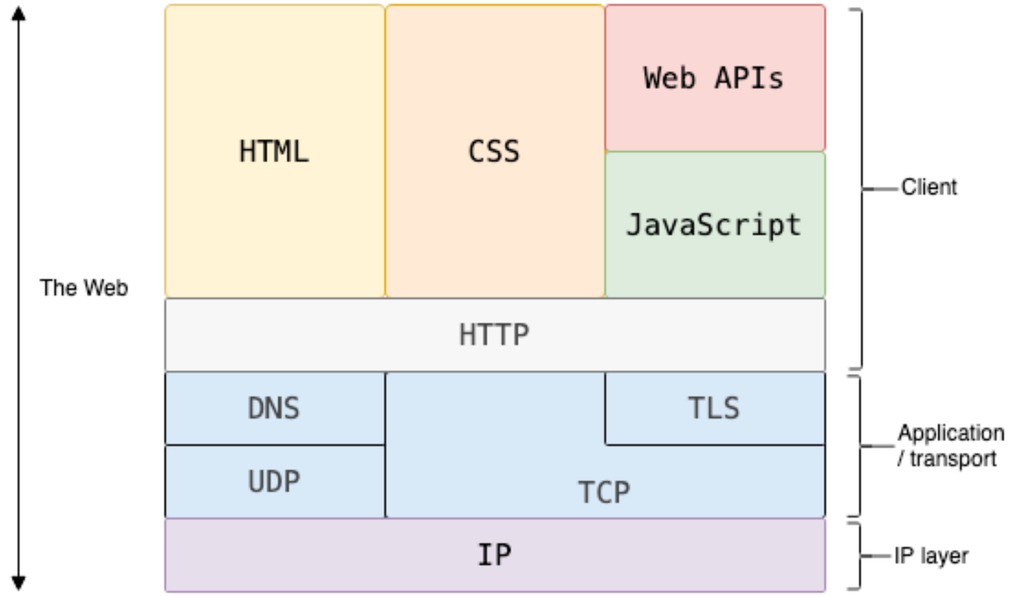
The server sends back the search results, which are broken into small pieces called data packets, using protocols like Transmission Control Protocol/Internet Protocol (TCP/IP)

5. Display

Your browser receives these packets and assembles them, displaying the search results as a list of links and summaries for you to see.

https://aws.amazon.com/blogs/mobile/what-happens-when-you-type-a-url-into-your-browser/

TCP/IP

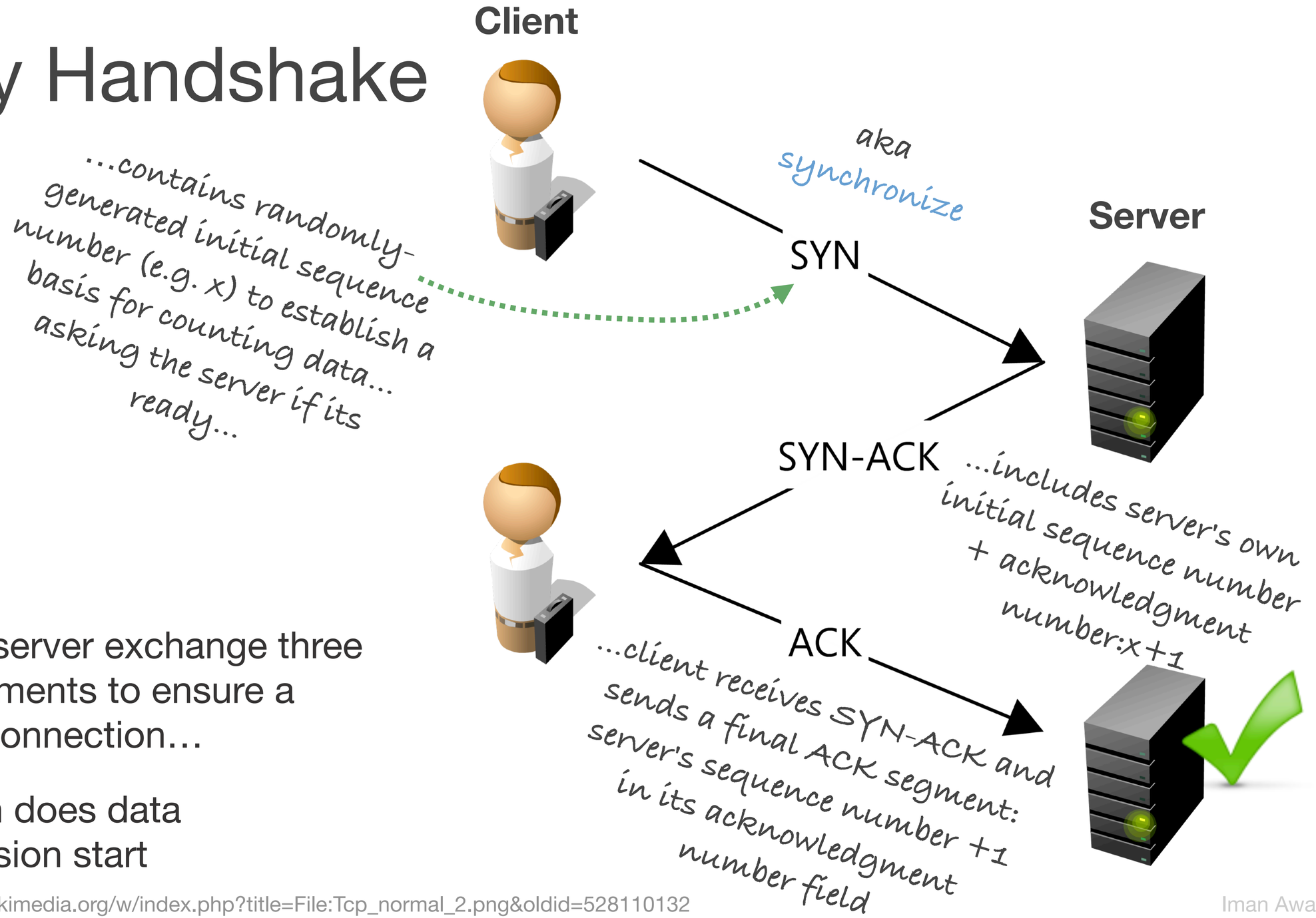


Rules of routing & addressing packets to arrive to your address.

- TCP on top of IP to ensure reliable packet transmission
- Handles lost packets, out of order packets, and corrupted packets
- Packet has header containing info regarding the sender and receiver
- Establishes a connection with acknowledgement aka ACKS
- Packets sent are received with acknowledgement

https://developer.mozilla.org/en-US/docs/Web/HTTP/Guides/Overview

3-Way Handshake



- Client & server exchange three TCP segments to ensure a reliable connection…
- only then does data transmission start

https://commons.wikimedia.org/w/index.php?title=File:Tcp_normal_2.png&oldid=528110132

Take a minute…

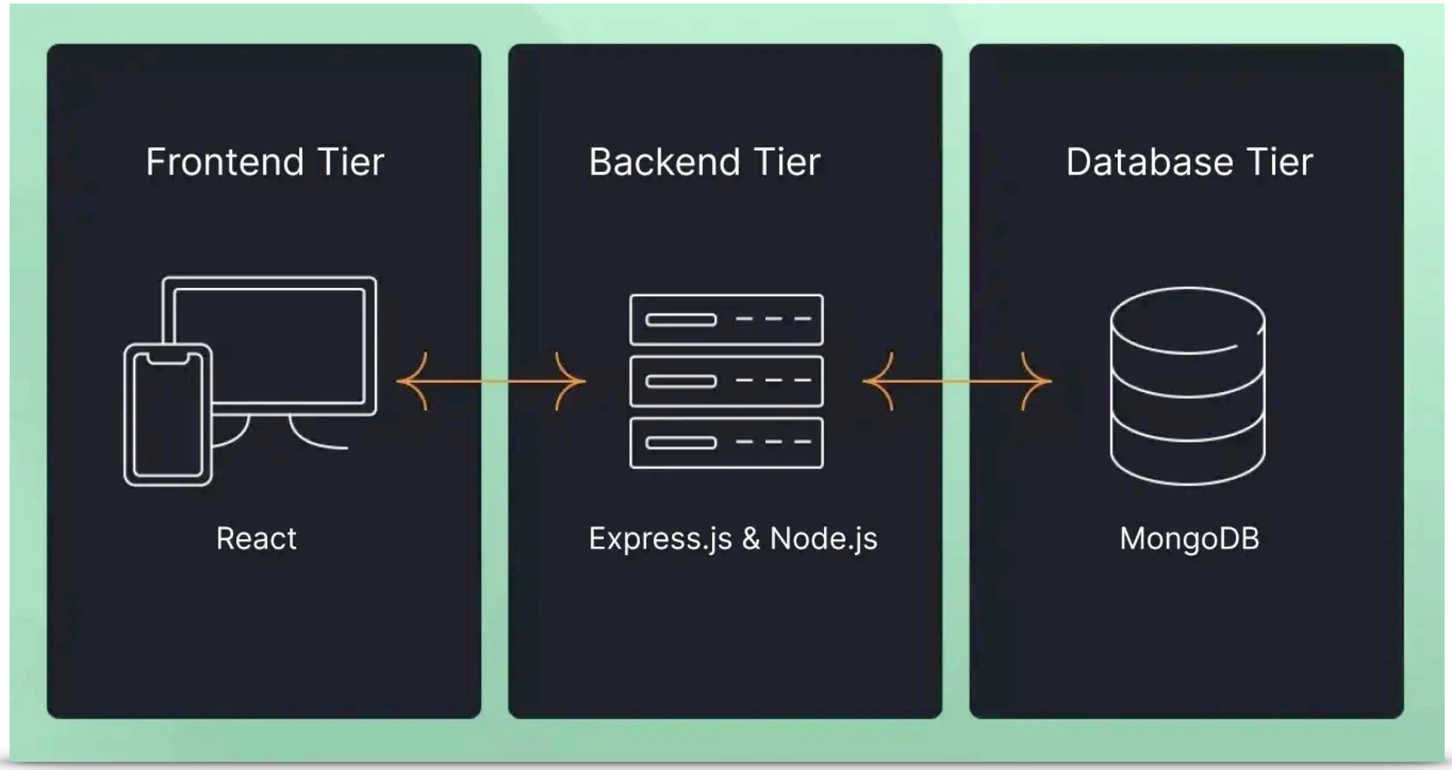
What is
the difference between
TCP/IP and UDP?

Take a minute…

How does TCP/IP handle
lost & out-of-order packets?

Big picture: How does the WWW work?

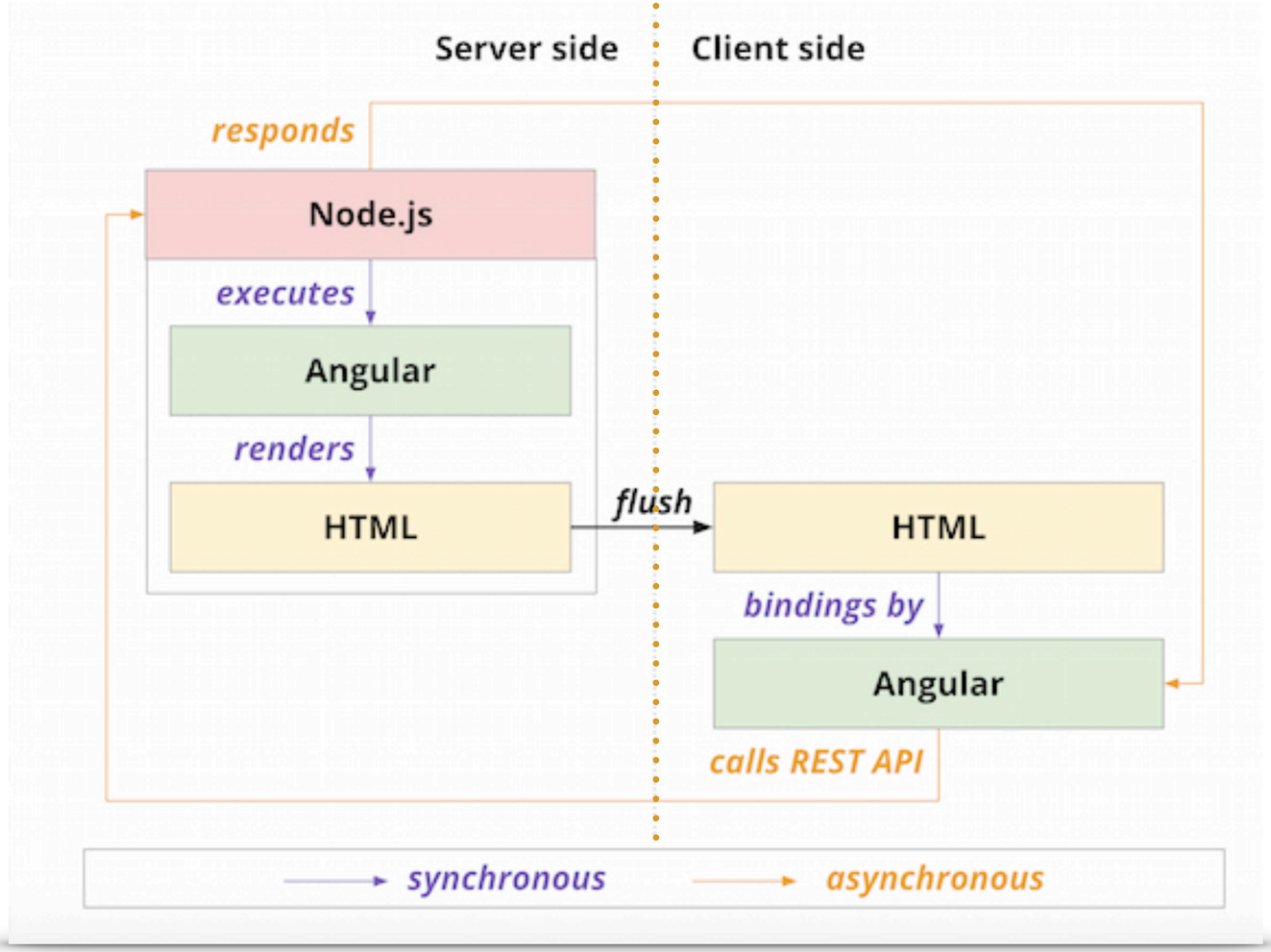
Looking ahead...



https://verpex.com/assets/uploads/images/blog/mern-architecture.webp?v=1740569511

Big picture: What is the Internet and how does it work?

Looking ahead...



https://dri.es/files/images/blog/universal-javascript.jpg

Just remember…

Reproduced from:
< https://positivepychology.com/comfort-zone >