Introduction to Computer Networks

CS640

Introduction

Ming Liu

mgliu@cs.wisc.edu

Today

- Course Logistics

- Computer Networks Overview

- Computer Networks Basics

- Computer Networks Design Requirements

Administrative Details

- ## Instructor: Ming Liu
  - mgliu@cs.wisc.edu
  - Office hour: Fr 1:30 pm — 2:30 pm @CS 7379
  - Research Interest: Networking and Systems

- ## TA1: Qianliang Wu (this section)
  - qwu293@wisc.edu
  - Office hour: TuTh 11 am — 12 pm @CS 3248

- ## TA2: Sarah Tanveer
  - sarah.tanveer@wisc.edu
  - Office hour: TBD

Course Communication Channels

- #1. Course website: slides, readings, and schedule
  - https://pages.cs.wisc.edu/~mgliu/CS640/S25/index.html

- #2. Course mailing list: announcements
  - compsci640-1-s25@g-groups.wisc.edu

- #3. Piazza: Q&A
  - https://piazza.com/wisc/spring2025/cs640

- #4. Submission
  - Canvas: labs and grades

Grade Breakdown

- 4 Programming Labs (50%)
  - Teams of 1-2 people

- Final Exam (35%)
  - 05/06/2025 (Thursday)
  - Open-book and open-notes

- 4 Quizzes (15%)
  - 5% each
  - Open-book and open-notes
  - The top three

Grading Option #1

- **A: [90, 100]**
- **AB: [85, 90)**
- **B: [80, 85)**
- **BC: [75, 80)**
- **C: [70, 75)**
- **D: [60, 70)**
- **F: [0, 60)**

Grading Option #2 (Curving)

- **A:** **[0, 35%]**

- **AB:** **[35%, 60%)**

- **B:** **[60%, 80%)**

- **BC:** **[80%, 90%)**

- **C:** **[,)**

- **D:** **[,)**

- **F:** **[,)**

Your final grade = Max (op#1, op#2)

- E.g., (AB, A) = A

Reading and References

- Required readings posted on the course website
  - Complete each reading before the lecture in which it is assigned

- Textbook
  - Computer Networks: A System Approach, Sixth Edition
  - https://book.systemsapproach.org/index.html
  - Just a reference. We will not follow it strictly.

- Additional references (check course website)
  - Computer Networking: A Top-Down Approach
  - Computer Networks
  - TCP/IP Illustrated, Volume 1: The Protocols
  - Some papers

Collaboration & Late Submission

- Working together is encouraged
  - Discussion of course materials, debugging issues, etc.

- But the final submission must be your own work!
  - Labs, quizzes, and exams

- Meet deadlines
  - Turn assignments in on time; Late penalty (see each assignment)
  - Start lab sooner than you think you need to
  - Follow instructions for submission codes

How do we learn

- Before class
  - Finish the reading

- In class
  - What is the key problem?
  - What is the solution?

- After class
  - What is the takeaway?
  - Labs

Learning Outcomes

- #1: Explain how computer networks work

- #2: Develop small-scale network applications

- #3: Evaluate design trade-offs of networked systems

What are computer networks?

Take the Internet as an Example
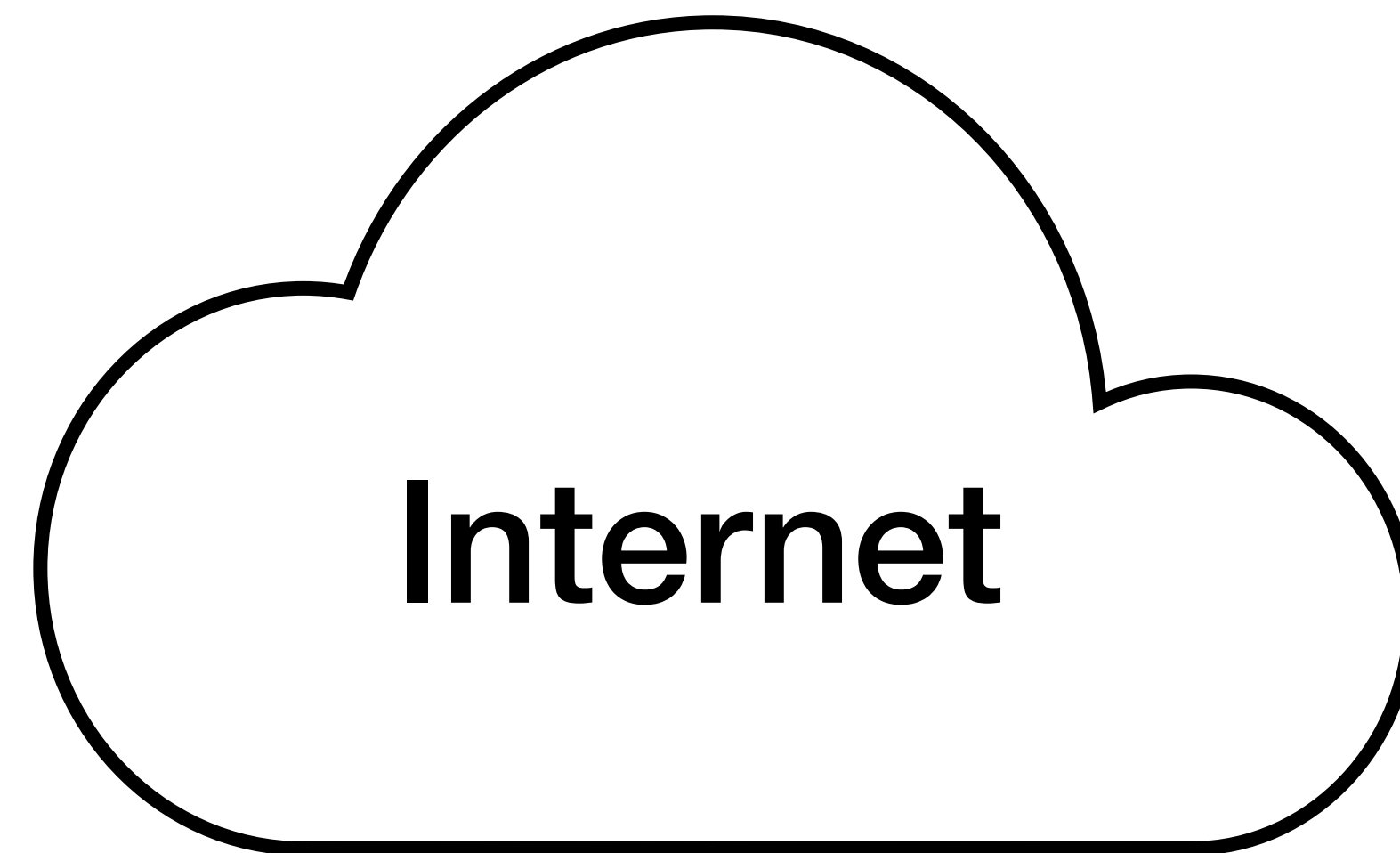
- The largest engineered system people have built so far

Internet

Take the Internet as an Example

- The largest engineered system people have built so far
  - Connect billions of devices
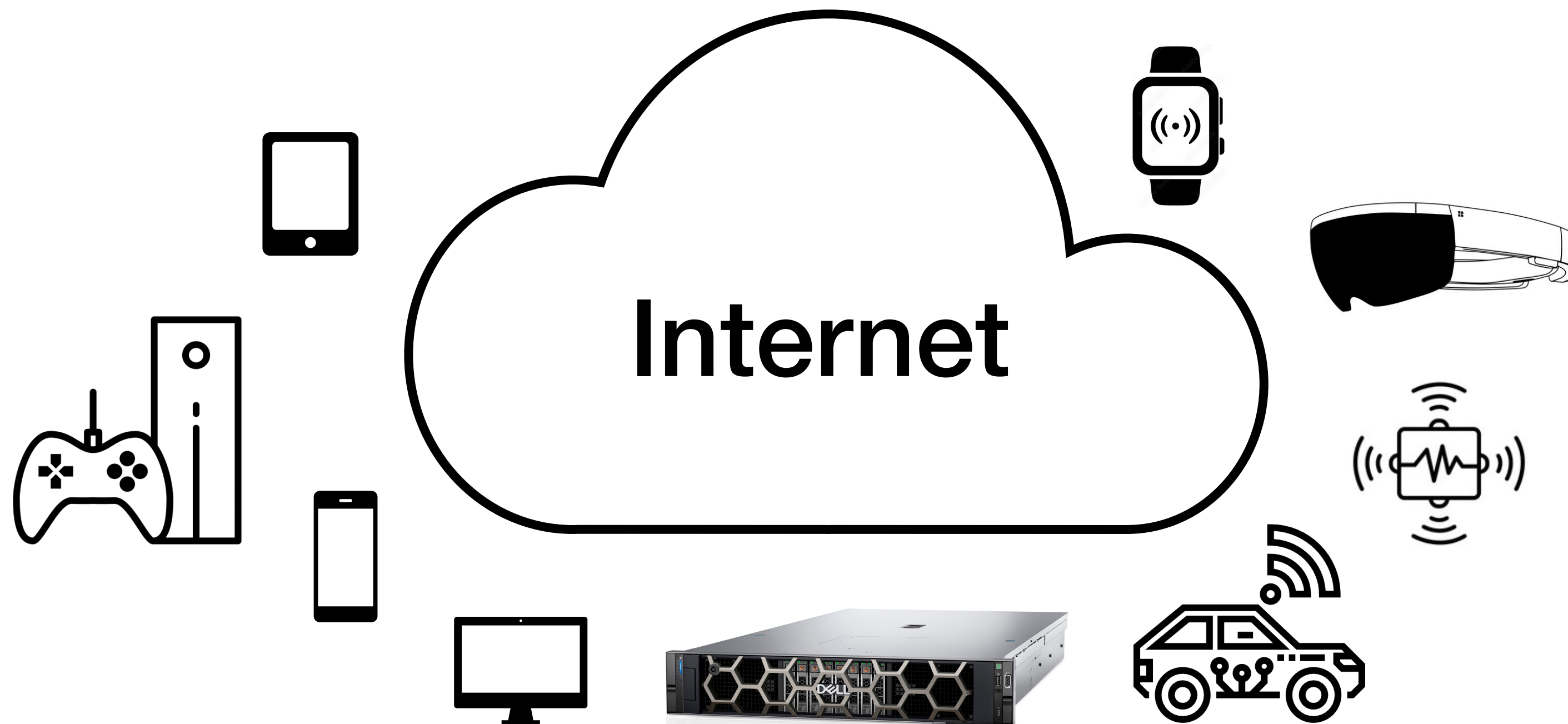
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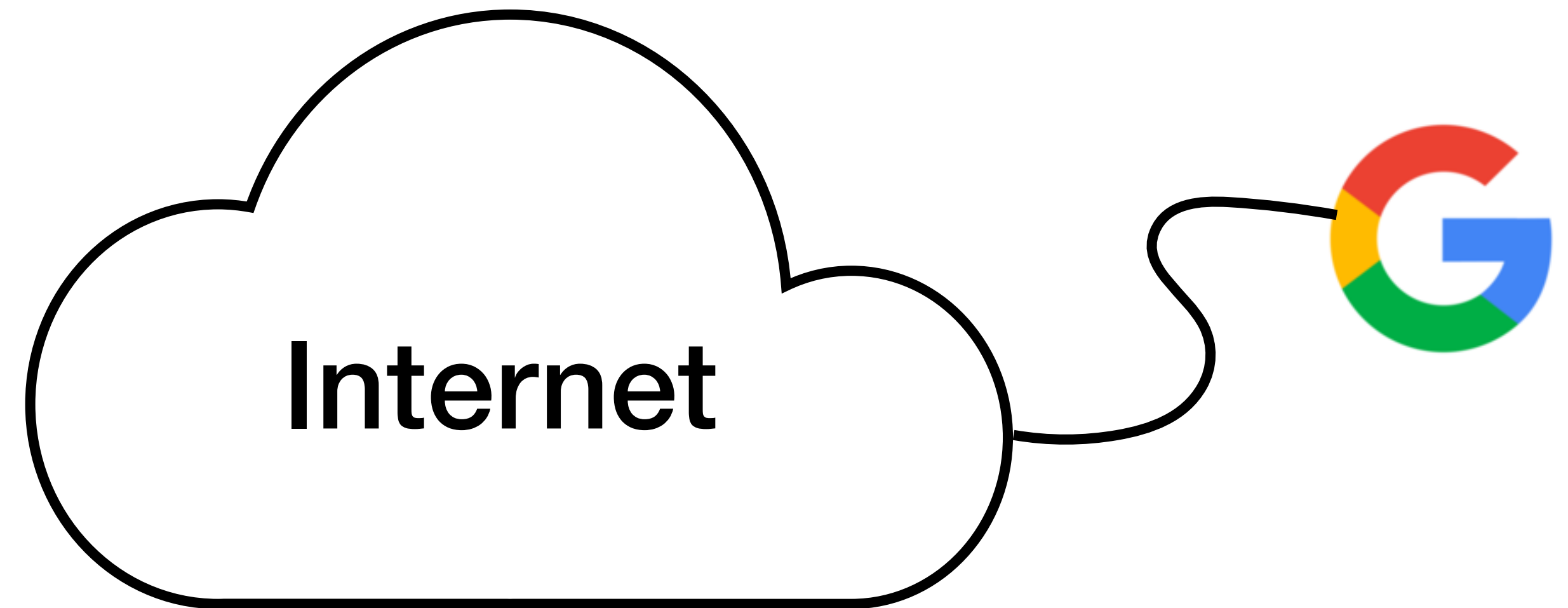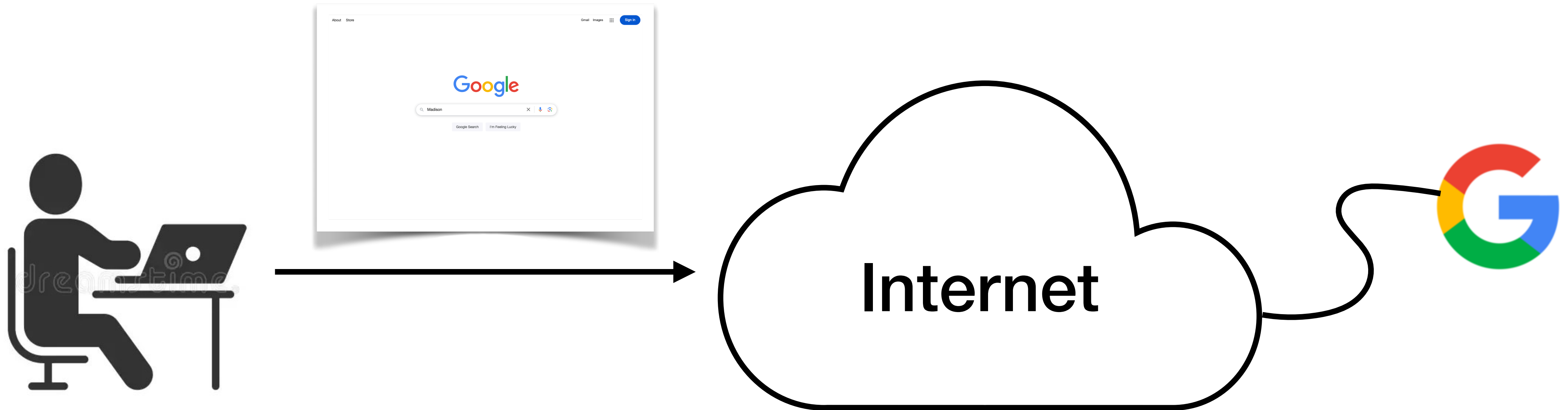 - Provide application service for billions of users
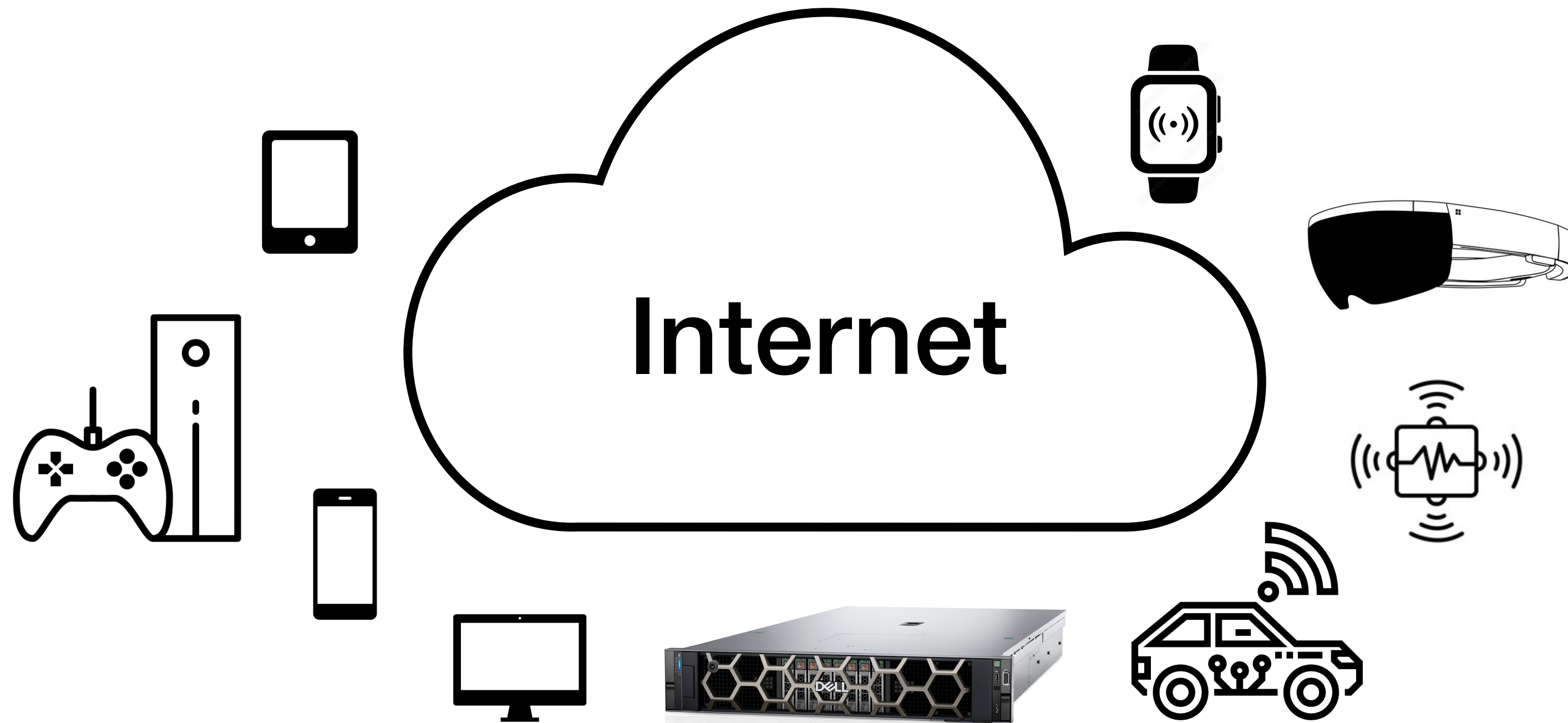
Take the Internet as an Example

- The largest engineered system people have built so far
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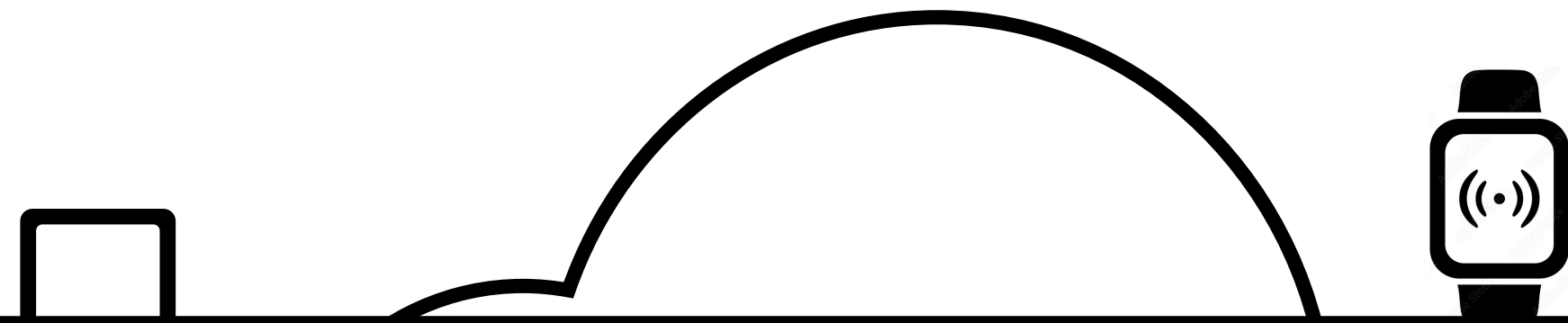
But,
- **What is the Internet?**
- **How does the Internet work?**

A Google Search Example
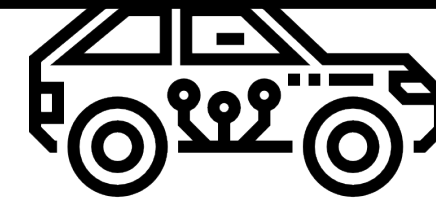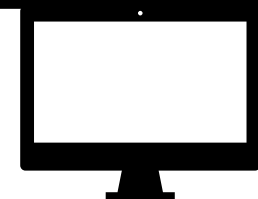
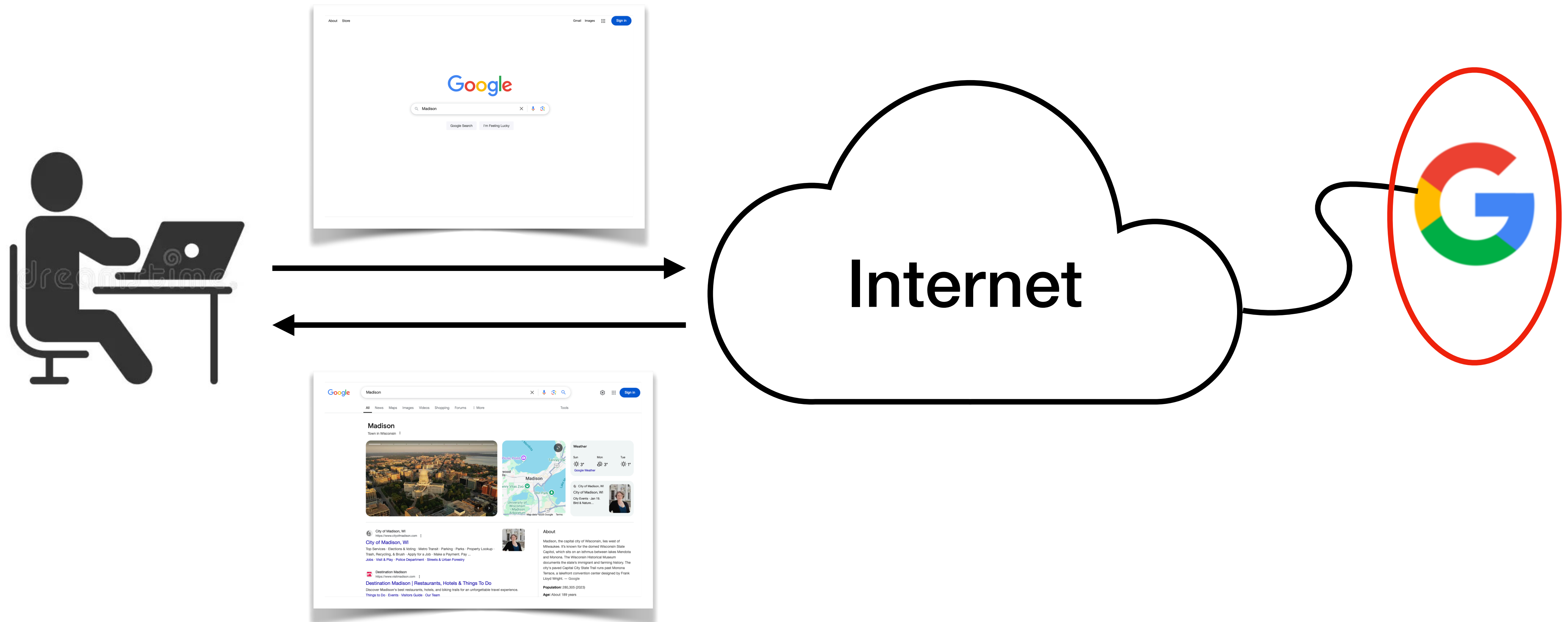Internet

A Google Search Example

A Google Search Example
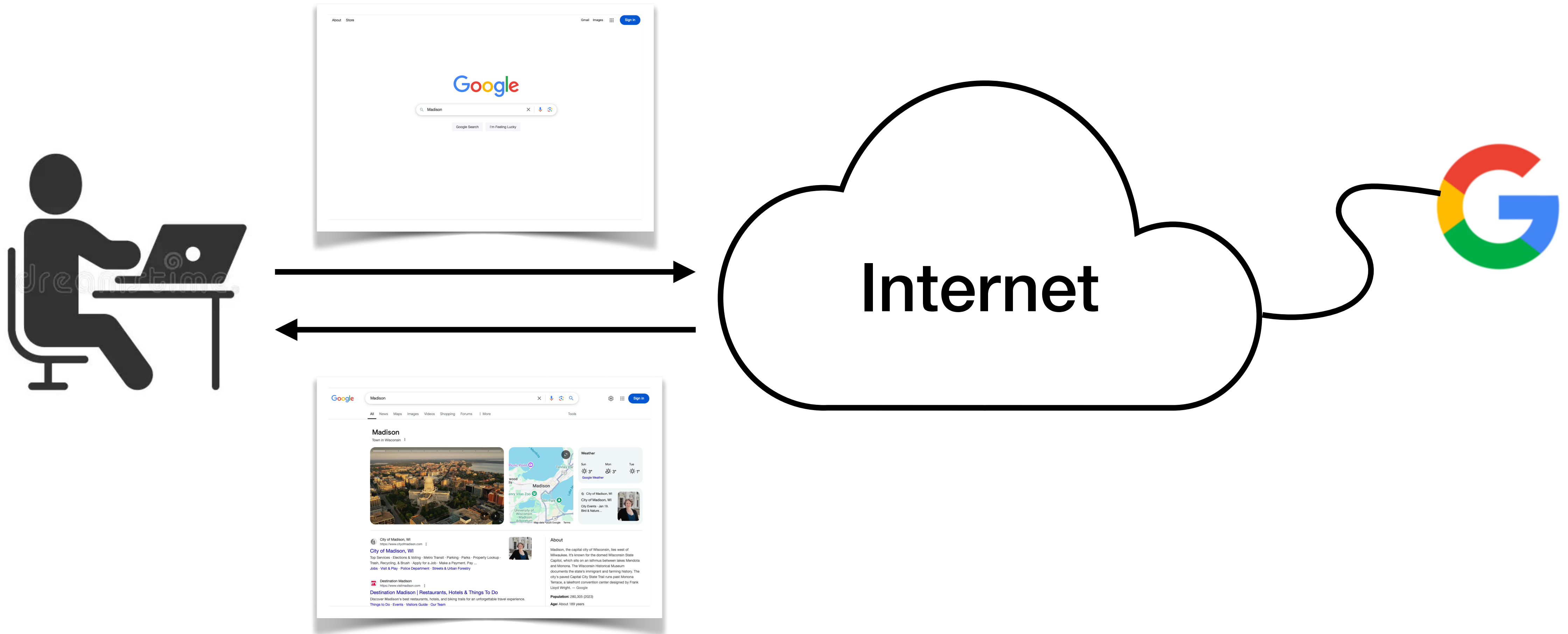
Internet

Host (End System)

- A host is a device that connects to the Internet
  - E.g., desktops, smartphones, tablets, servers, gaming consoles, etc.
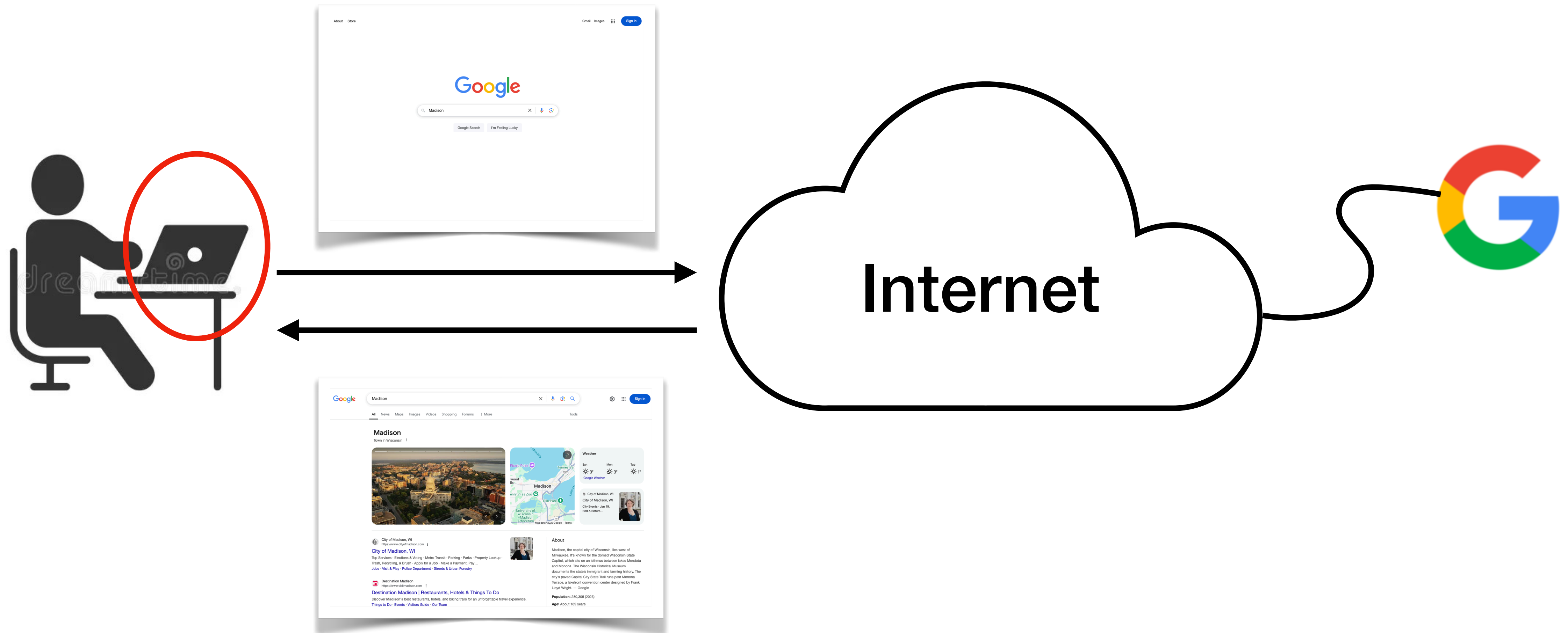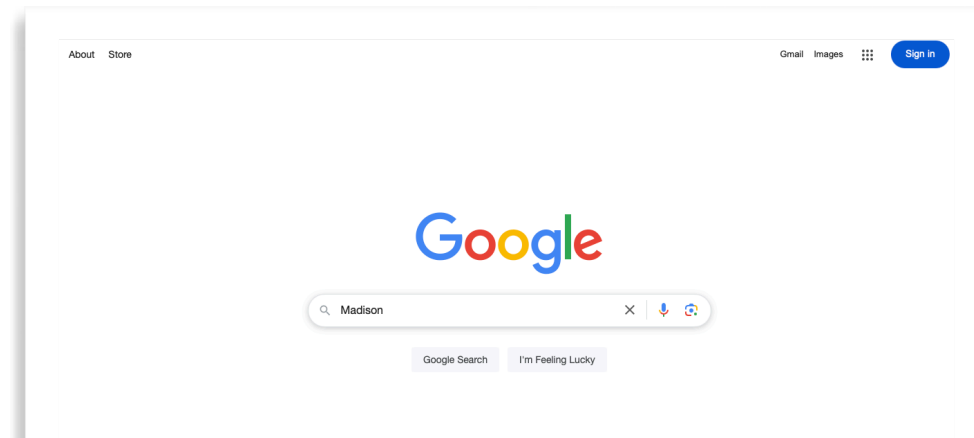
Service

- A service is a (distributed) app that offers certain functionalities
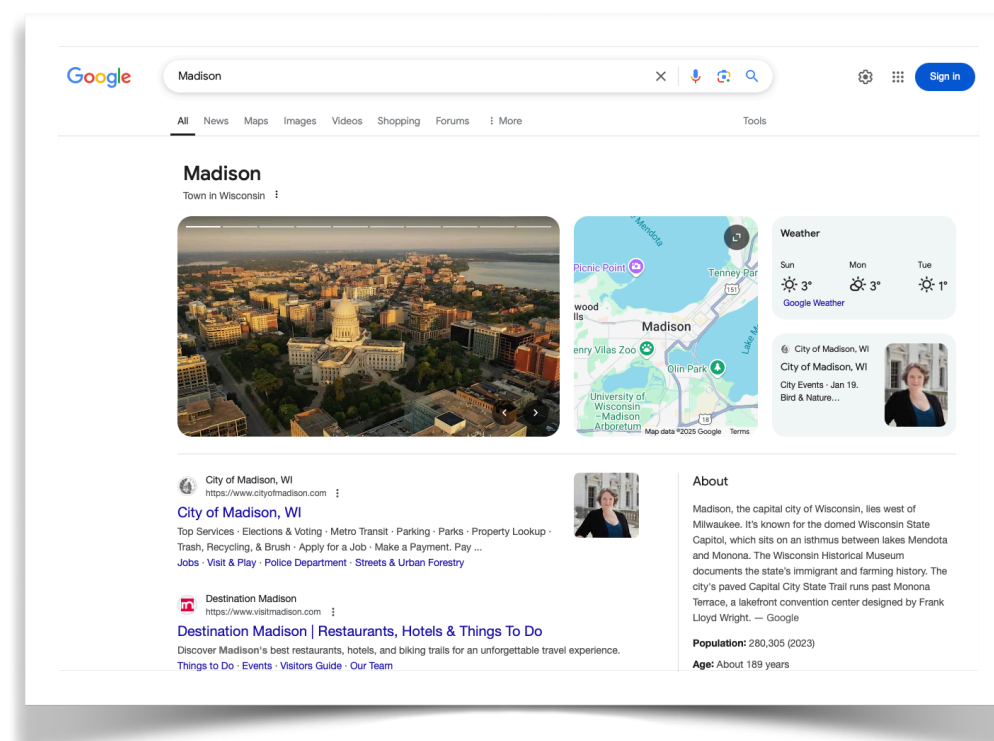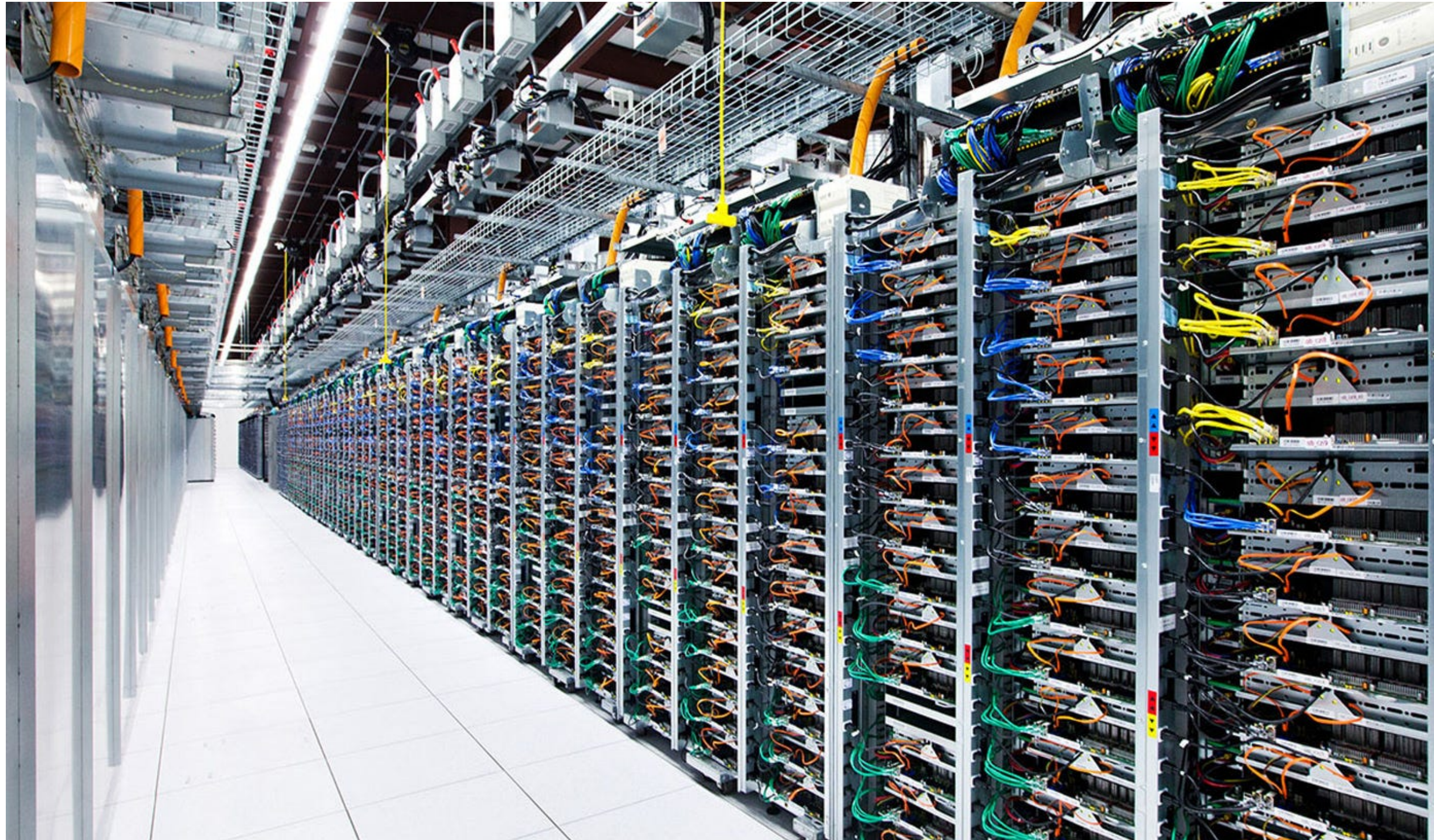 - E.g., email, messaging, social media, music/video streaming, etc.

Service

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  - E.g., email, messaging, social media, music/video streaming, etc.

Where does Google run?

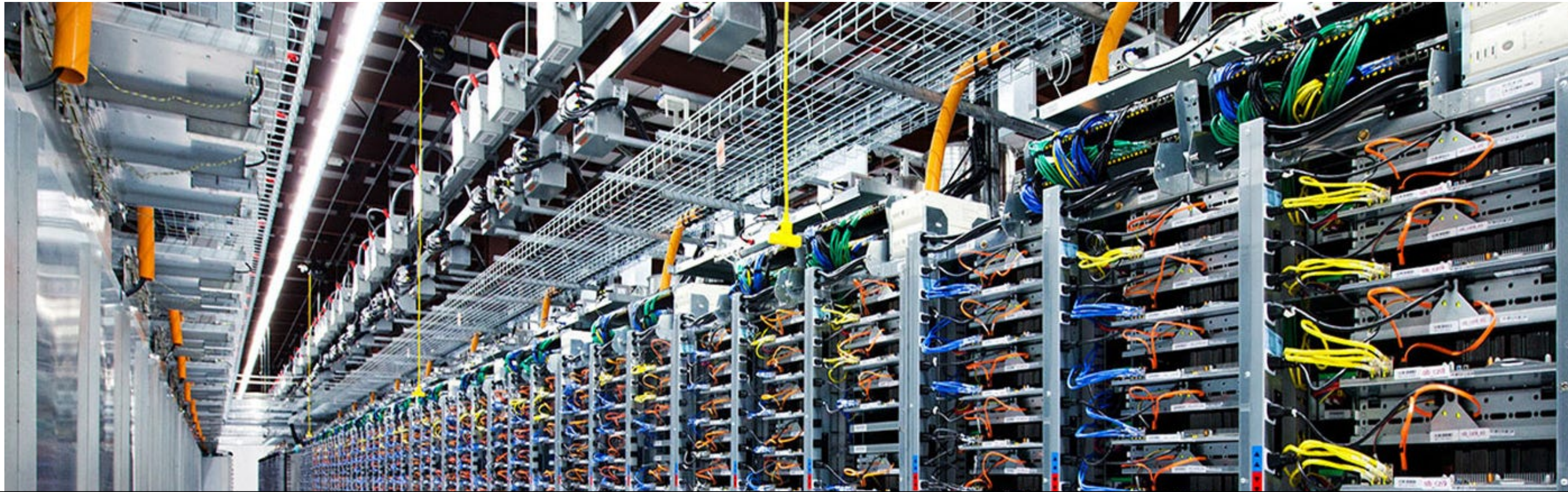# Services Run atop One or Multiple Hosts

- They can be data centers, enterprise on-premise clusters, etc.
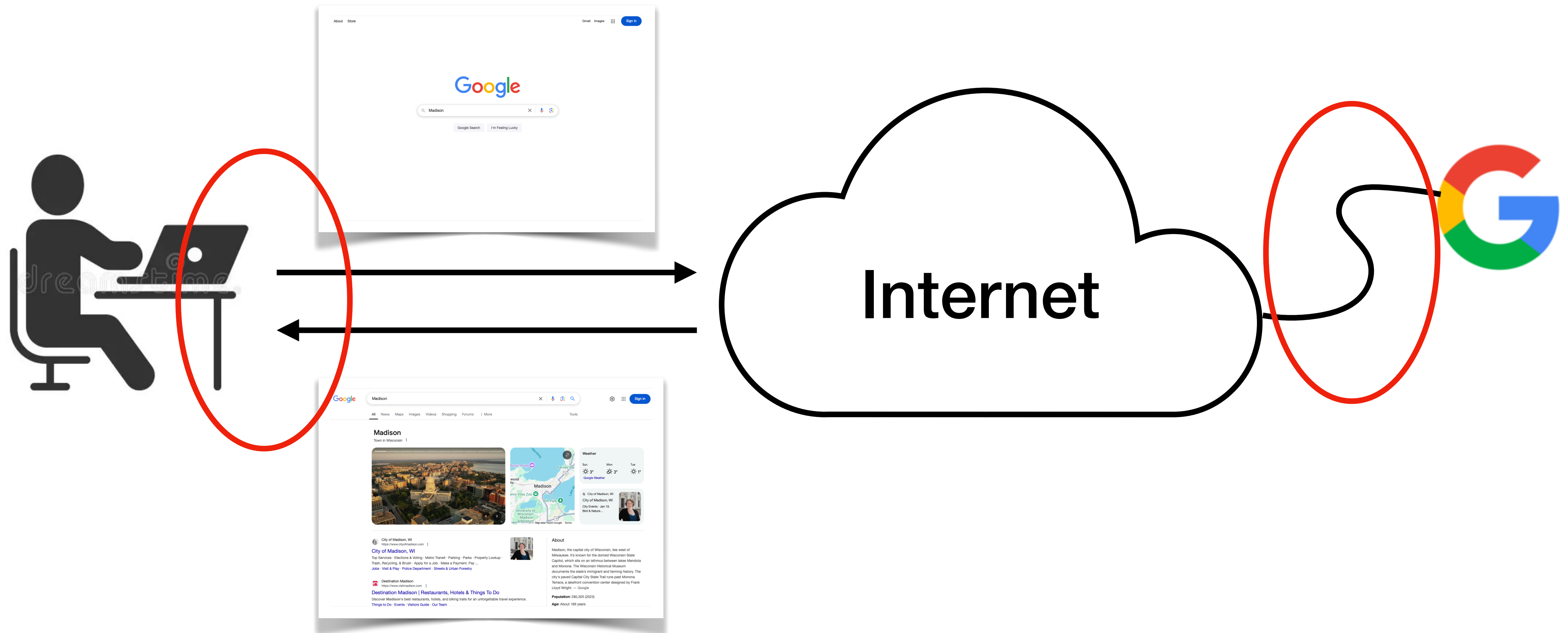
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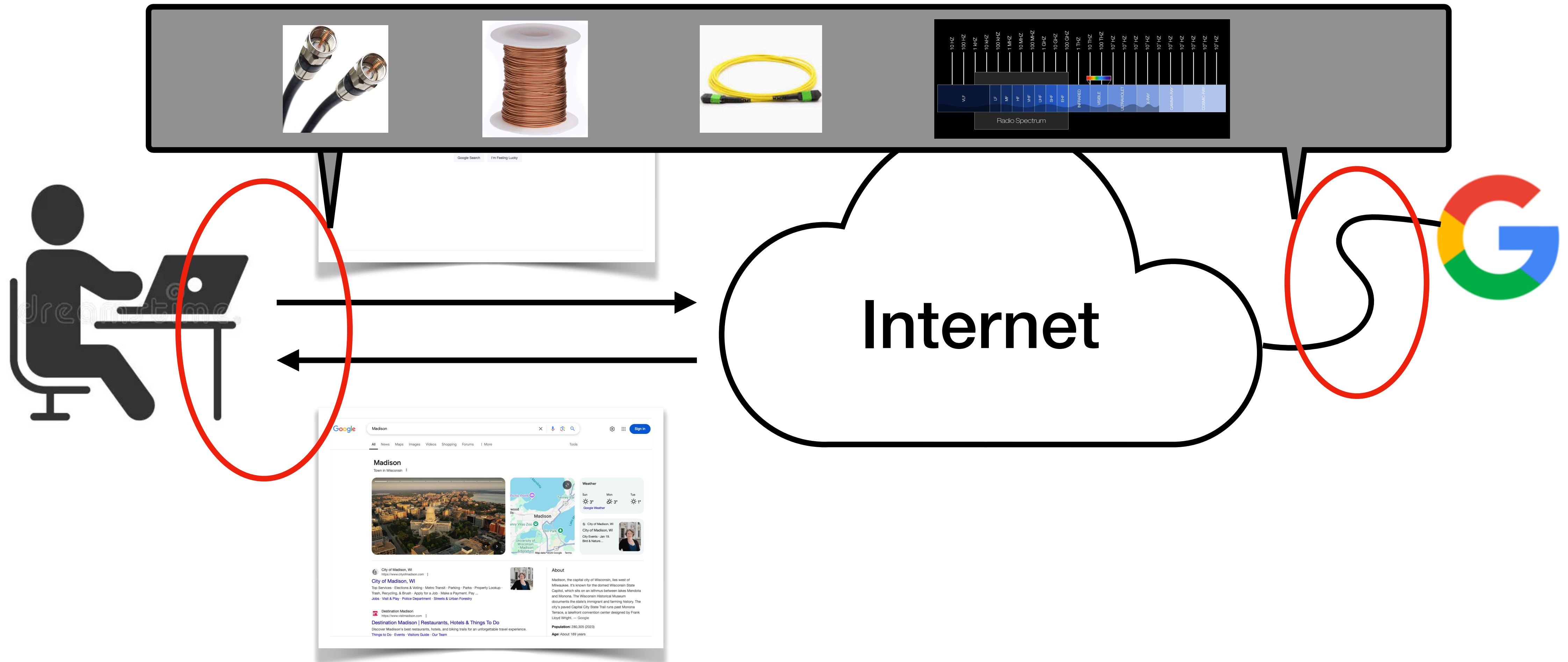**Data centers are an agglomeration of compute, network, and storage resources.**

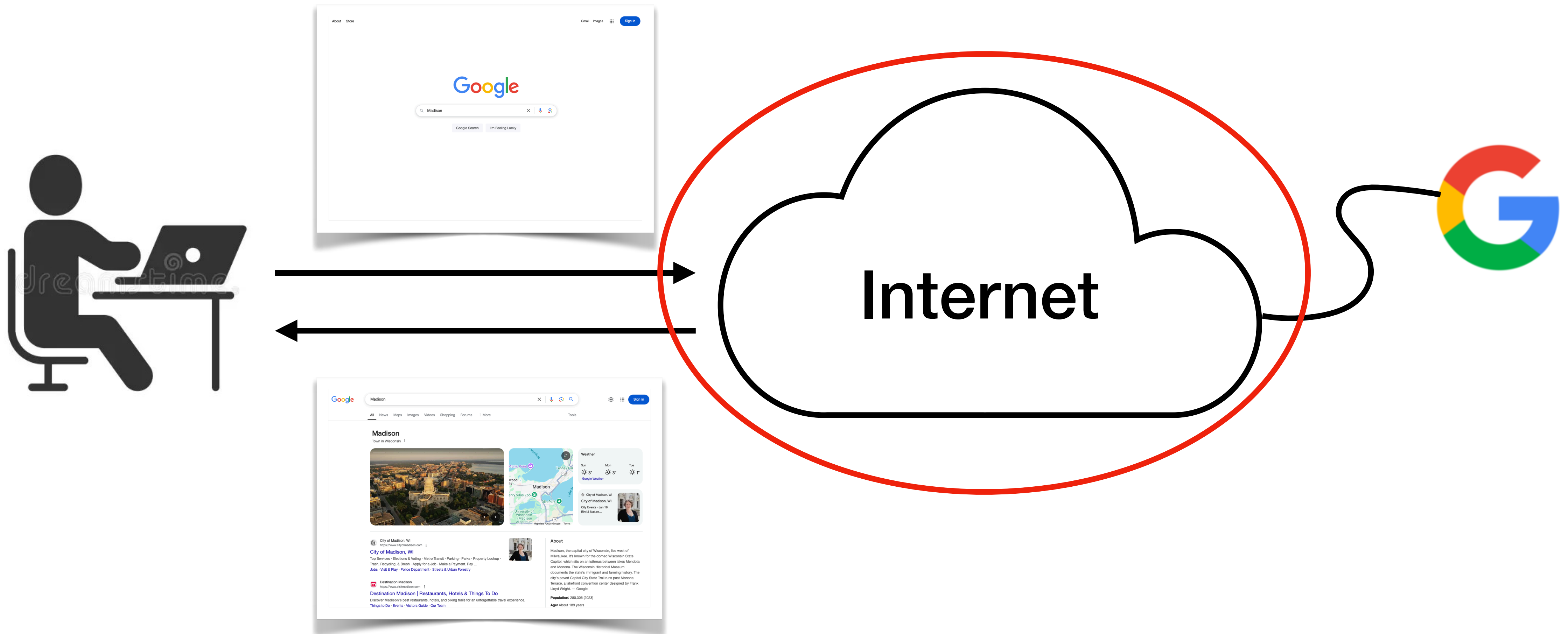# How does a host connect to the Internet?

Internet

Communication Link

- A communication link is a physical media that carries data
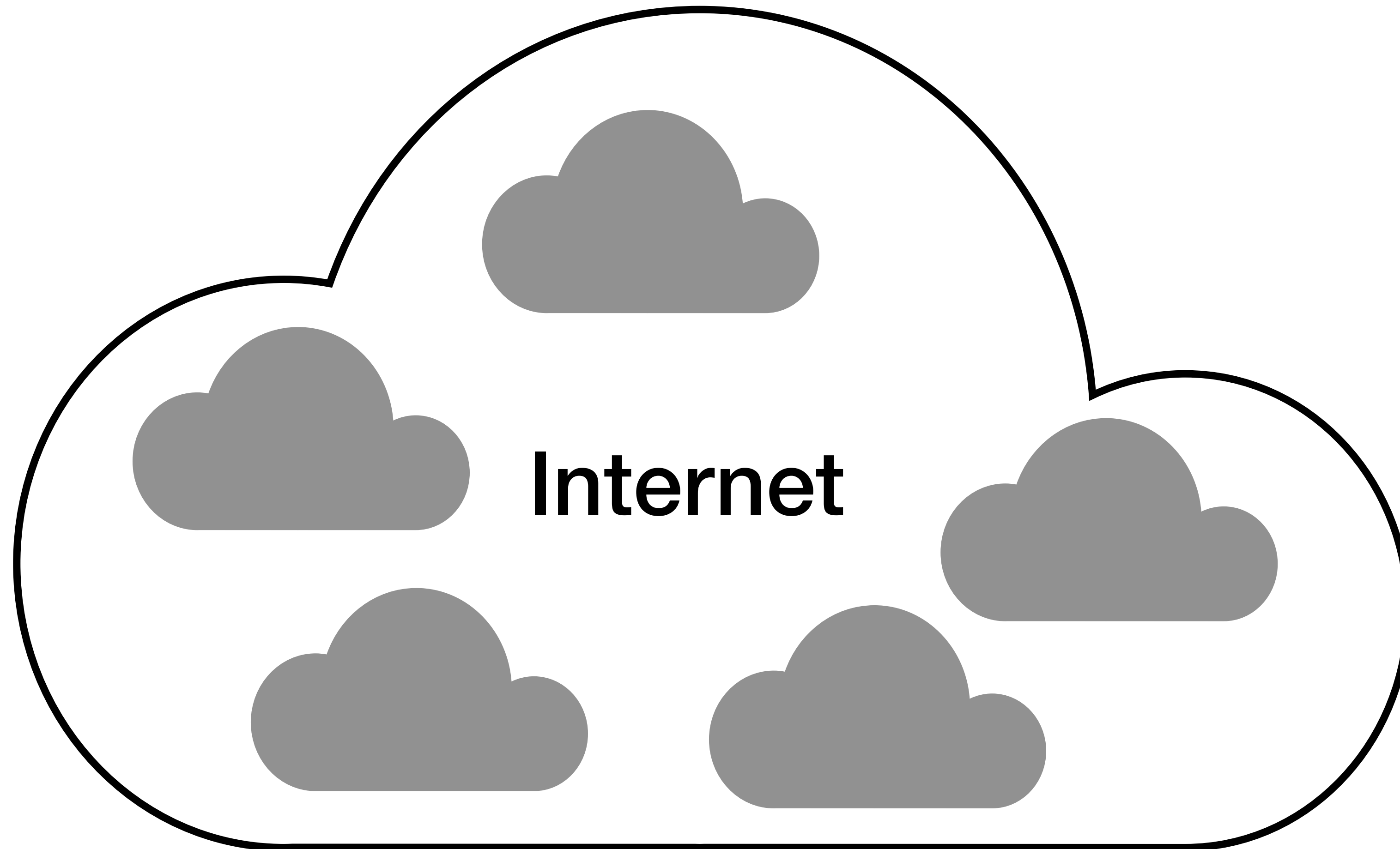 - E.g., coaxial cable, copper wire, optical fiber, radio spectrum, etc.
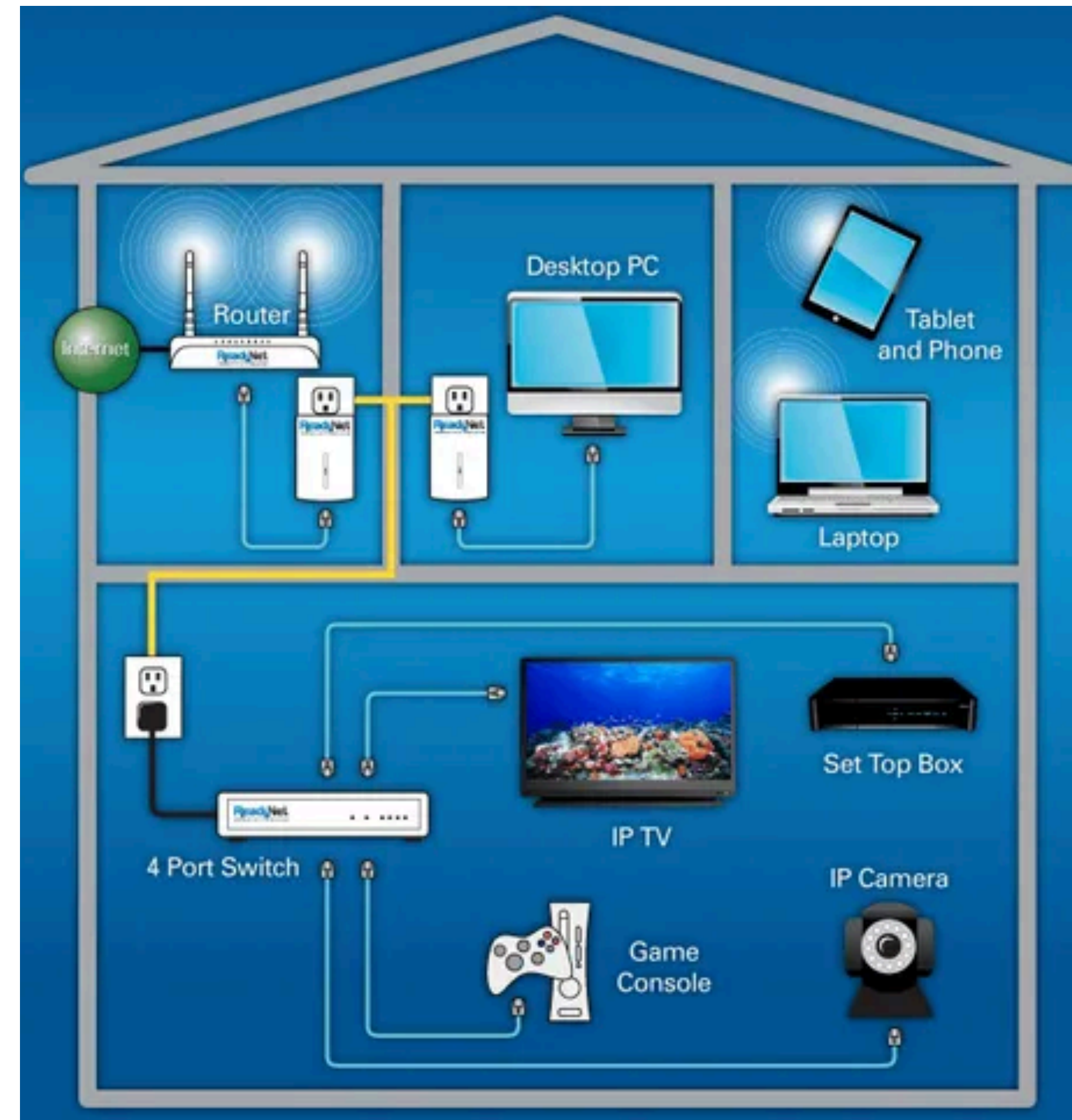
What is inside the Internet?

The Interent

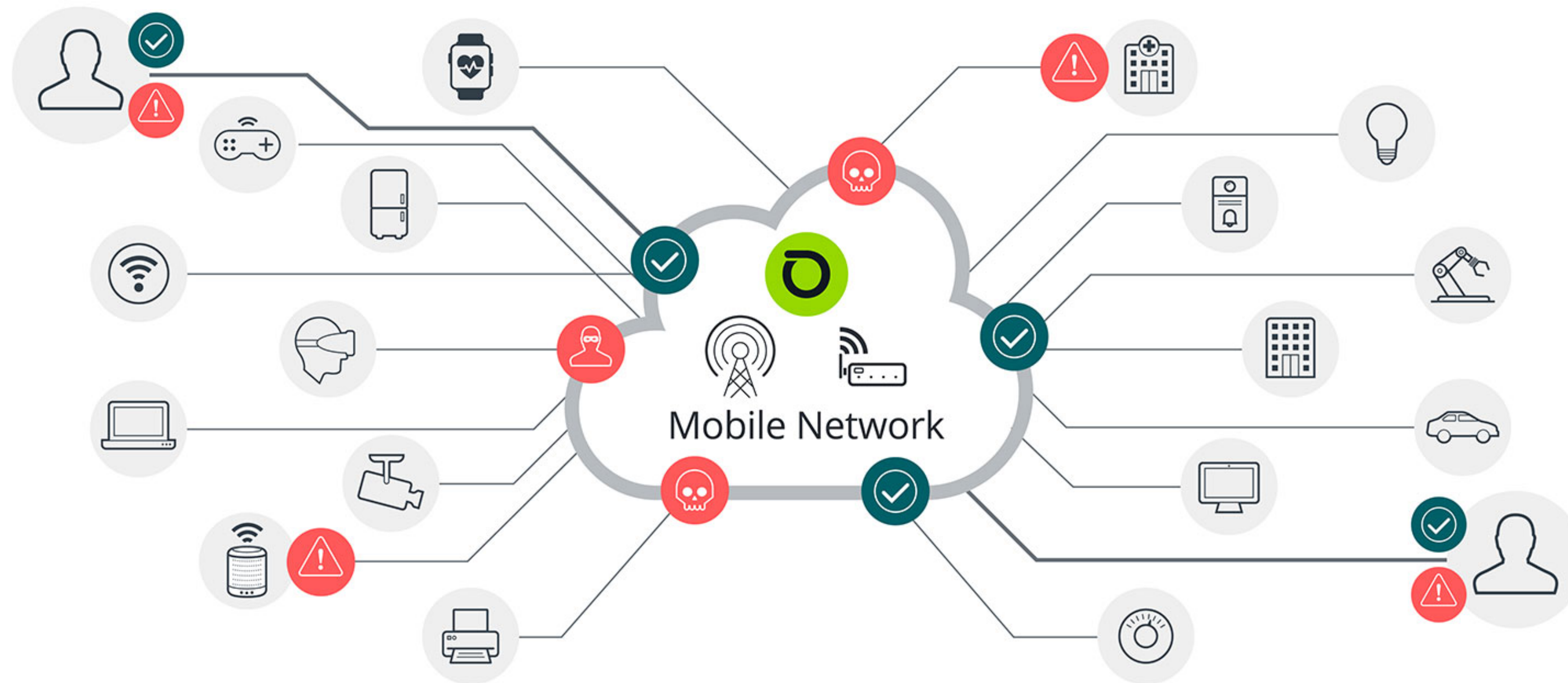- The Internet is a network of networks

Home Network

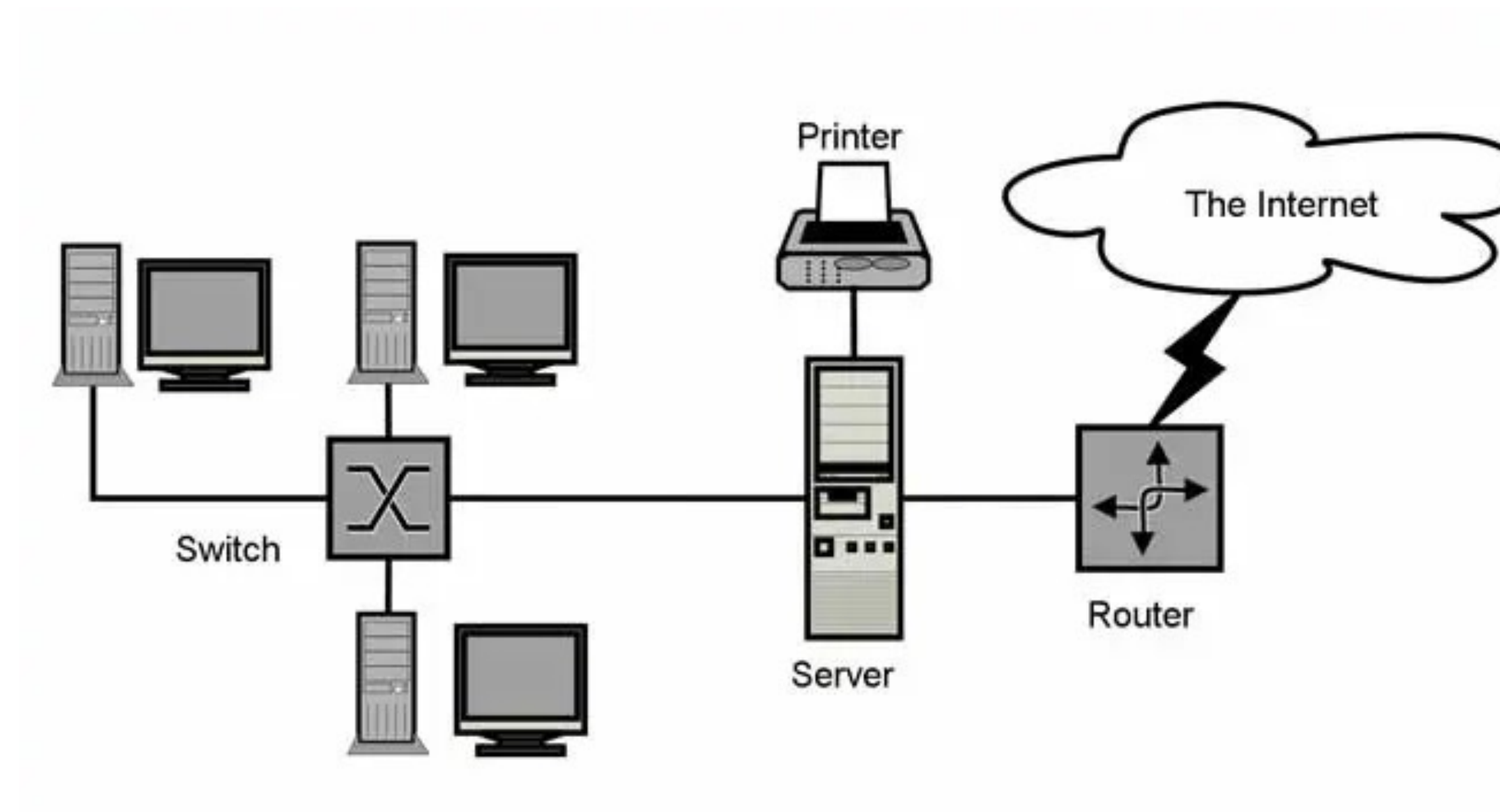- Provide Internet access for intra-house devices

Mobile Network

- Provide Internet access for moving devices

Enterprise Network

- Provide Internet access for devices within an organization
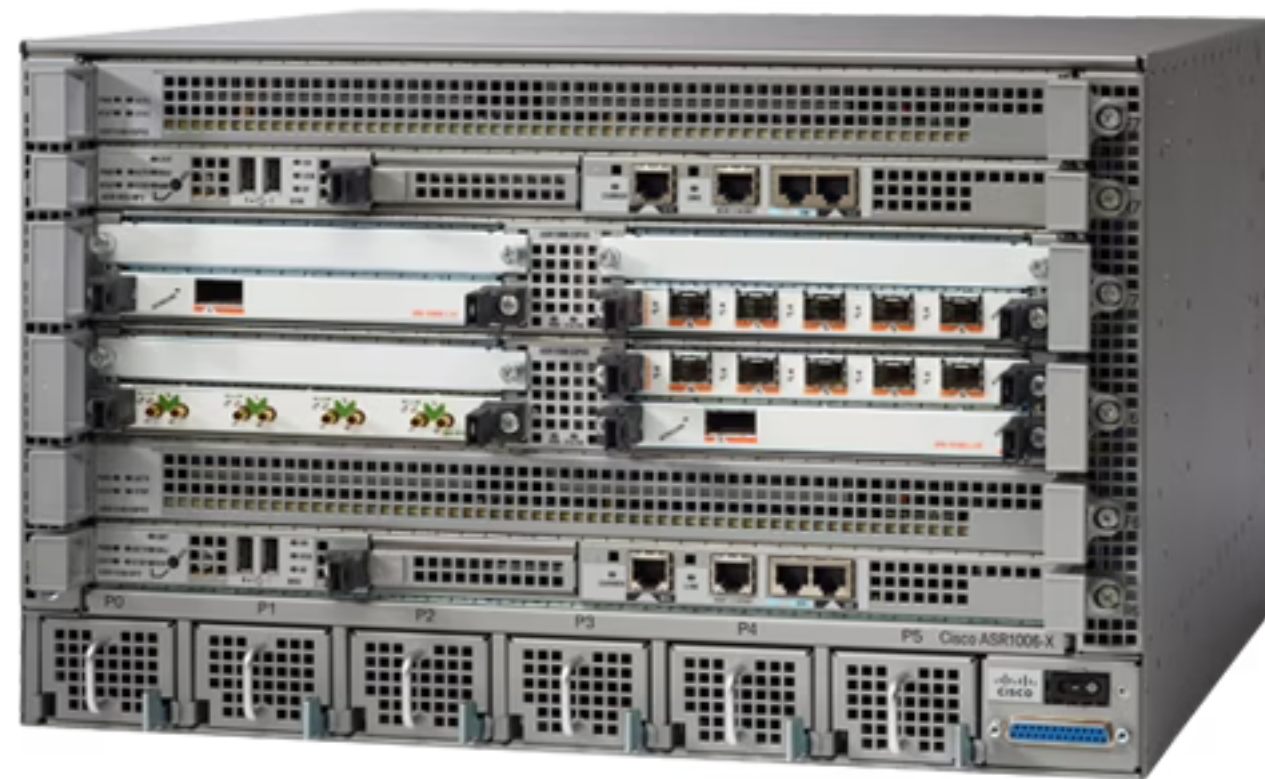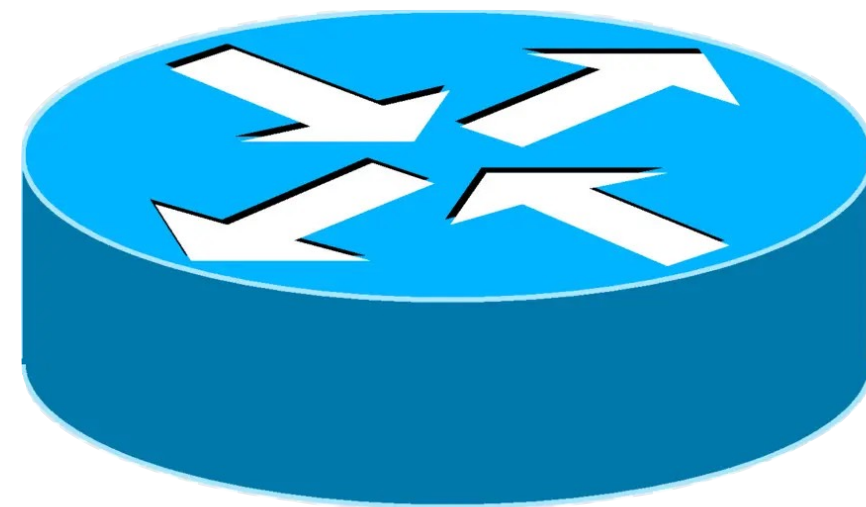
Data Center Network

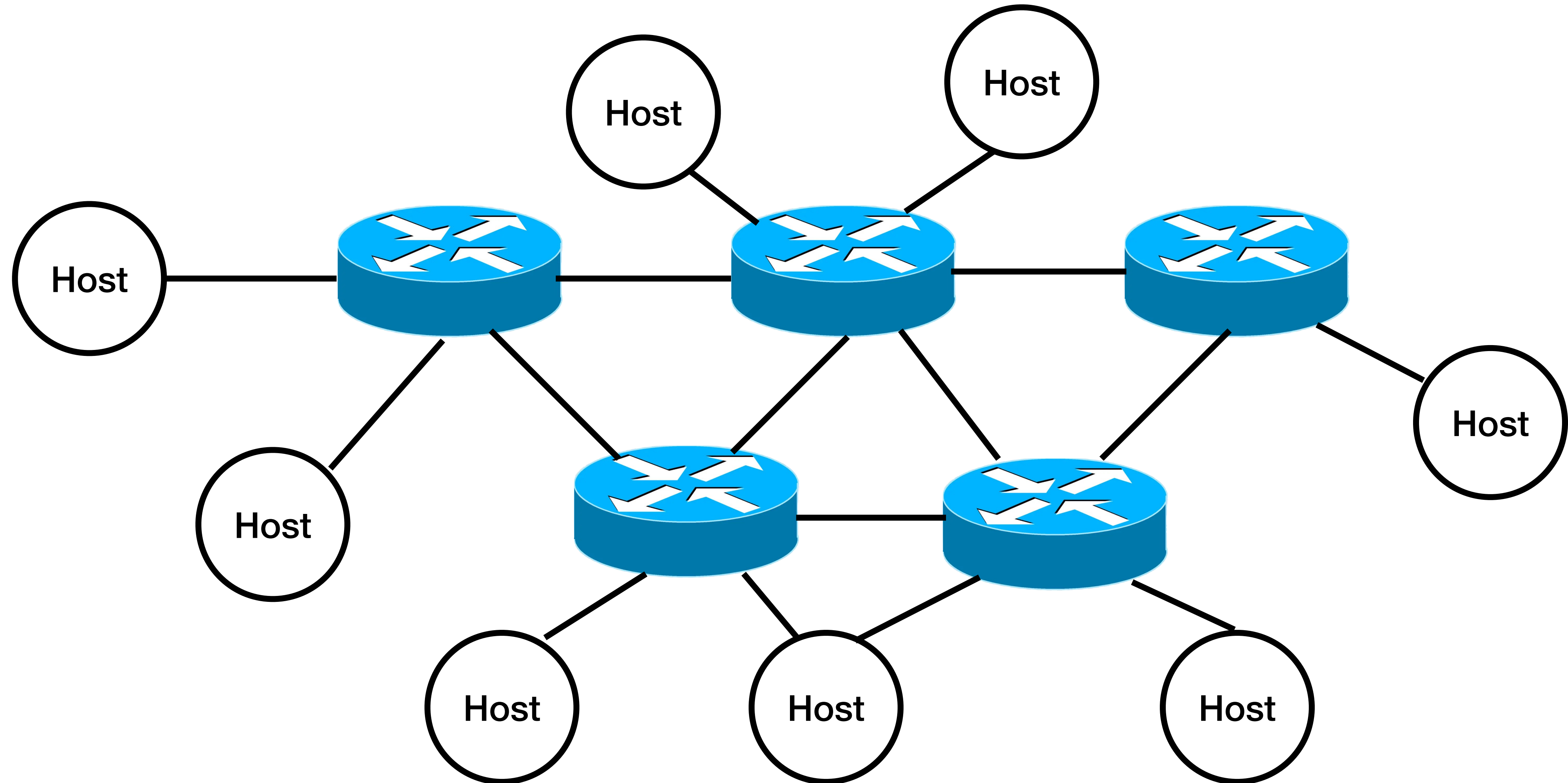- Provide Internet access for devices within a data center

Inside a network, how do we connect multiple devices?

Router and Switch

- A router (switch) is a special networking device
  - Consisting of tens to (even) hundreds of communication ports

A Conceptual Network Structure

How do different types of networks connect together?

Internet Service Provider (ISP)

- An ISP is a vendor that offers Internet connection services
  - Residential ISPs —> home network
  - Corporate ISPs —> enterprise network
  - University ISPs —> university network
  - Cellular data ISPs —> mobile network
 - ……

Internet Service Provider (ISP)

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- ISPs are hierarchical and multi-tier
  - Lower-tier ISPs are connected via national or international upper-tier ISPs
  - Upper-tier ISPs are connected directly to each other

Internet Service Provider (ISP)

- An ISP is a vendor that ~~provides~~ ~~Internet~~ connection services
  - Residential ISPs —> ~~...~~
  - Corporate ISPs —> ~~...~~
  - University ISPs —~~...~~
  - Cellular ~~...~~
  - ......
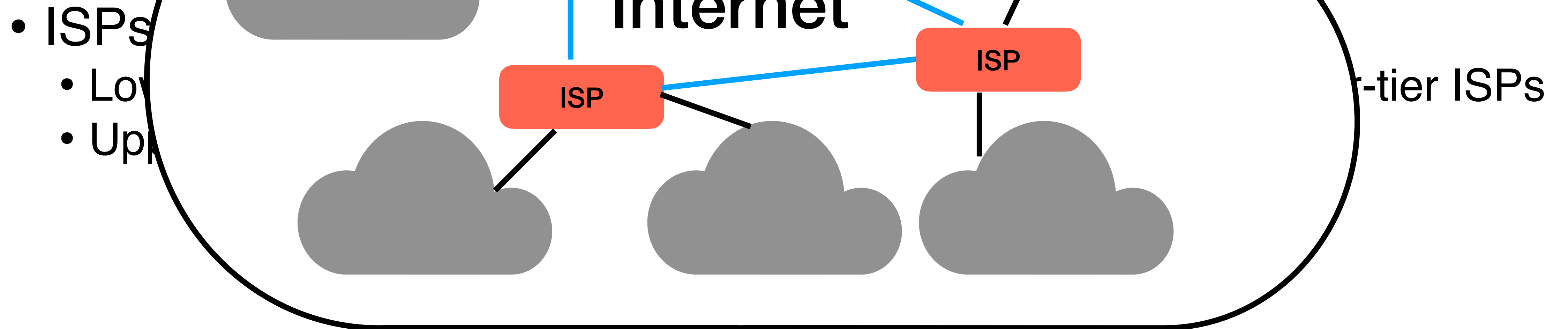
- ISPs ~~...~~
  - Lo~~...~~ ~~...~~-tier ISPs
  - Up~~...~~

Internet

ISP

ISP

ISP

Using the Internet

- The sending host (sender) issues a request
- The receiving host (receiver) returns a response
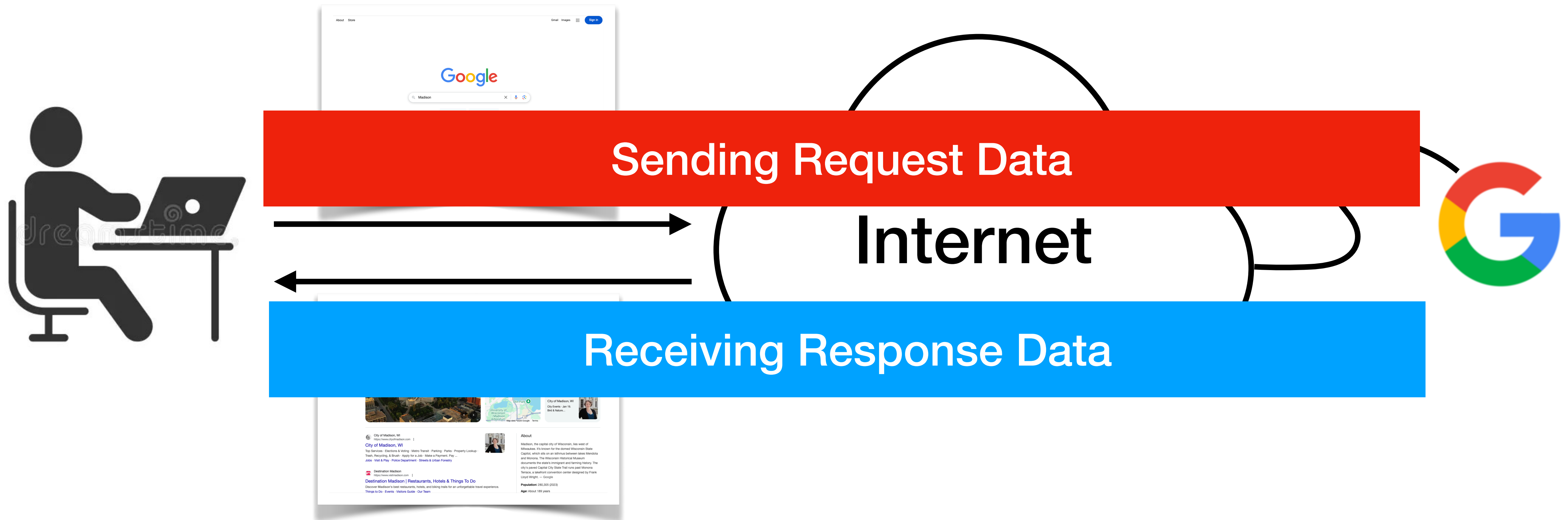- The Internet delivers the request and response
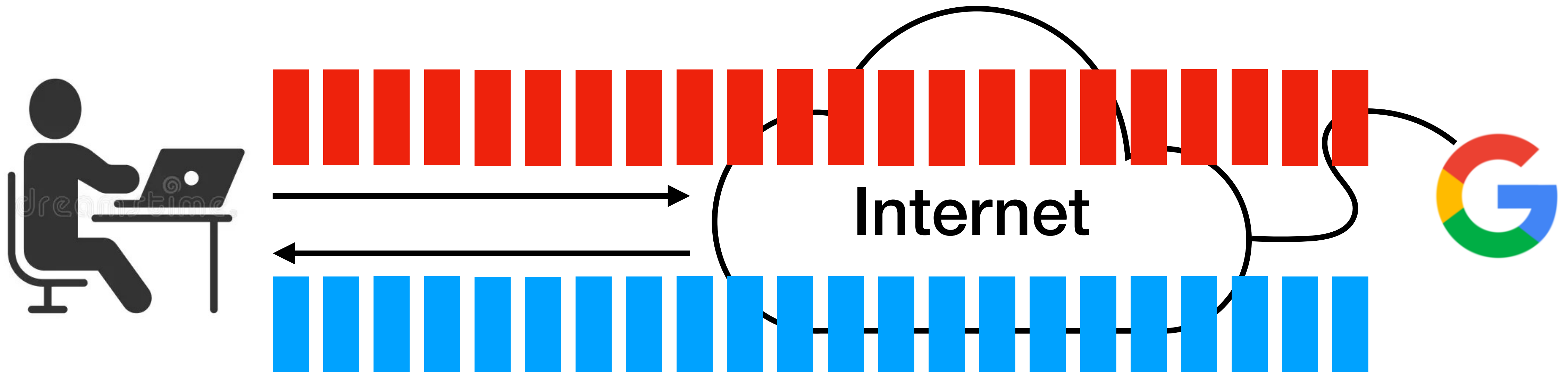
Using the Internet

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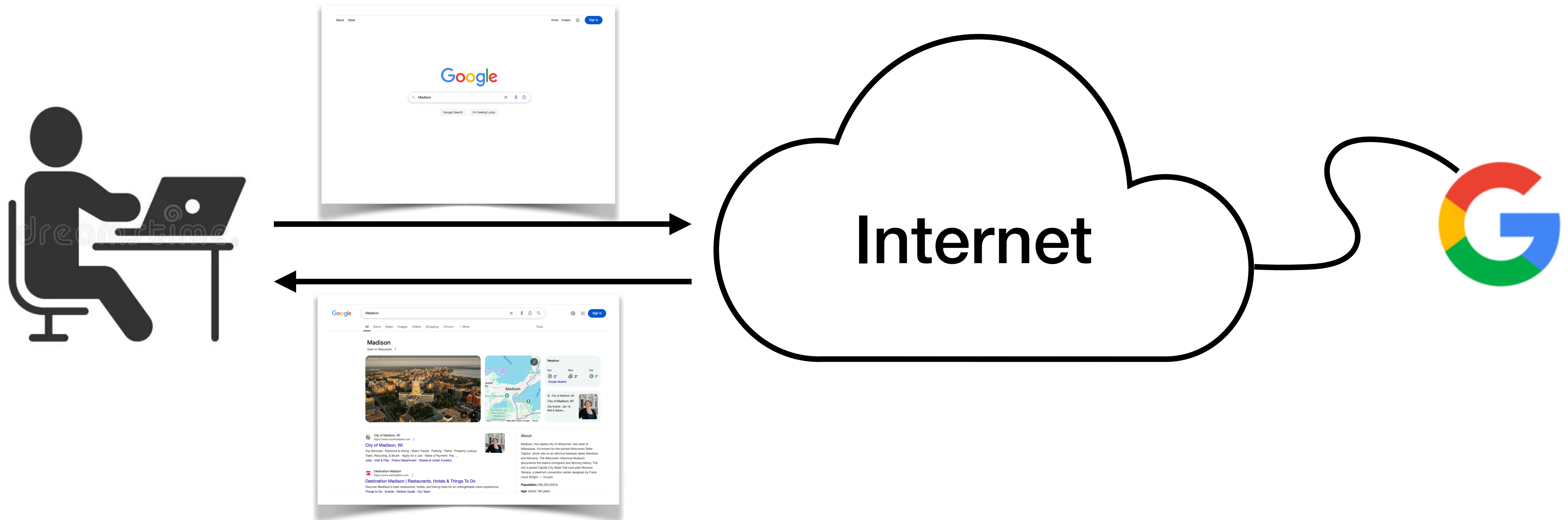
Sending Request Data

Internet

Receiving Response Data

Data as Packet

- A packet is the smallest unit of data that traverses the network
  - Consist of header and payload
  - The sender divides data and encapsulates them as packets
  - The receiver decapsulates packets and rebuilds the data

Internet

How does the Internet agree to deliver the request and response?

Communication Interface

- The communication interface is a set of predefined rules that
  - The sending program must follow so that the Internet can carry the data and deliver the data to the destination program
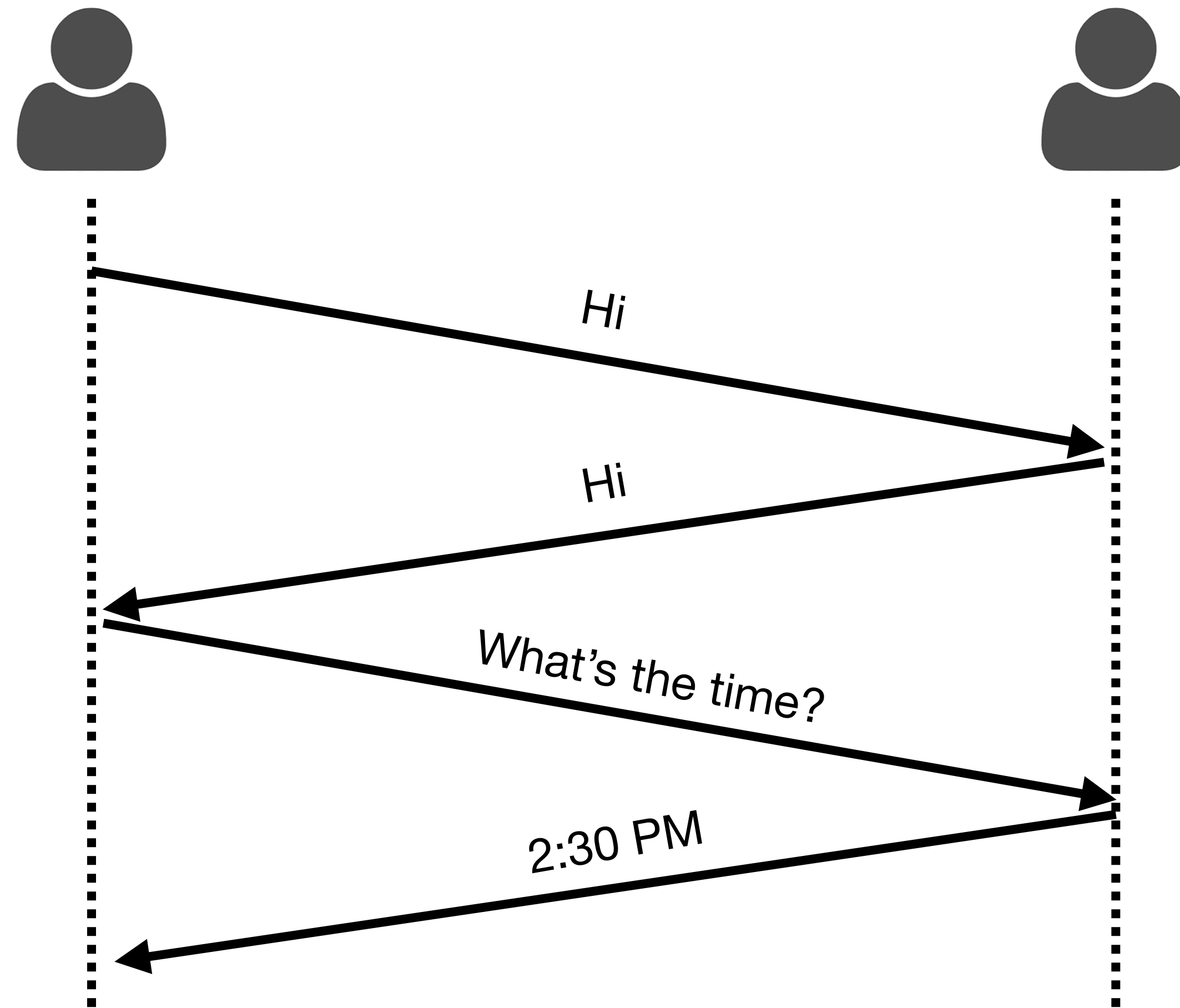 - E.g., socket interface
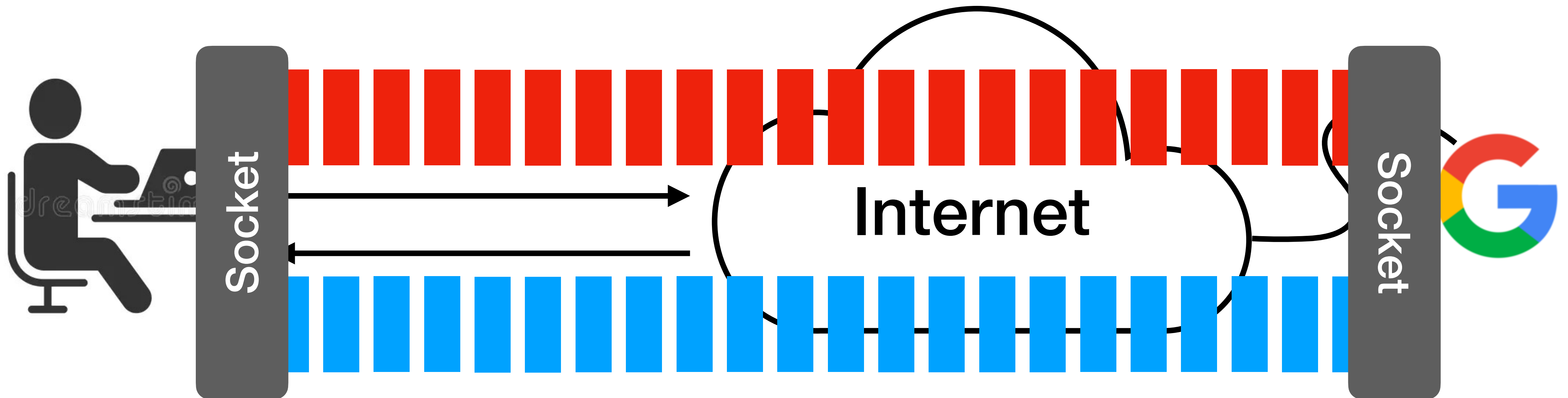
How do different devices understand each other?

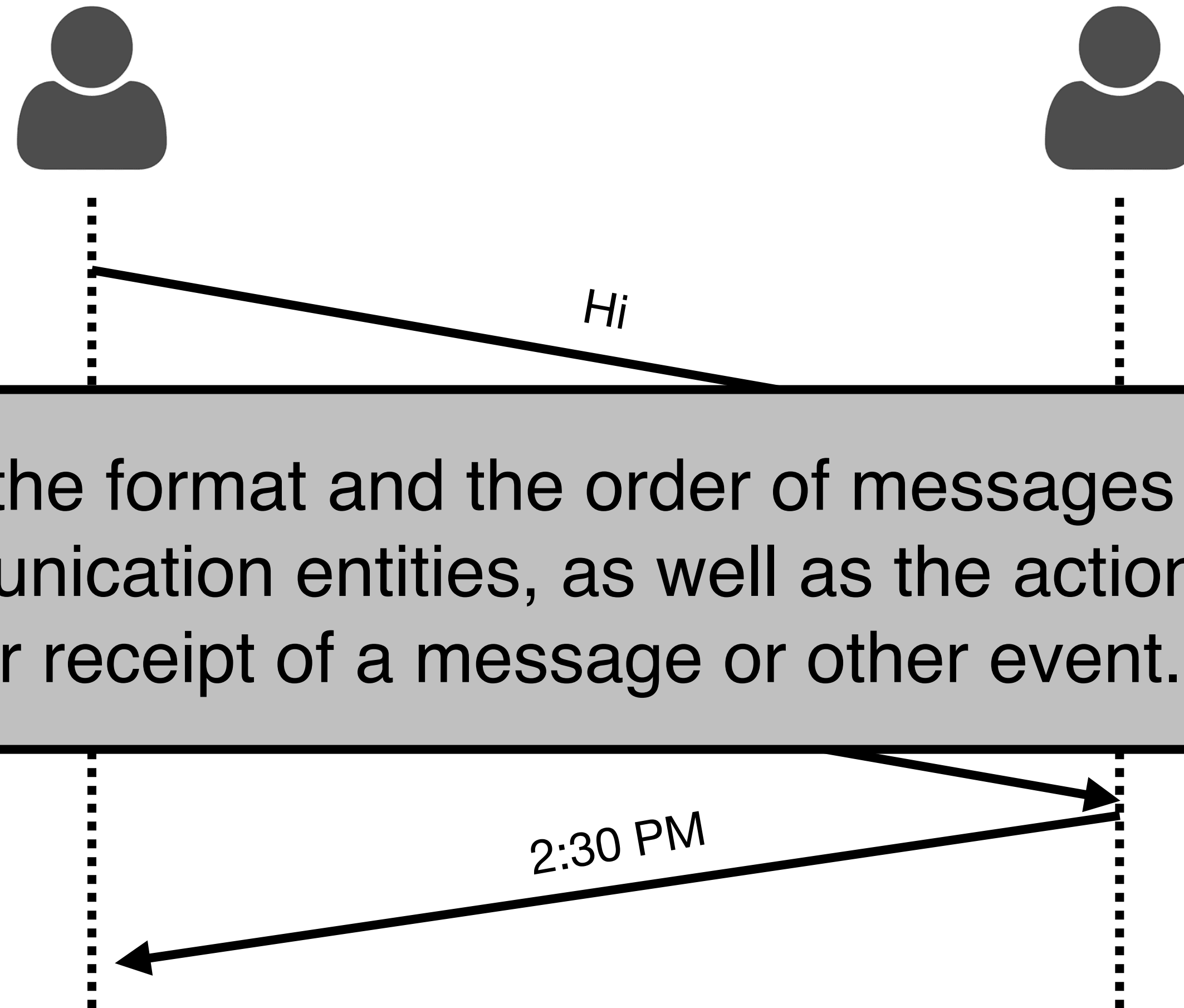# How do different devices understand each other?
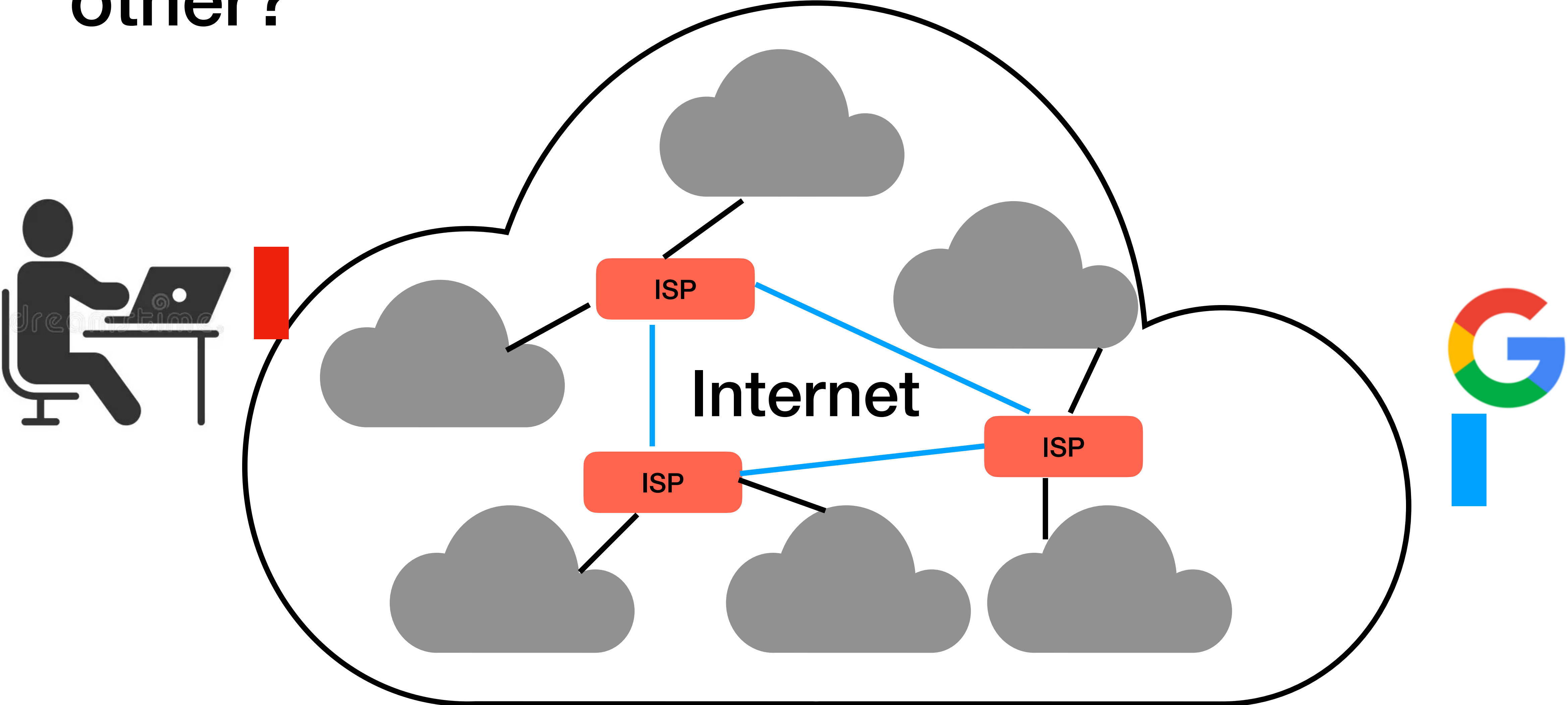
Protocol

- A protocol defines the communication standards

Protocol

- A protocol defines the communication standards

Hi

A protocol defines the format and the order of messages exchanged between two or more communication entities, as well as the actions taken on the transmission and/or receipt of a message or other event.

2:30 PM

What are computer networks?

What are computer networks?

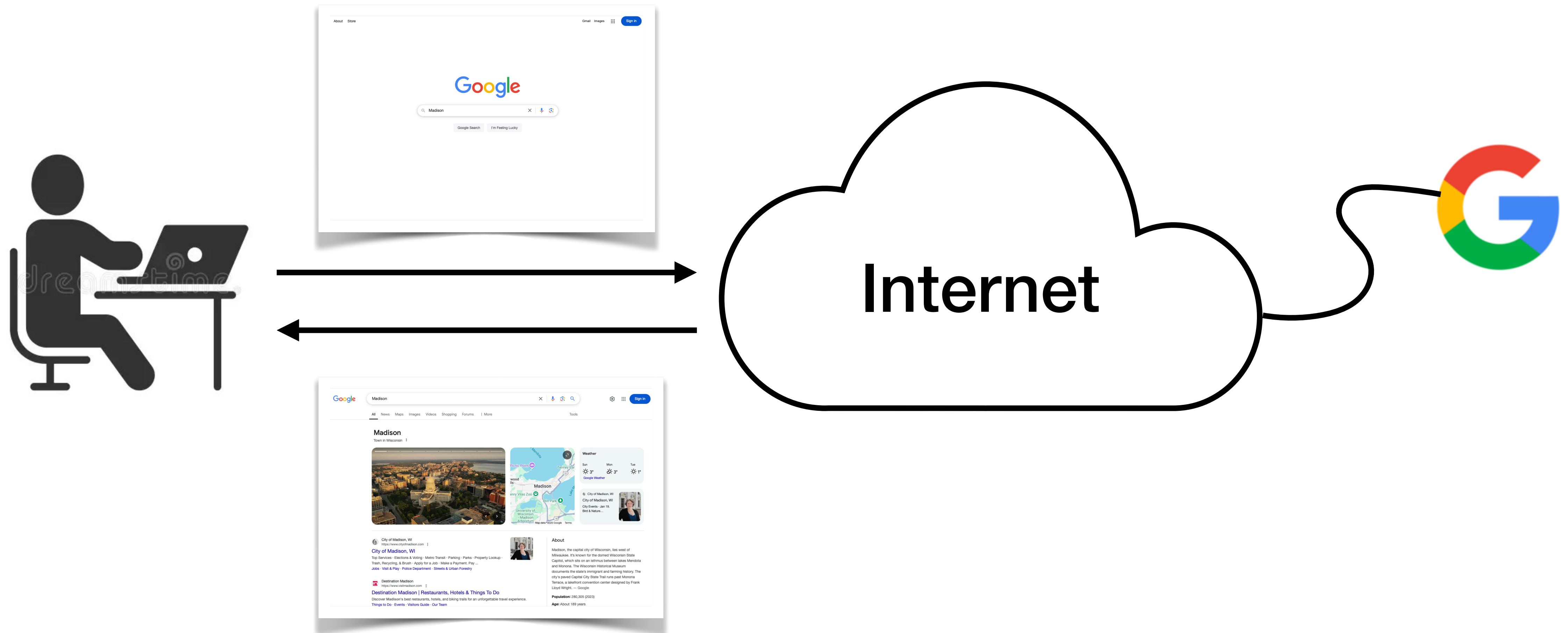**A system** provides **cross-host communication** for **information exchange**

What are the design requirements of computer networks?

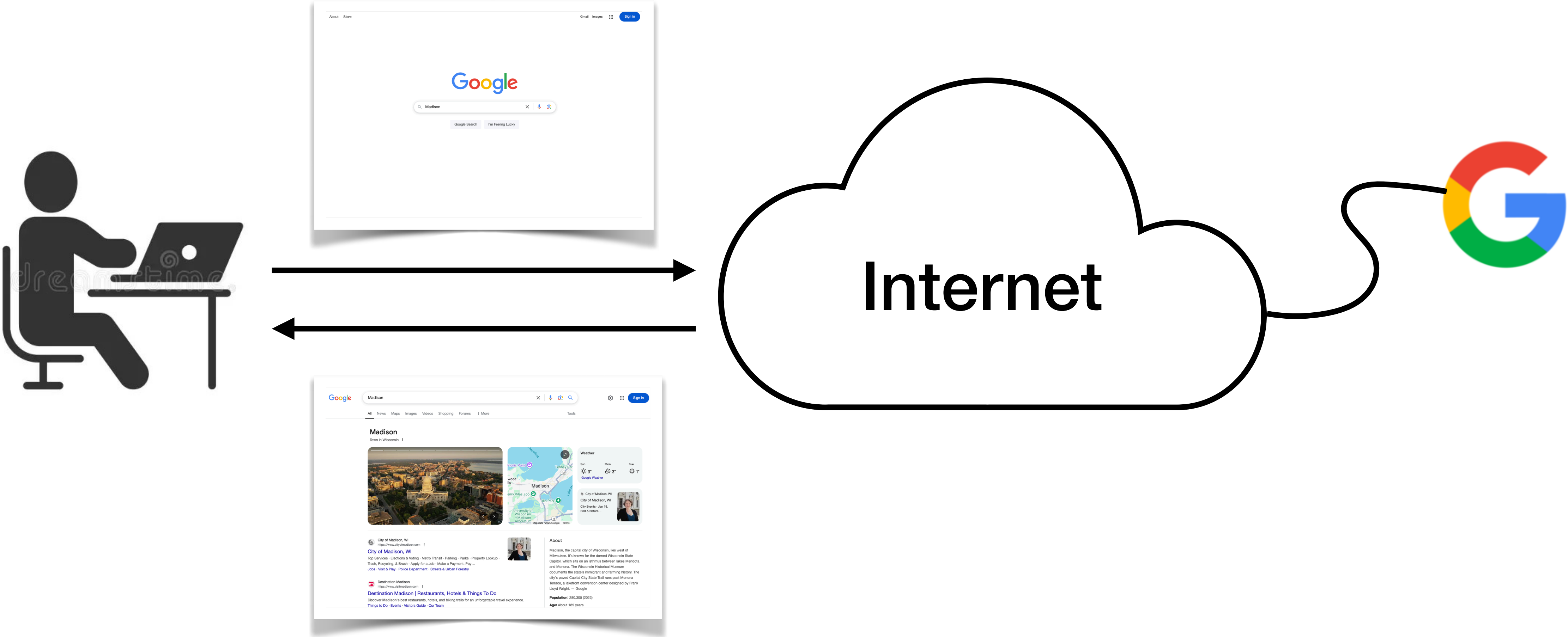# Design Requirements

Internet
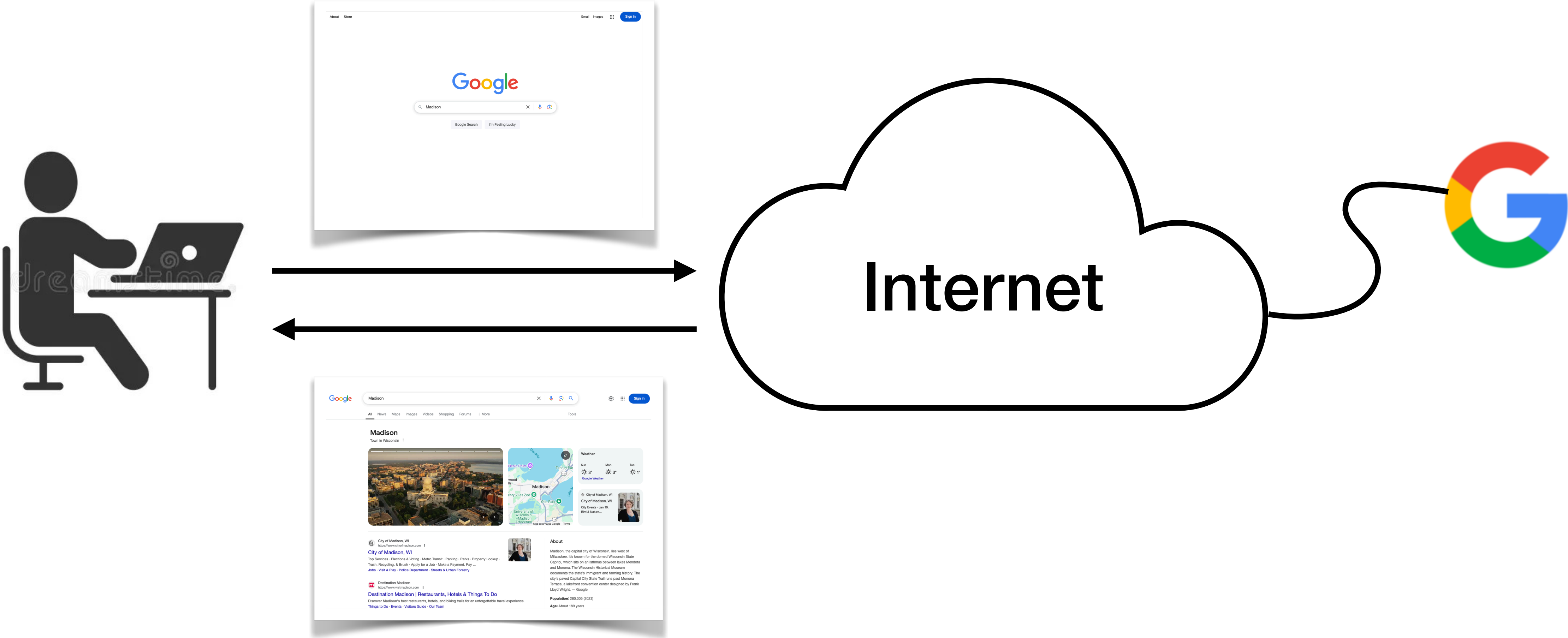
Design Requirements

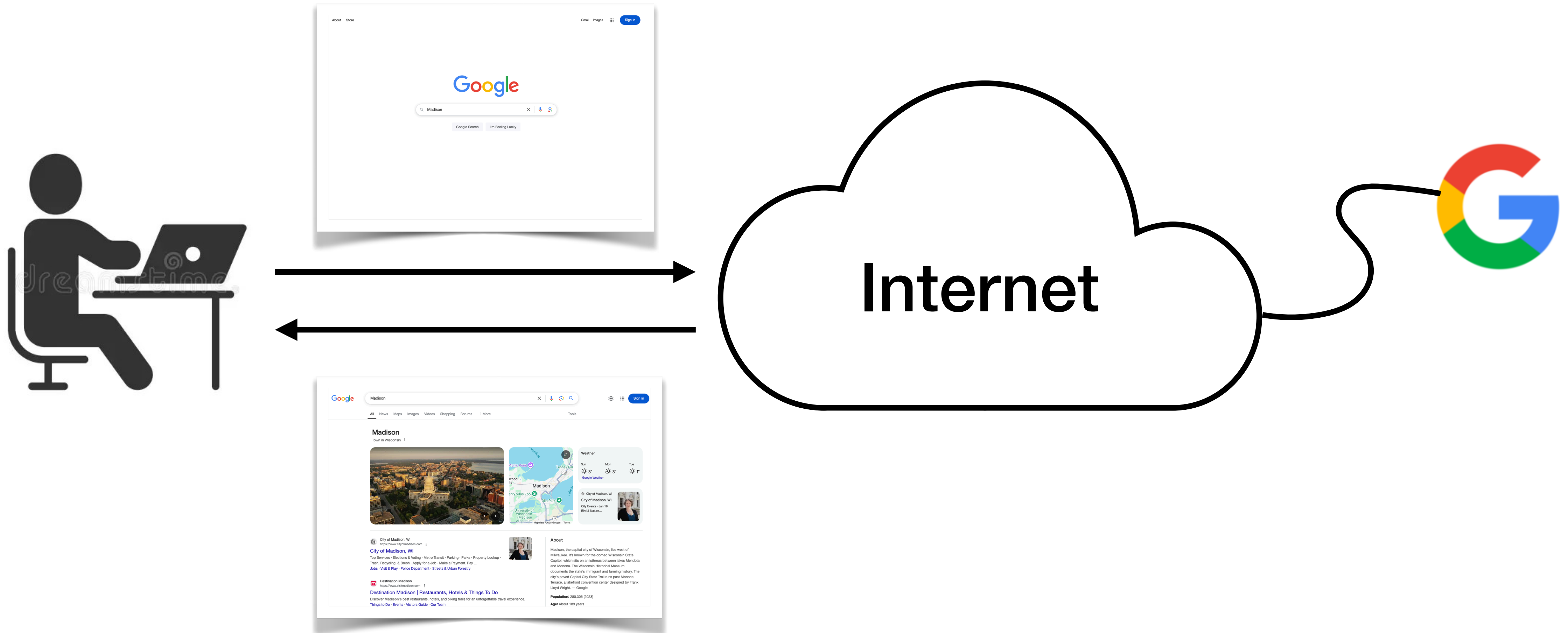- #1: Anytime and anywhere **connectivity**

Design Requirements

- #2: Always-on **correctness**

Design Requirements
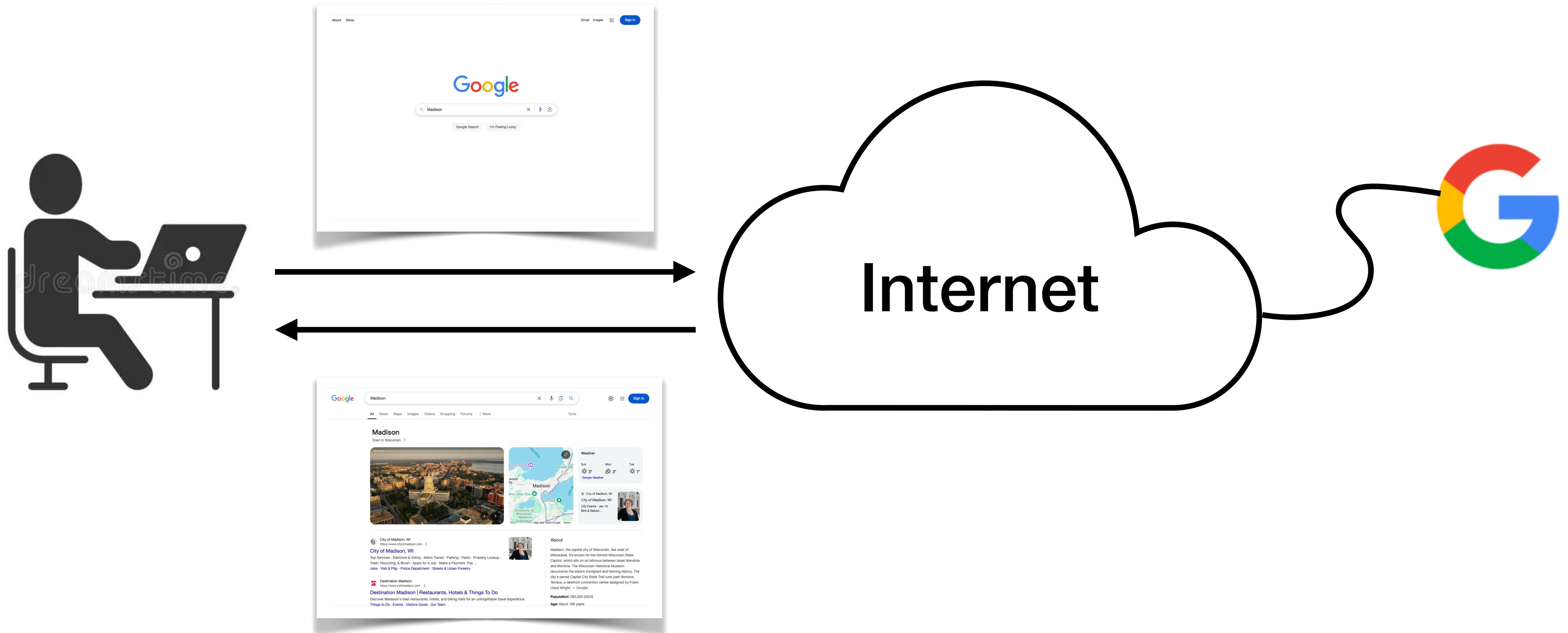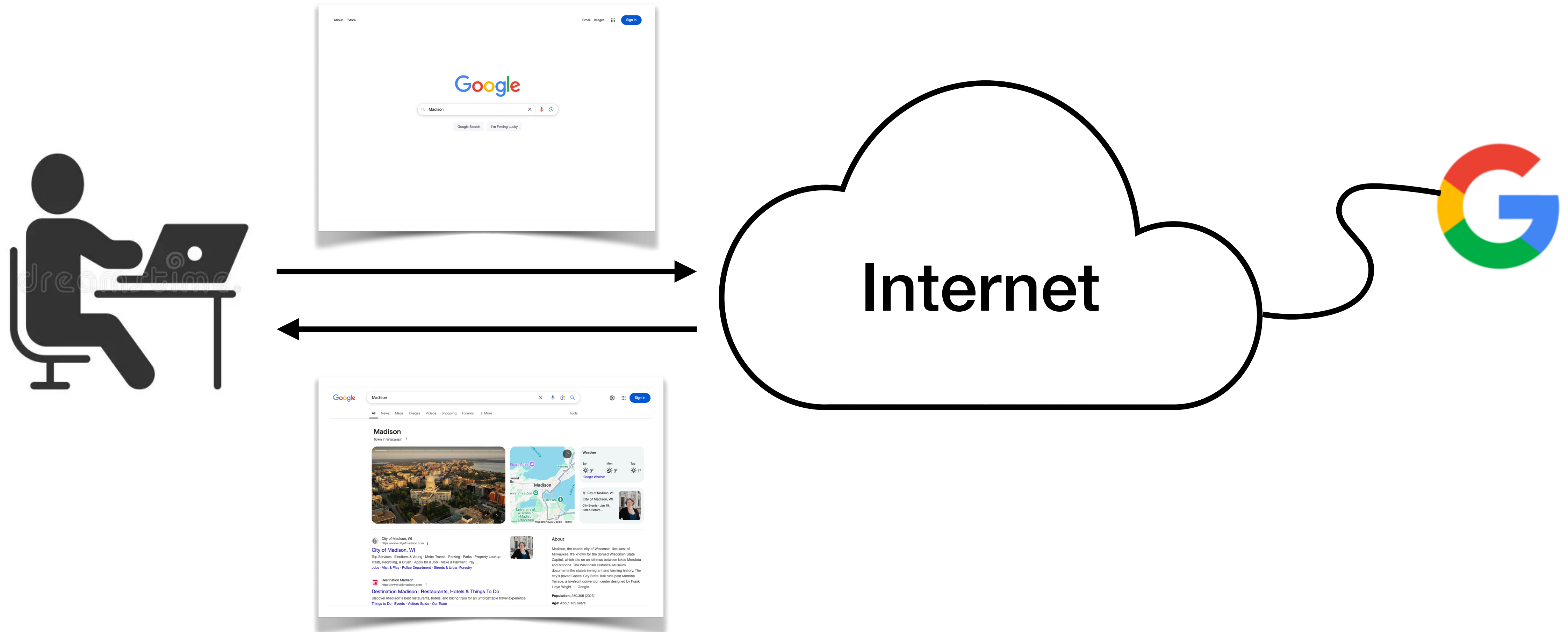
- #3: Reasonable **performance**

Design Requirements

- #4: Low **cost**

Internet

Design Requirements

- #5: Tolerable **security**

Internet

What are the design requirements of computer networks?

#1: Anytime and anywhere connectivity
#2: Always-on correctness
#3: Reasonable performance
#4: Low cost
#5: Tolerable security

Summary

- Today
  - Computer networks basics
  - Computer networks design requirements

- Next lecture
  - Computer networks: hardware and software