How the Internet Works

Network

What is the Internet?

- A global network of billions of interconnected devices that request and receive information
- Every device can be uniquely identified by an **IP (Internet Protocol)** address, just like you have your physical home address
- Many **network protocols** serve different purposes; think of them as “**network languages**”
- Within the scope of your home network, devices are assigned *local* IP addresses, and they are all “hidden” from the Internet with a single *external* IP address that is assigned to your main home router by the **ISP (Internet Service Provider)**

- _**So, what happens when you want to get to a website?**_

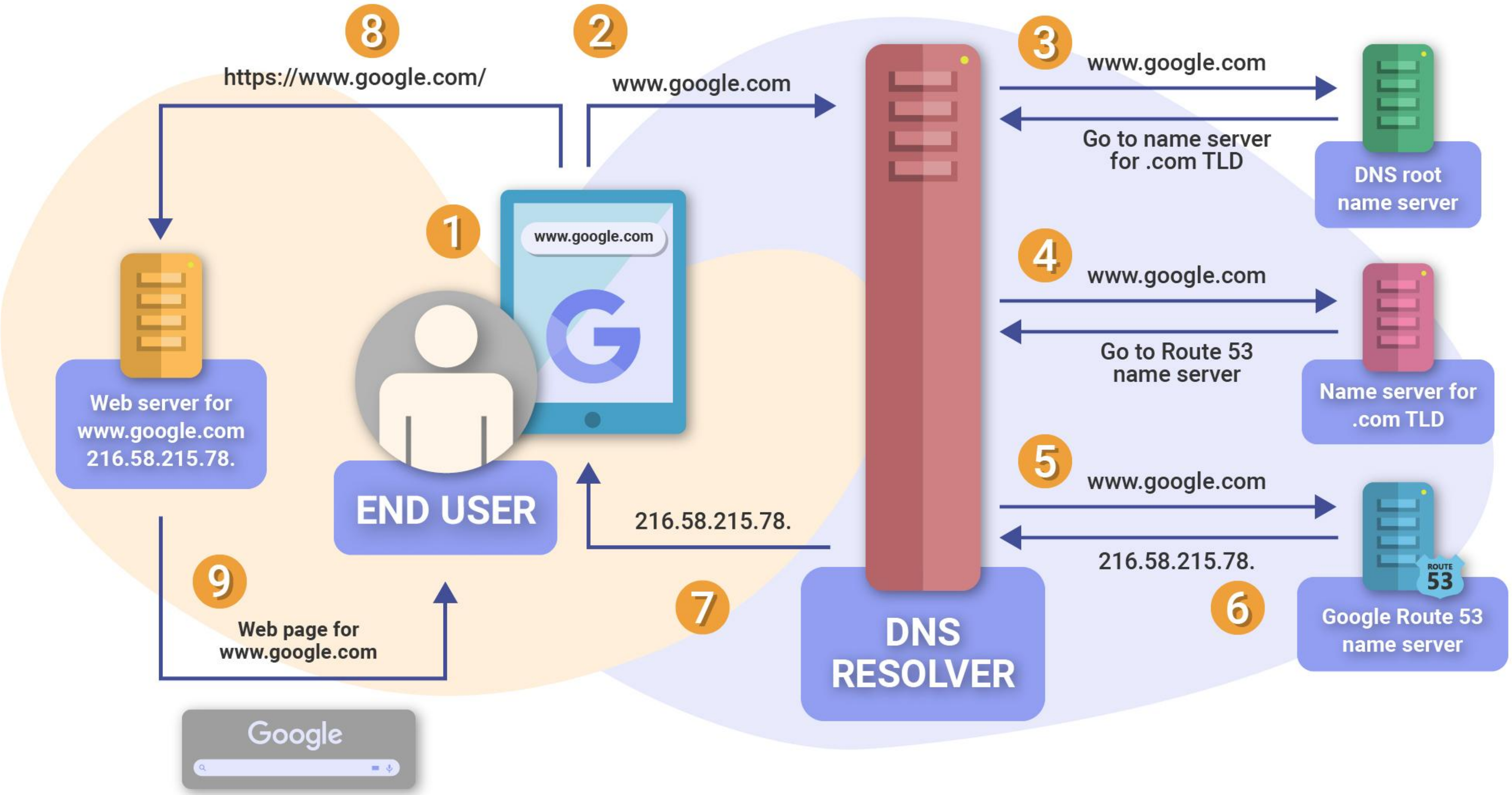
DNS – the Domain Name System

- Let’s say you enter a **domain name** (a human-readable address): `chatgpt.com`
- Devices can only navigate the Internet using IP addresses, which are numeric, like `192.168.0.2` for your home network or `172.64.155.209` for ChatGPT
- But how would your device know that `172.64.155.209` belongs to ChatGPT based on a single `chatgpt.com` name?
- This is where a **DNS** protocol comes in handy (port number **53**, and you’ll see more on ports later) that helps look up an IP, just like you would look up a **phone in a phonebook**
- Your browser will first ask a DNS server (the network you join provides the IP address of that server automatically) to *resolve* the domain name and provide the IP address

DNS Record Type	Hostname	Value
A	chatgpt.com	172.64.155.209

DNS: A Quick Glance

Name server: think of it as the DNS server itself
TLD: top-level domain like `.com` or `.edu`



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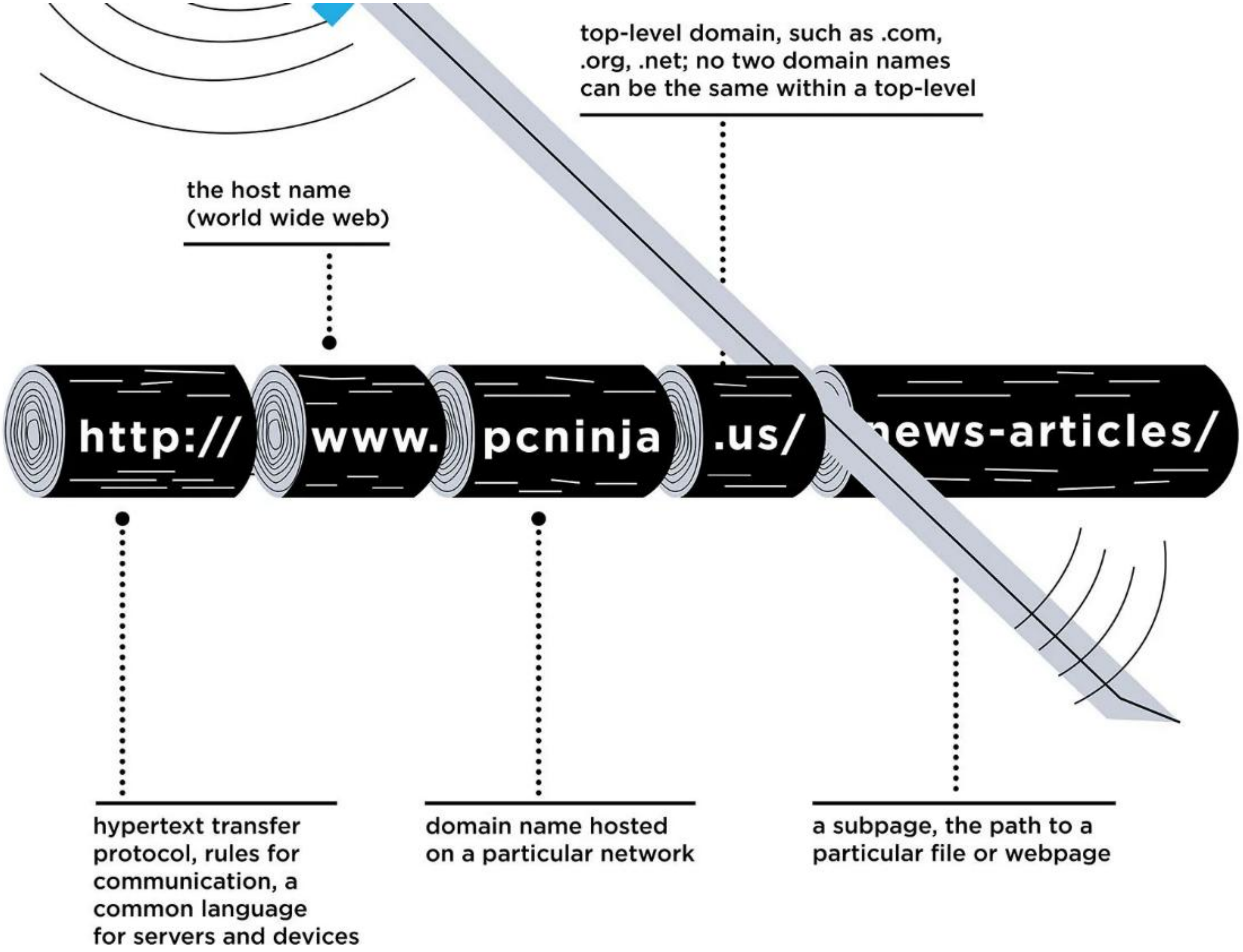
TLD and URL: Quick Glance

URL: Uniform Resource Locator, we know it as a website address

TLD: Top-Level Domain like `.com` or `.edu`



top-level domain, such as .com, .org, .net; no two domain names can be the same within a top-level
the host name (world wide web)
http://
www.
pcninja
.us/
news-articles/
hypertext transfer protocol, rules for communication, a common language for servers and devices
domain name hosted on a particular network
a subpage, the path to a particular file or webpage

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HTTPS and Port Number

- After your browser gets the `chatgpt.com` IP address, it needs to use **HTTPS** (Hypertext Transfer Protocol Secure) and a combination of IP and *port number* (a number between `0` and `65,535`) to begin searching for the actual resources that belong to `chatgpt.com` webpage
- Think of a port number as a *door* to a specific program on a device, and the program communicates on the network through that door; each device can have up to `2^16` port numbers (`2^16 = 65,536`)
  - Does it mean you can open `65,536` tabs?! Nope, browsers limit it to only several thousand…
- Each **browser tab** in this case is a different **program**, and each application that talks over the Internet is a different program that needs to run on a port that has not been taken by another program
  - Your operating system (Windows, Linux, MacOS, Android, iOS) helps manage all of that

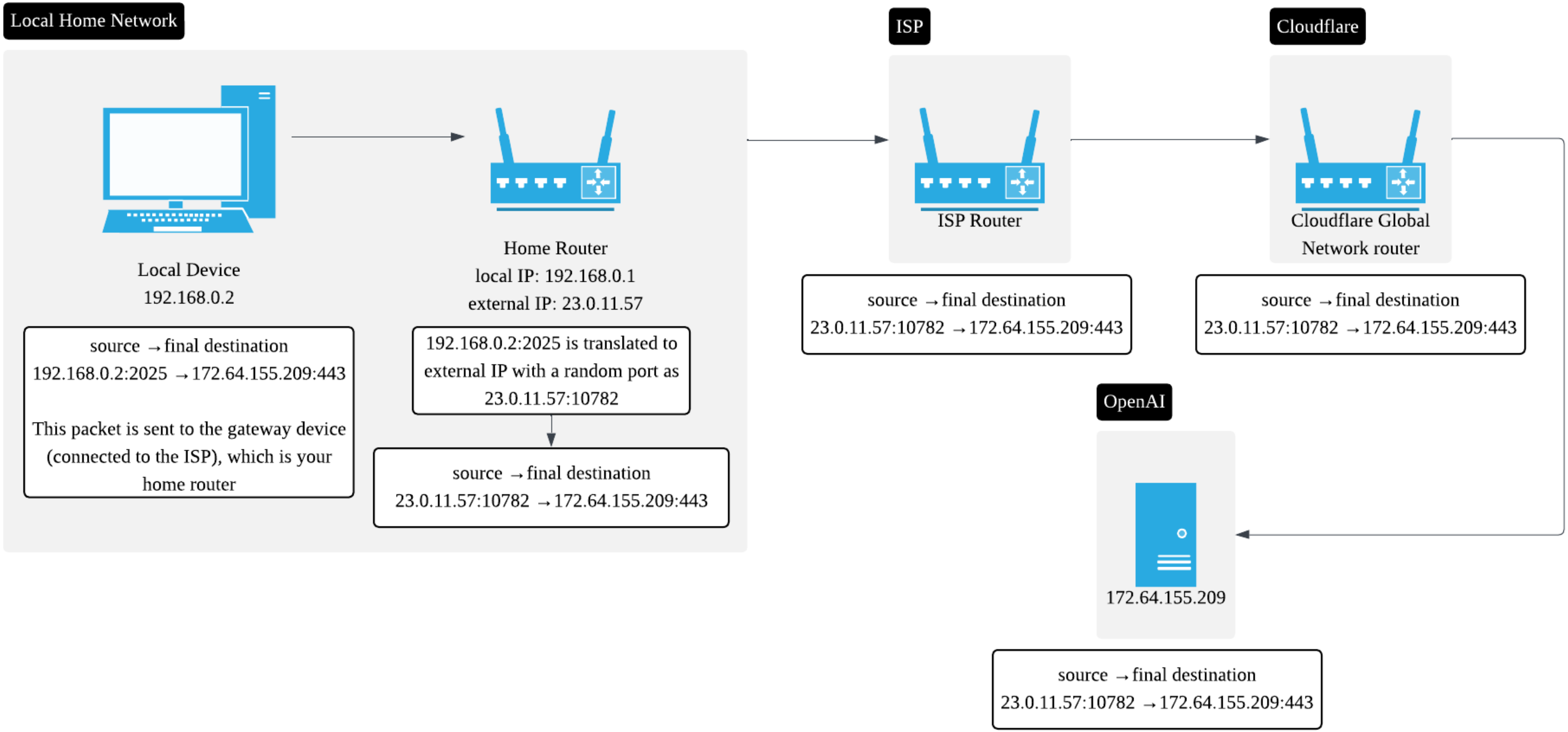
IP + Port = program’s identity on the device

- Let’s say your device’s local IP address is `192.168.0.2`
- Let’s say that the browser’s tab with `chatgpt.com` got a port number `2025` assigned by the operating system
- Then your browser will send a request to your home router, saying that it wants to find `172.64.155.209:443` and that if it has been found, then please return the result to `192.168.0.2:2025`
  - Note that the port number is now attached to the IP address via the colon
- Now your program (a specific browser tab) has an *identity* (IP + port), and your home router will map that identity to its public (external) IP and a random port, like `23.0.11.57:11111`
- From now on, your original packet will be known as `23.0.11.57:11111` during the rest of its journey across the Internet in search of `172.64.155.209:443`
- This is where *routing* algorithms kick in to determine the optimal path between your device and `chatgpt.com` server that *serves* (hence, it’s called a *server*) the website files that are later shown in your browser

*Side Note: Reserved Ports

- As a side note, there are many ports that are “reserved” to be used by certain programs that do a common task on the network
- For instance, if a program resolves DNS queries, it will be *listening* on port `53` (for secure DNS, `853`)
  - **Listening** means the program is visible (discoverable) on the network, and others can send packets to it and receive a response
- Another example: if a program serves websites over the **HTTPS** protocol, then it will be listening for connections on port **`443`**
- Reserved ports do not necessarily mean they cannot be used for something else, but it *does represent a standard* that many application developers follow

Routing (From Home to ChatGPT)



Local Home Network

Local Device
192.168.0.2

source → final destination
192.168.0.2:2025 → 172.64.155.209:443

This packet is sent to the gateway device (connected to the ISP), which is your home router

Home Router
local IP: 192.168.0.1
external IP: 23.0.11.57

192.168.0.2:2025 is translated to external IP with a random port as 23.0.11.57:10782

source → final destination
23.0.11.57:10782 → 172.64.155.209:443

ISP

ISP Router

source → final destination
23.0.11.57:10782 → 172.64.155.209:443

Cloudflare

Cloudflare Global Network router

source → final destination
23.0.11.57:10782 → 172.64.155.209:443

OpenAI

172.64.155.209

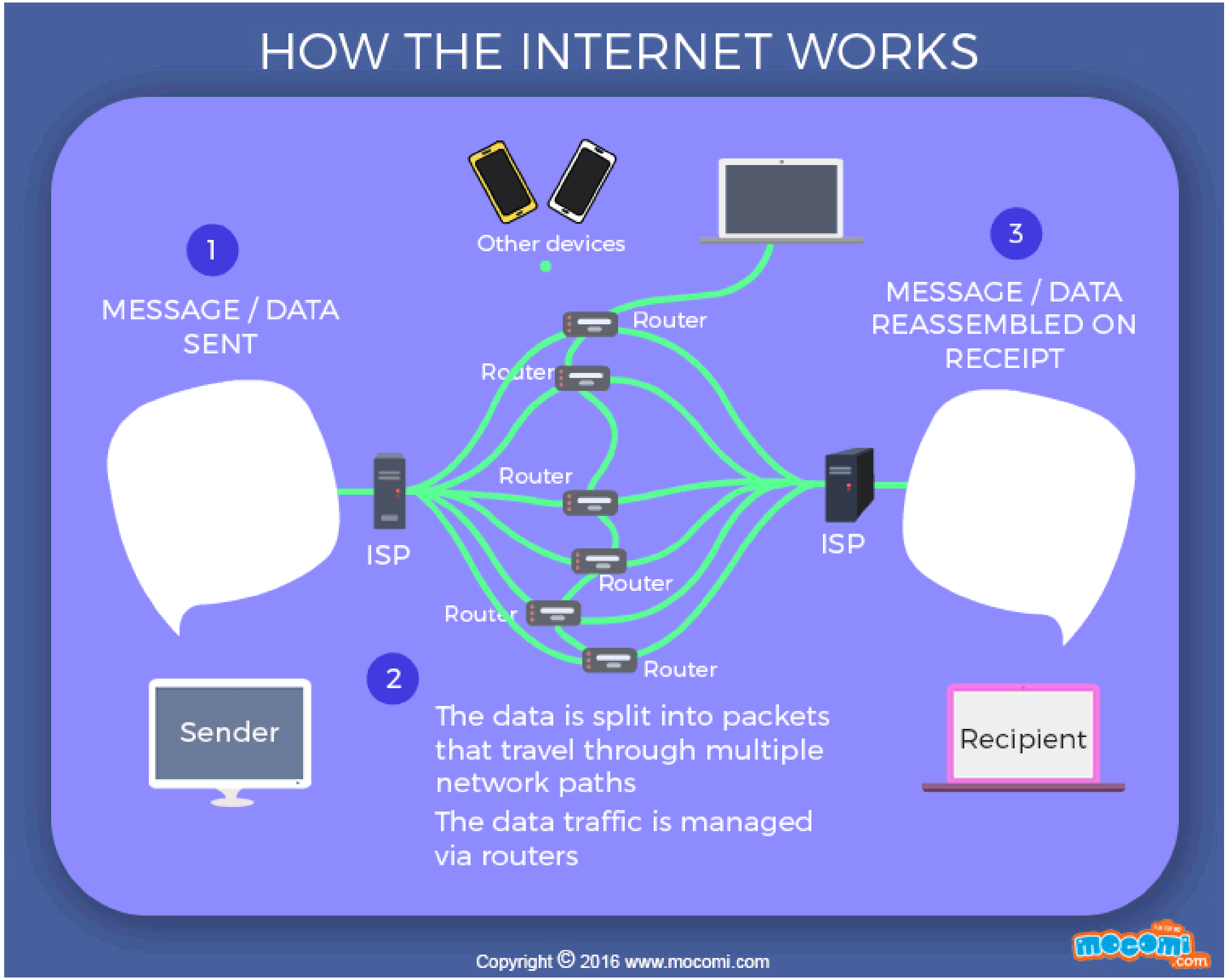
source → final destination
23.0.11.57:10782 → 172.64.155.209:443

Routing

- Every time your original request travels to the next routing device (aka *hop*) on the Internet, that device looks up the packet's destination and sends it to the *hop* that it believes is the closest to that destination
- On every *hop,* starting from the ISP, the routing device (aka *router*) knows where the packet is going to (`172.64.155.209:443`) and where it came from (`23.0.11.57:11111`)
- On average, it may take between `12-18` hops before your request reaches your destination
- When `chatgpt.com` server responds with a web page, the data gets split into packets and they are all sent to `23.0.11.57:11111`
- Next, your home router picks them up, looks at what they were mapped to (`192.168.0.2:2025`), and sends them to your device, where your operating system finds the program (browser tab) and forwards the packets to that program

Packet

- Your original request is often heavy, especially if your browser loads media data
- Thus, each request is split into smaller parts called *packets*, and all packets are assembled in the right order at their destination, but they can all take **different routing paths**!
- Some packets may get lost or dropped due to hardware, software, and other random issues



The data is split into packets that travel through multiple network paths

The data traffic is managed via routers

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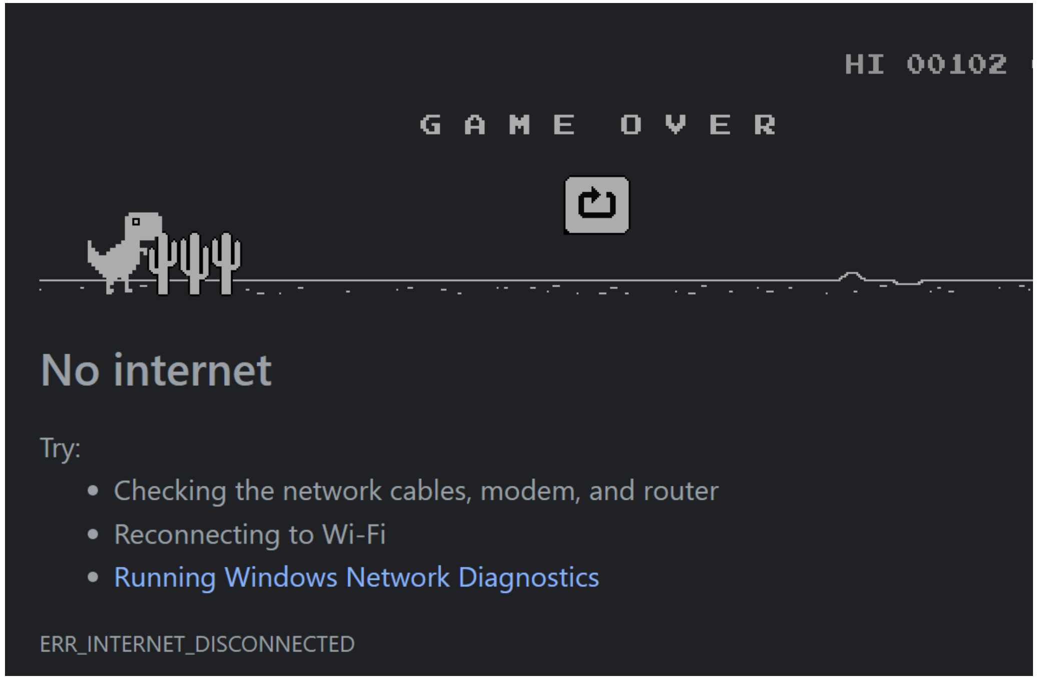
Network Problems: There Are Many



No internet

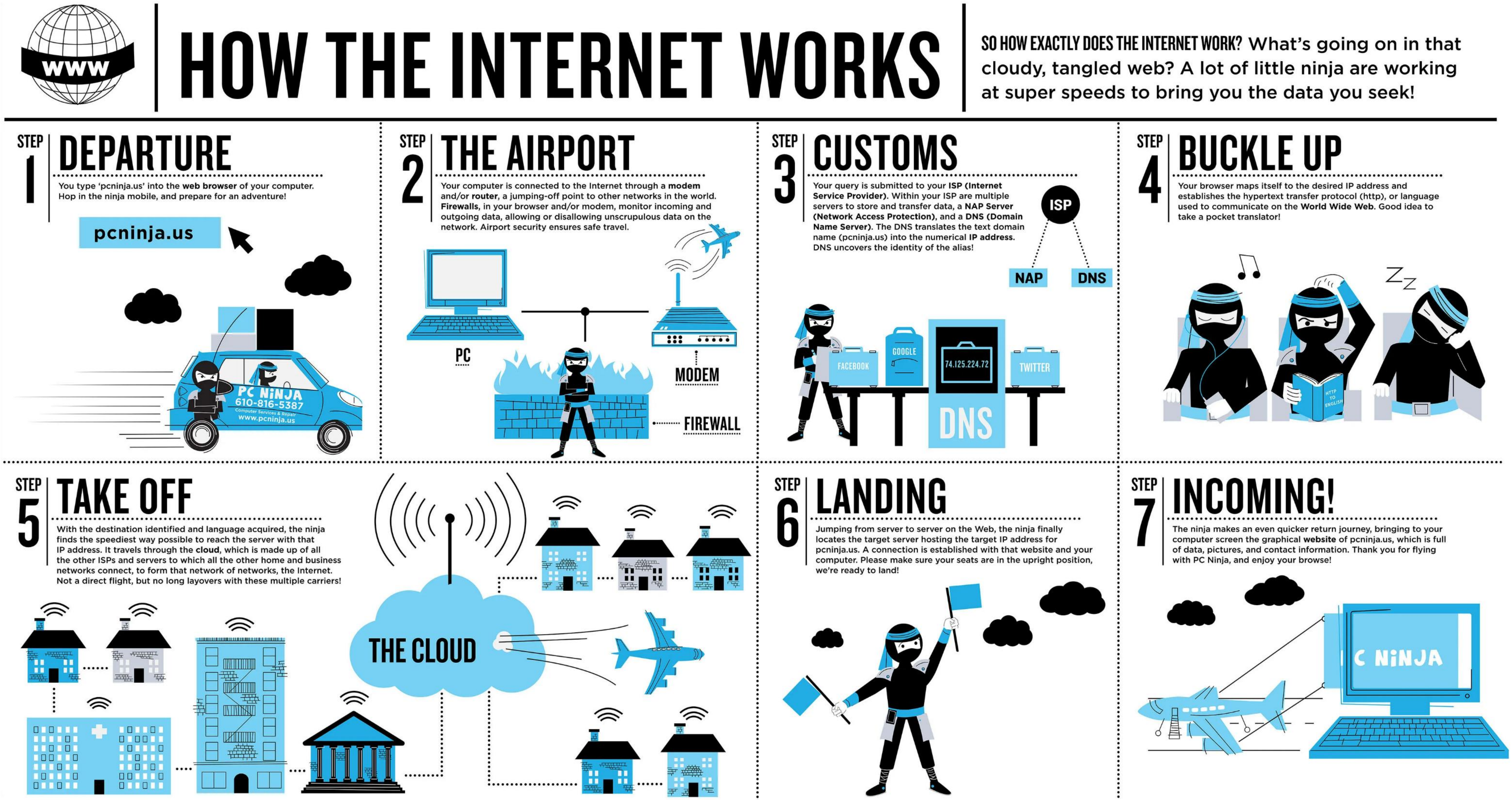
Try:

- Checking the network cables, modem, and router
- Reconnecting to Wi-Fi
- Running Windows Network Diagnostics

ERR_INTERNET_DISCONNECTED

- What happens if the destination is unreachable?
  - Each packet has an attribute called `TTL` (Time To Live, what a name!!), and depending on your operating system, it can be set to `64`, `128`, or `255`
  - At each hop, the `TTL` gets reduced by 1
  - Every routing device checks if `TTL = 0`; if it is, then it deletes that packet as if it never existed
  - This mechanism prevents packets from looping around the world forever, and a simple `TTL` attribute **saves the Internet from being instantly overloaded**

- What happens if the packet is lost?
  - Depending on the protocol, your device will **try resending** it a few times and then eventually give up if no response comes back, **or it may just not even care about it** (like the *User Datagram Protocol*, UDP, used in **gaming and streaming**)



HOW THE INTERNET WORKS

SO HOW EXACTLY DOES THE INTERNET WORK? What's going on in that cloudy, tangled web? A lot of little ninja are working at super speeds to bring you the data you seek!

STEP 1 DEPARTURE

You type 'pcninja.us' into the **web browser** of your computer. Hop in the ninja mobile, and prepare for an adventure!

STEP 2 THE AIRPORT

Your computer is connected to the Internet through a **modem** and/or **router**, a jumping-off point to other networks in the world. **Firewalls**, in your browser and/or modem, monitor incoming and outgoing data, allowing or disallowing unscrupulous data on the network. Airport security ensures safe travel.

STEP 3 CUSTOMS

Your query is submitted to your **ISP (Internet Service Provider)**. Within your ISP are multiple servers to store and transfer data, a **NAP Server (Network Access Protection)**, and a **DNS (Domain Name Server)**. The DNS translates the text domain name (pcninja.us) into the numerical **IP address**. DNS uncovers the identity of the alias!

STEP 4 BUCKLE UP

Your browser maps itself to the desired IP address and establishes the hypertext transfer protocol (http), or language used to communicate on the **World Wide Web**. Good idea to take a pocket translator!

STEP 5 TAKE OFF

With the destination identified and language acquired, the ninja finds the speediest way possible to reach the server with that IP address. It travels through the **cloud**, which is made up of all the other ISPs and servers to which all the other home and business networks connect, to form that network of networks, the Internet. Not a direct flight, but no long layovers with these multiple carriers!

STEP 6 LANDING

Jumping from server to server on the Web, the ninja finally locates the target server hosting the target IP address for pcninja.us. A connection is established with that website and your computer. Please make sure your seats are in the upright position, we're ready to land!

STEP 7 INCOMING!

The ninja makes an even quicker return journey, bringing to your computer screen the graphical **website** of pcninja.us, which is full of data, pictures, and contact information. Thank you for flying with PC Ninja, and enjoy your browse!

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