

Introduction to Computer Networks

CS640 Introduction

<https://pages.cs.wisc.edu/~mgliu/CS640/S26/index.html>

Ming Liu

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Today

- Course Logistics
- Computer Networks Overview
- Computer Networks Basics and Design Requirements
- Intra-host v.s Inter-host Communication

Administrative Details

- Instructor: Ming Liu
 - mgliu@cs.wisc.edu
 - Office hour: By appointment (Just send me an email)
 - Research Interest: Networking and Systems
- TA: Peichen Guo (this section)
 - pguo36@wisc.edu
 - Office hour: TBD
- Three other TAs for the labs
 - Brandon Daniel Sommerfeld, Hojeong Lee, and Chendong Wang
 - Office hour: TBD

Course Communication Channels

- #1. Course website: slides, readings, and schedule
 - <https://pages.cs.wisc.edu/~mgliu/CS640/S26/index.html>
- #2. Course mailing list: announcements
 - compsci640-1-s26@g-groups.wisc.edu
- #3. Piazza: Q&A
 - <https://piazza.com/wisc/spring2026/cs640>
- #4. Submission
 - Canvas: labs and grades

Grade Breakdown

- 4 Programming Labs (50%)
 - Teams of 1-2 people
- Final Exam (35%)
 - 05/08/2026 (Friday)
 - 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

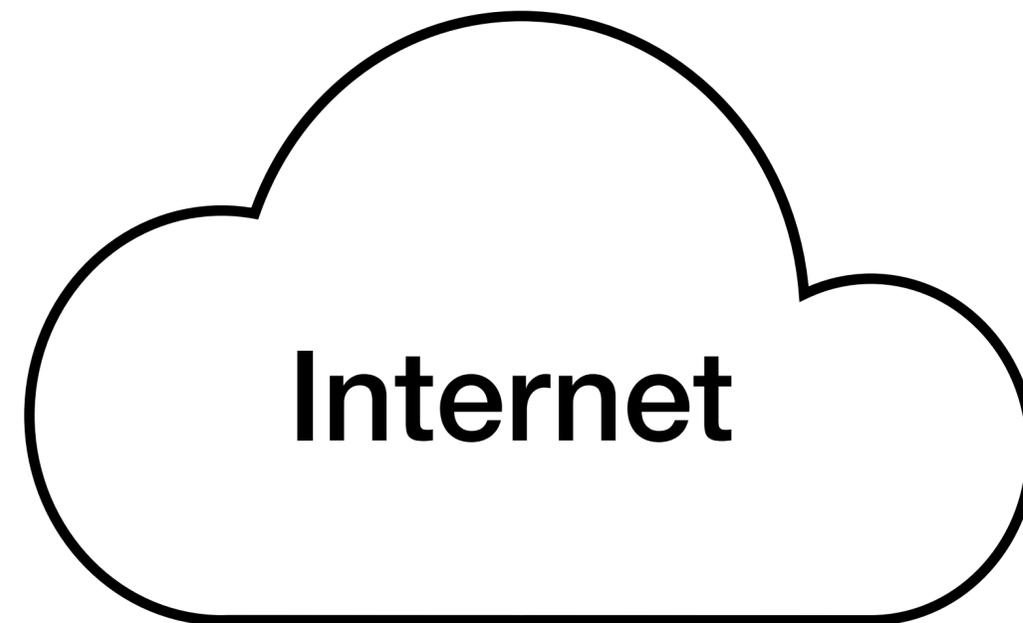
Learning Outcomes

- #1: Explain how computer networks work
- #2: Develop small-scale network applications
- #3: Evaluate design trade-offs of networked systems

What are computer networks?

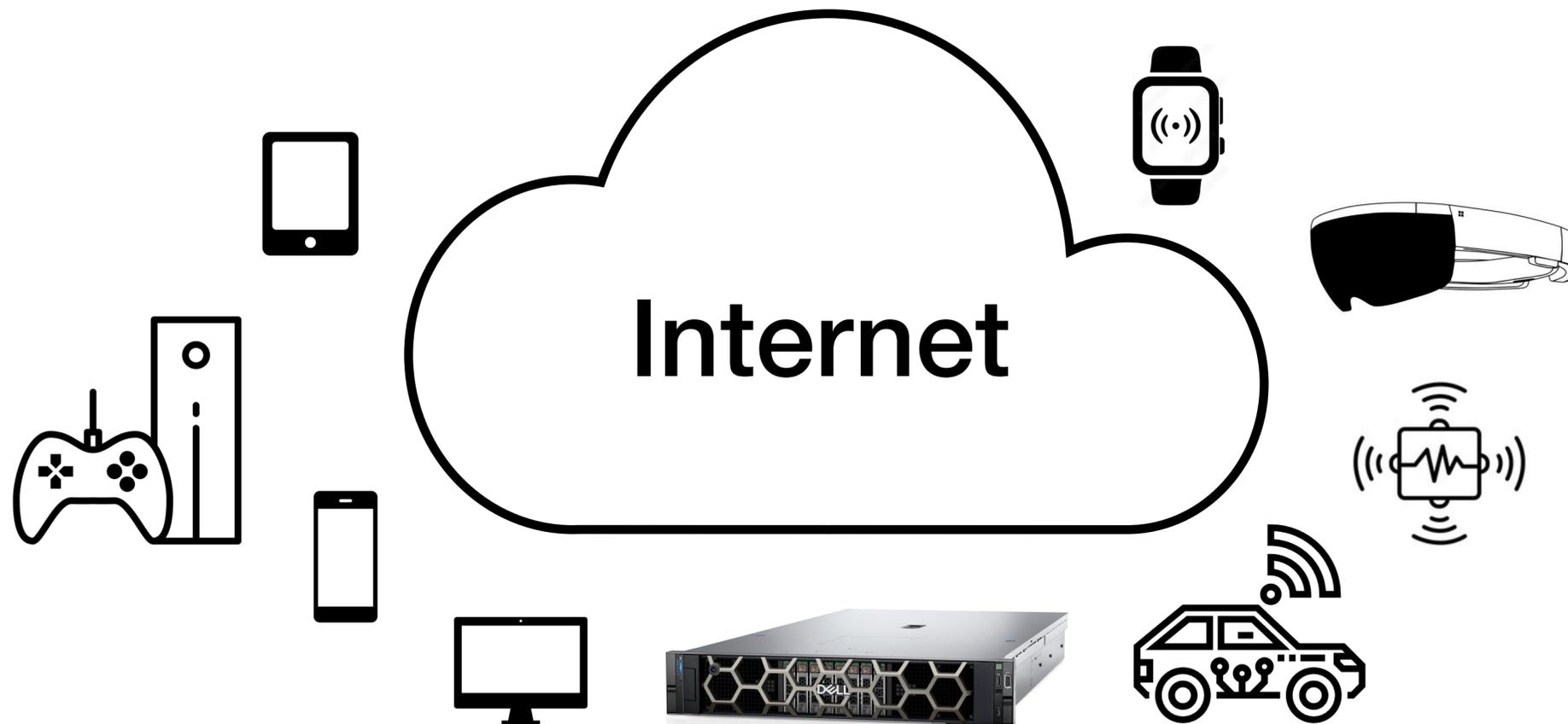
Take the Internet as an Example

- The largest engineered system people have built so far



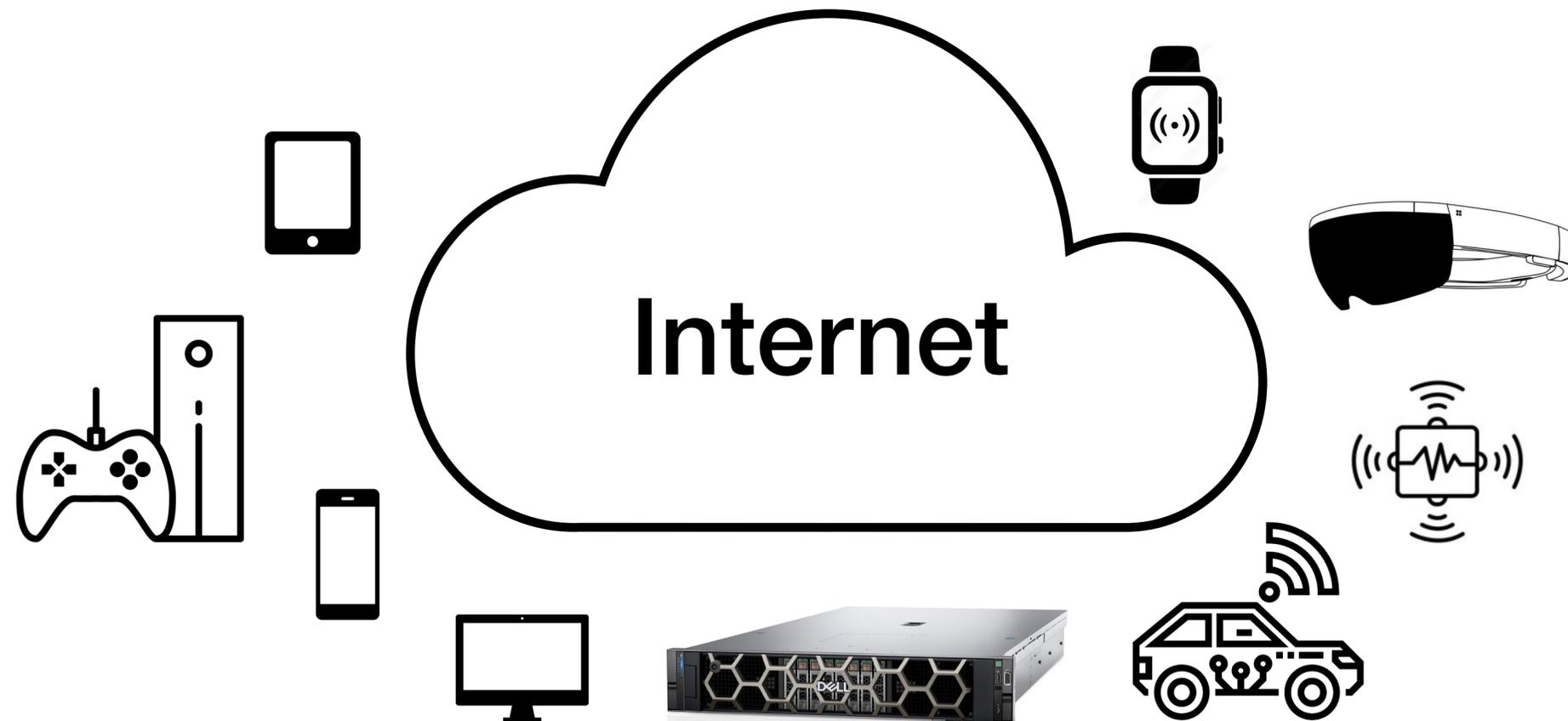
Take the Internet as an Example

- The largest engineered system people have built so far
 - Connect billions of devices



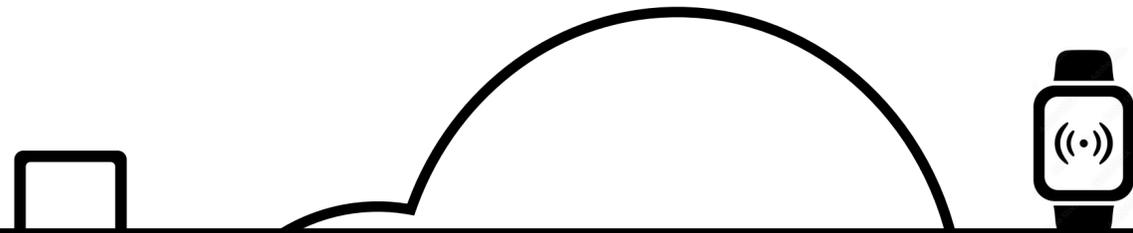
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- The largest engineered system people have built so far
 - Connect billions of devices
 - Provide application service for billions of users



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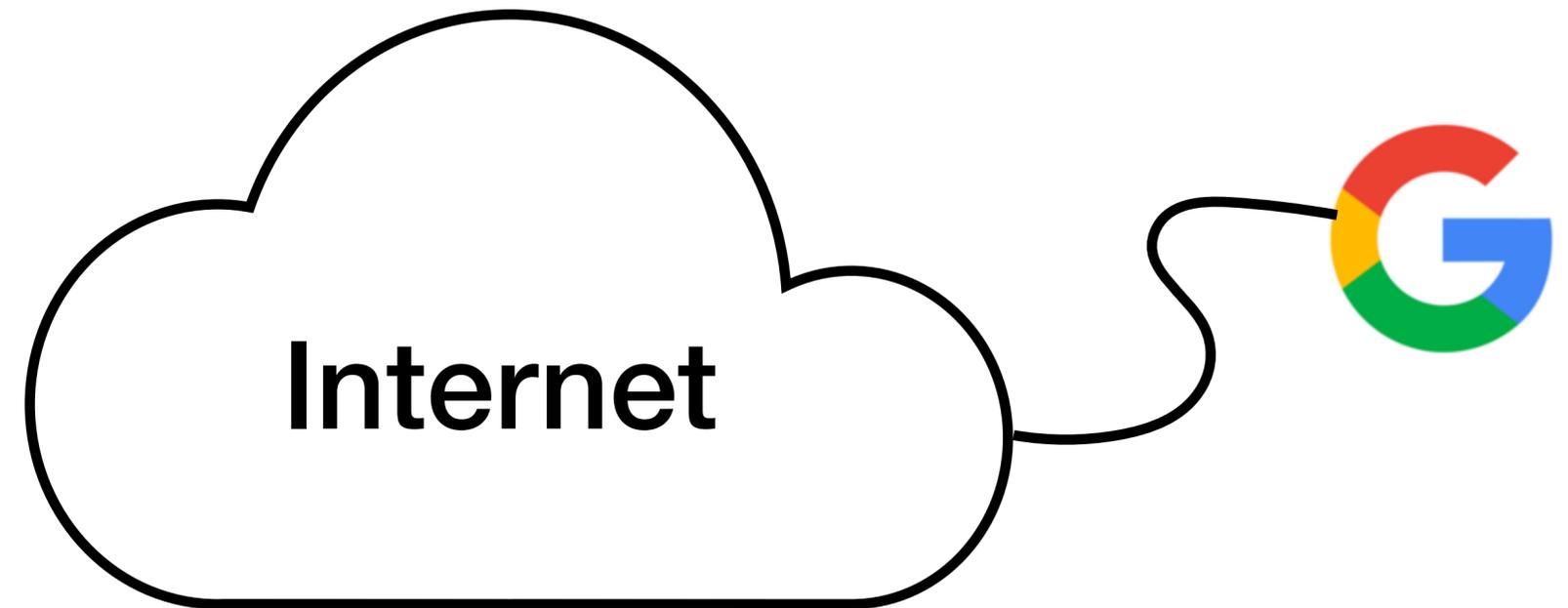


But,

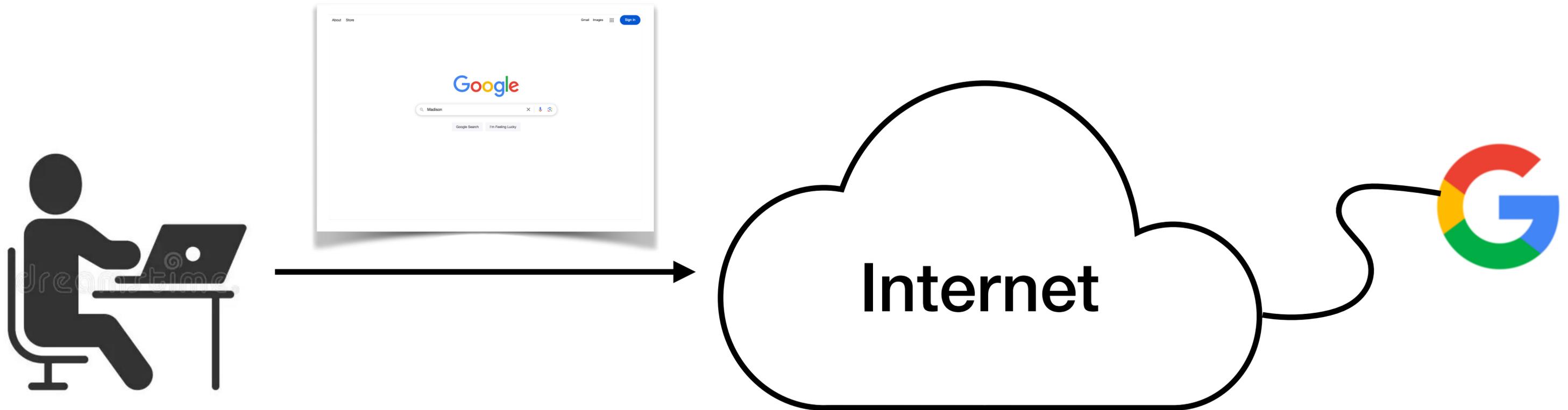
- **What is the Internet?**
- **How does the Internet work?**



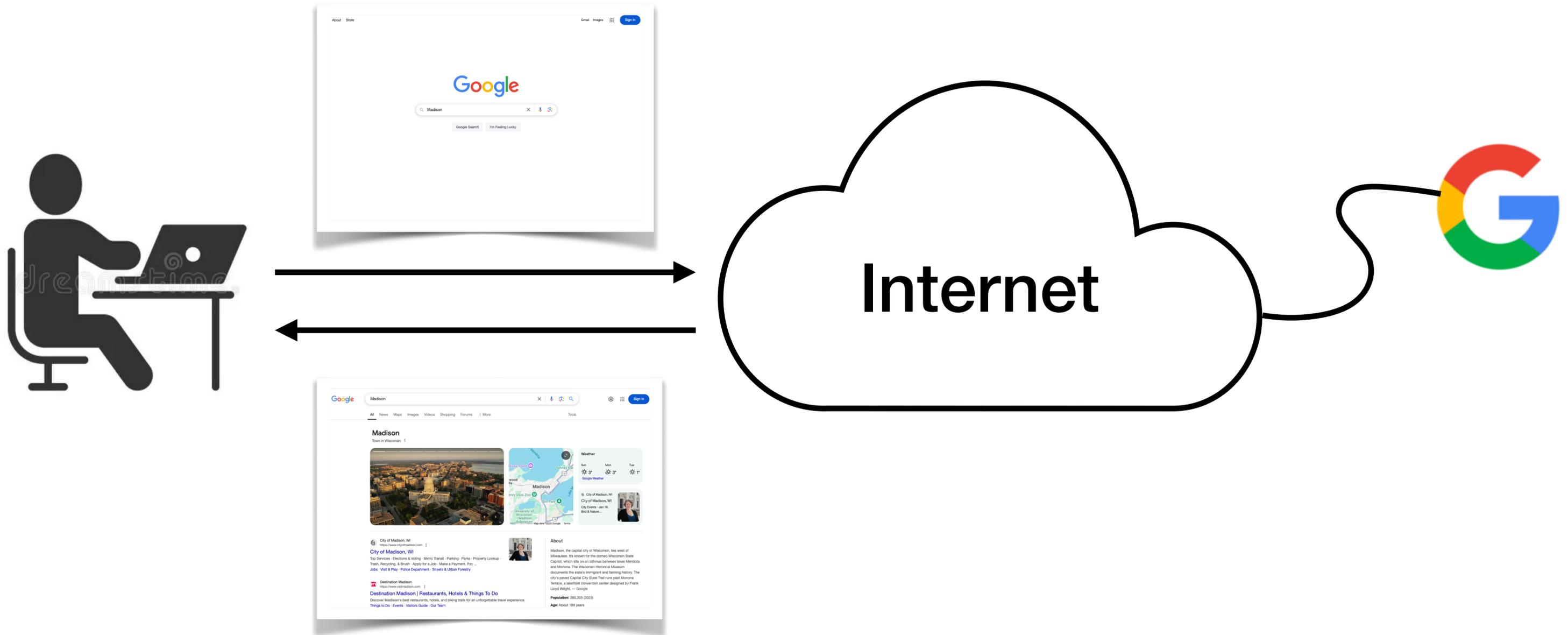
A Google Search Example



A Google Search Example

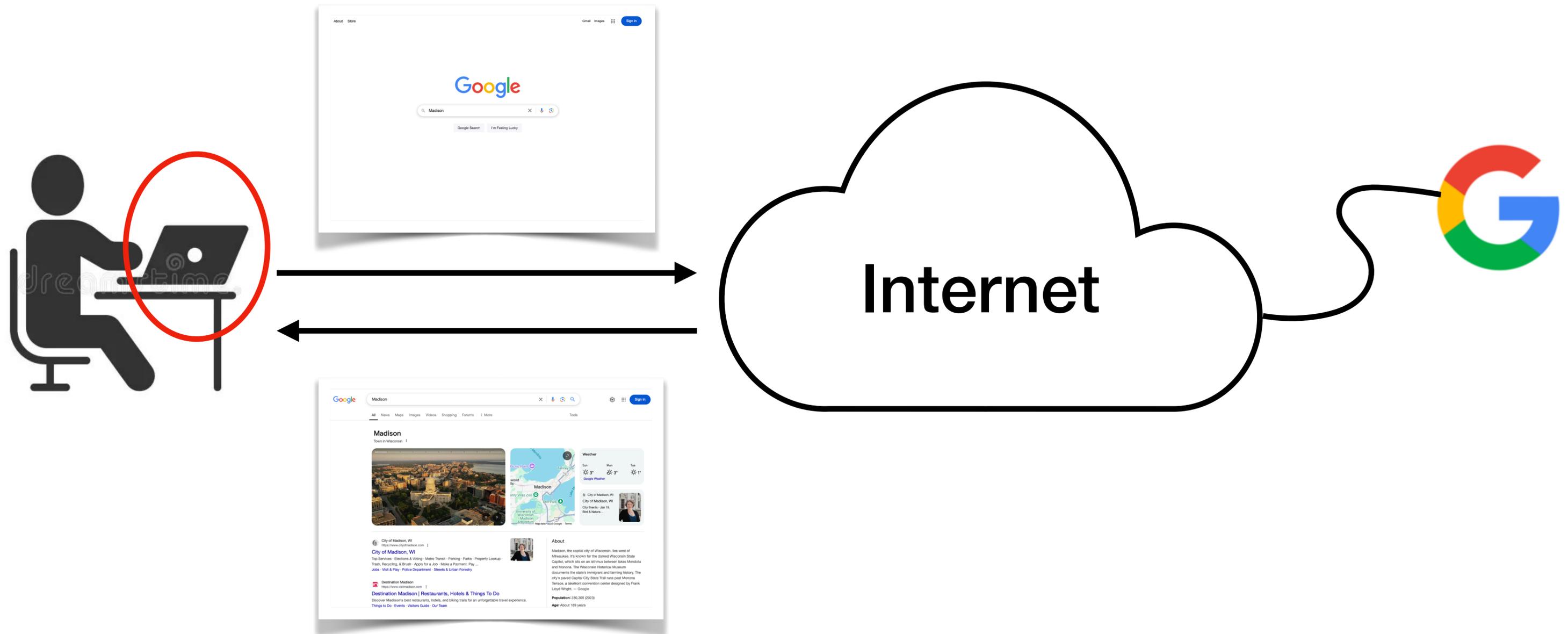


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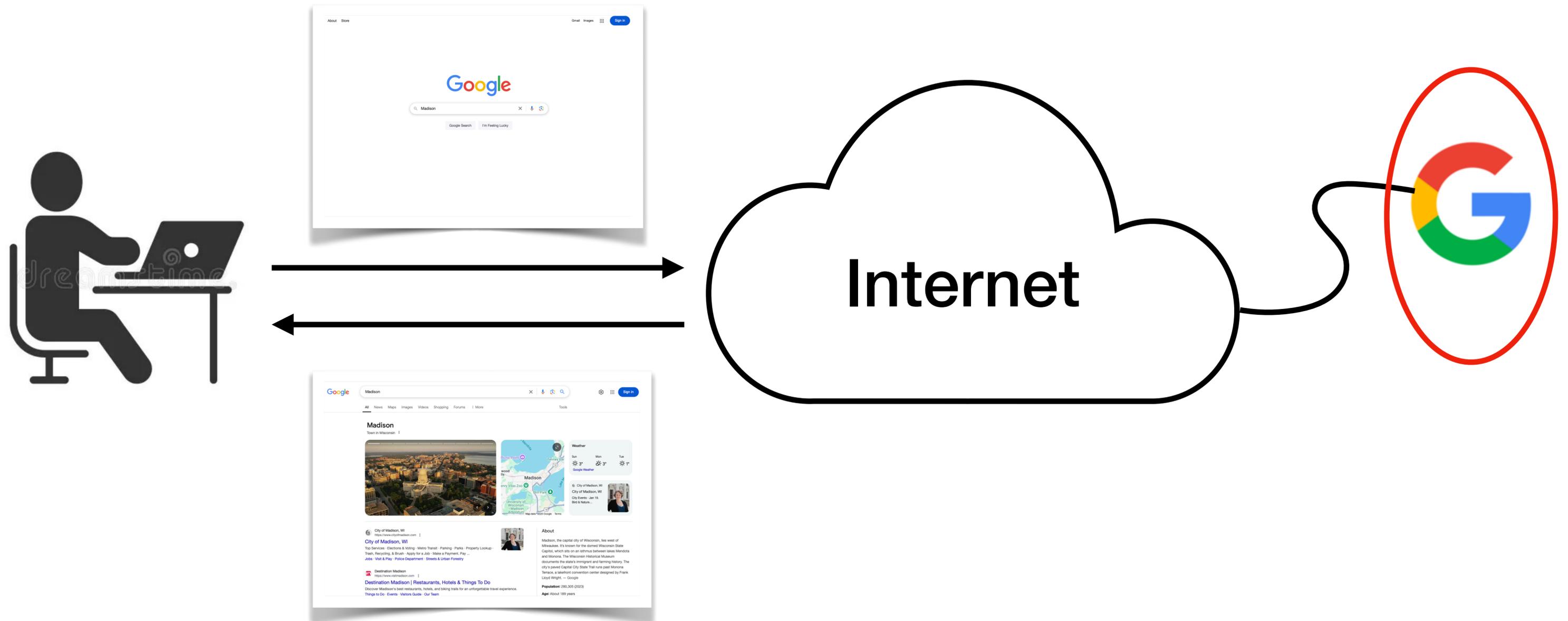
Host (End System)

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



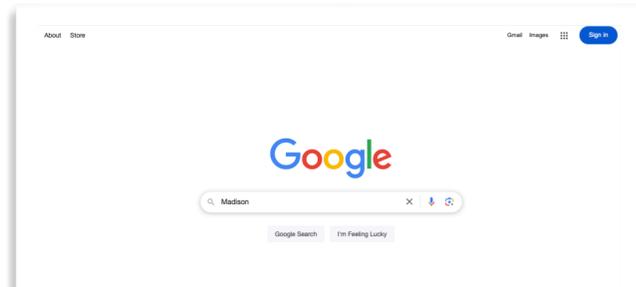
Service

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

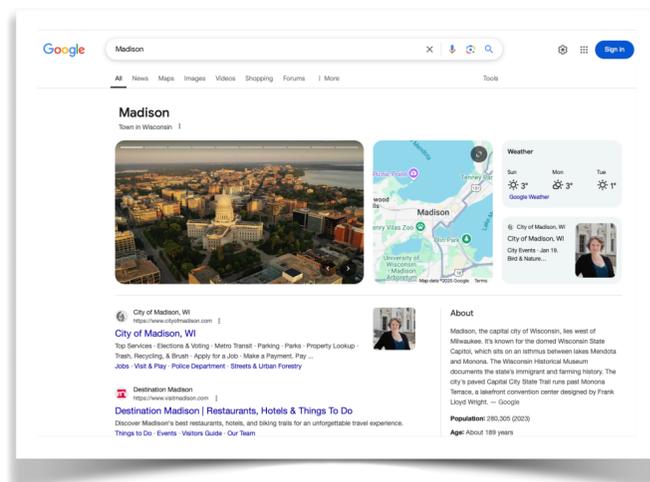


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Where does Google run?



Services Run atop One or Multiple Hosts

- They can be data centers, enterprise on-premise clusters, etc.



Services Run atop One or Multiple Hosts

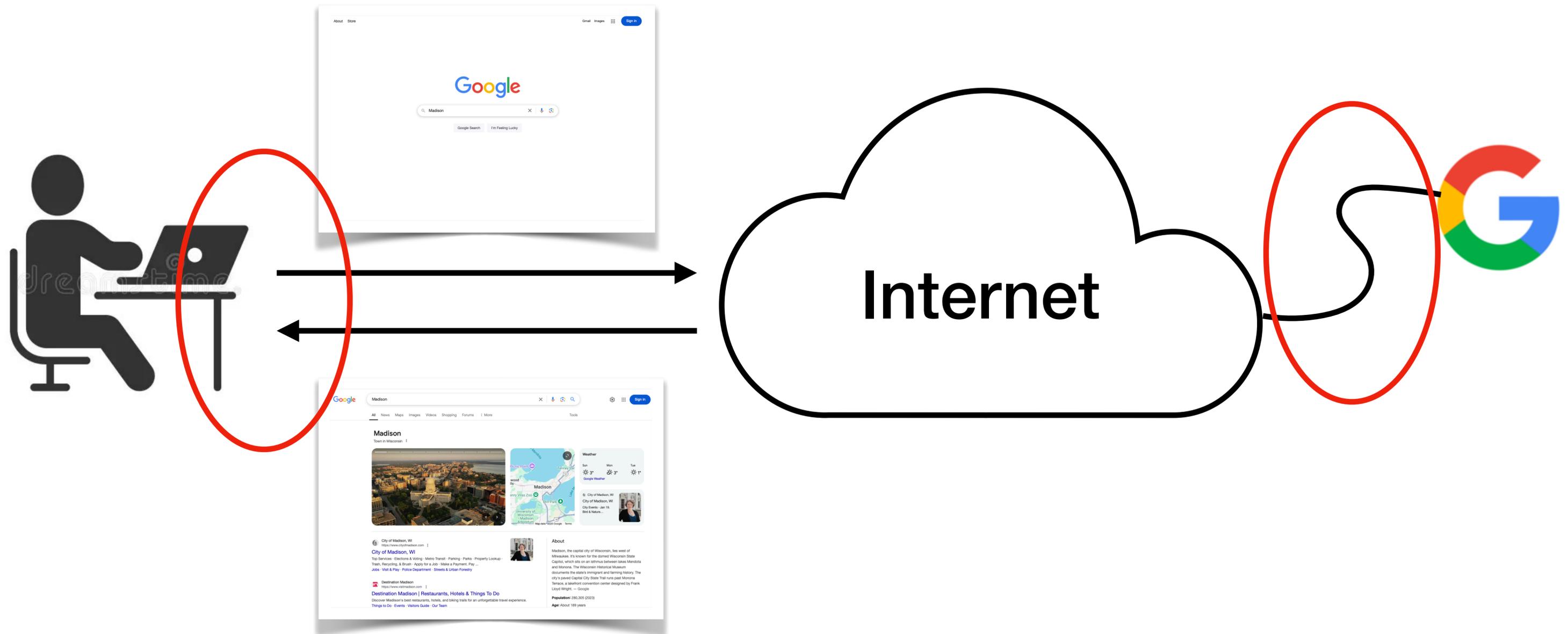
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Data centers are an agglomeration of compute, network, and storage resources.

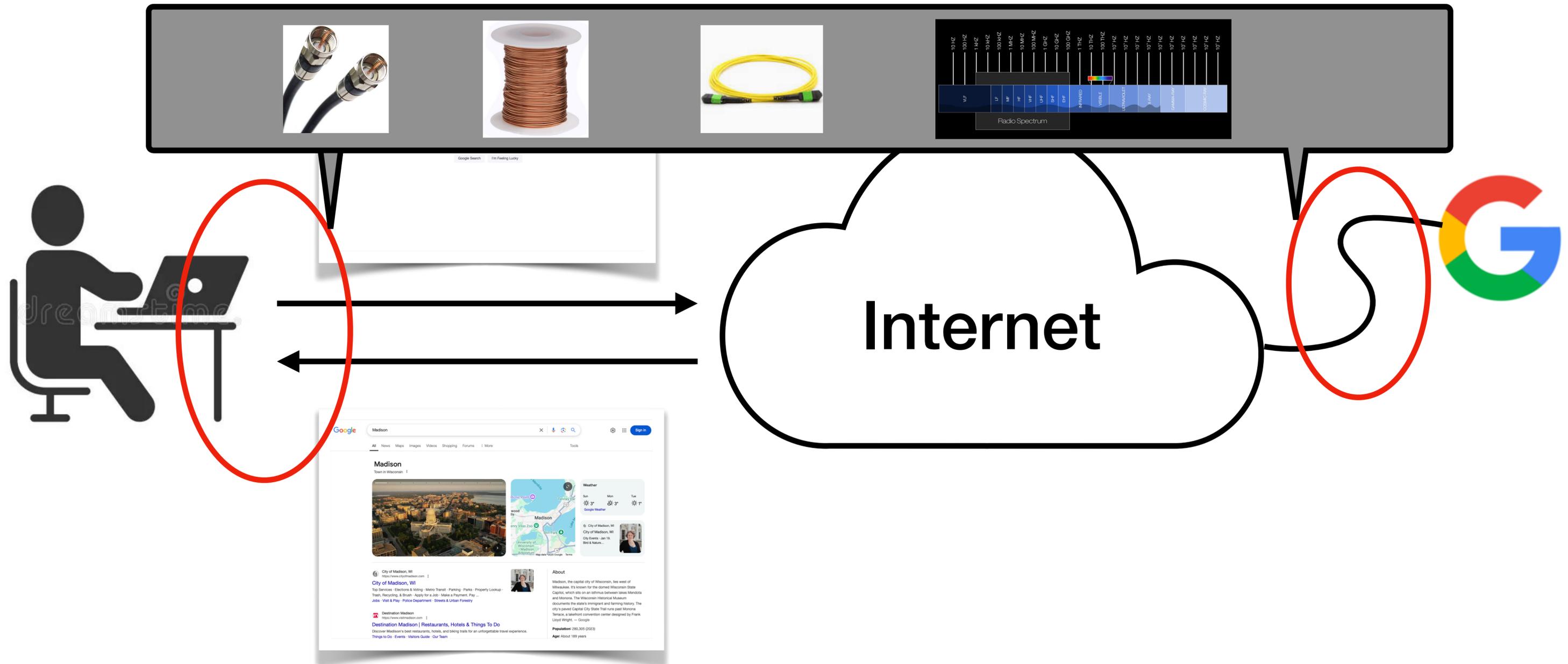


How does a host connect to the Internet?

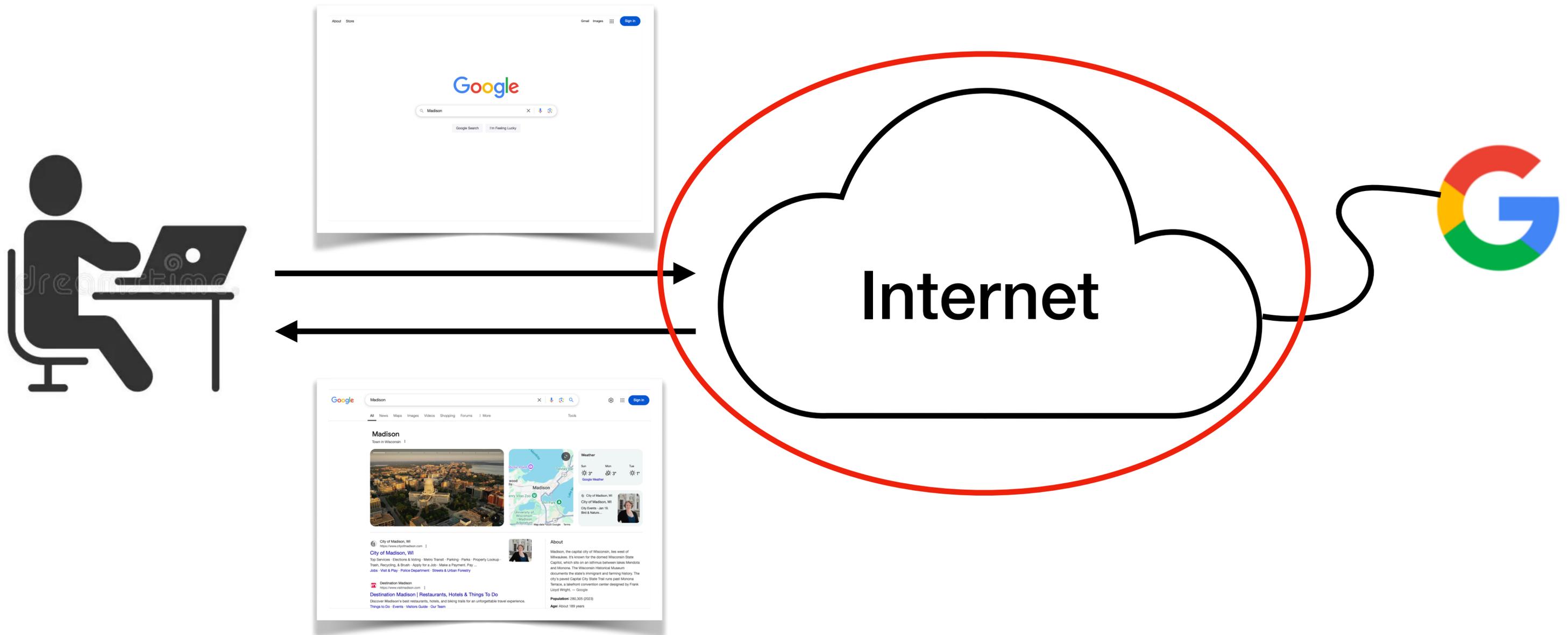


Communication Link

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

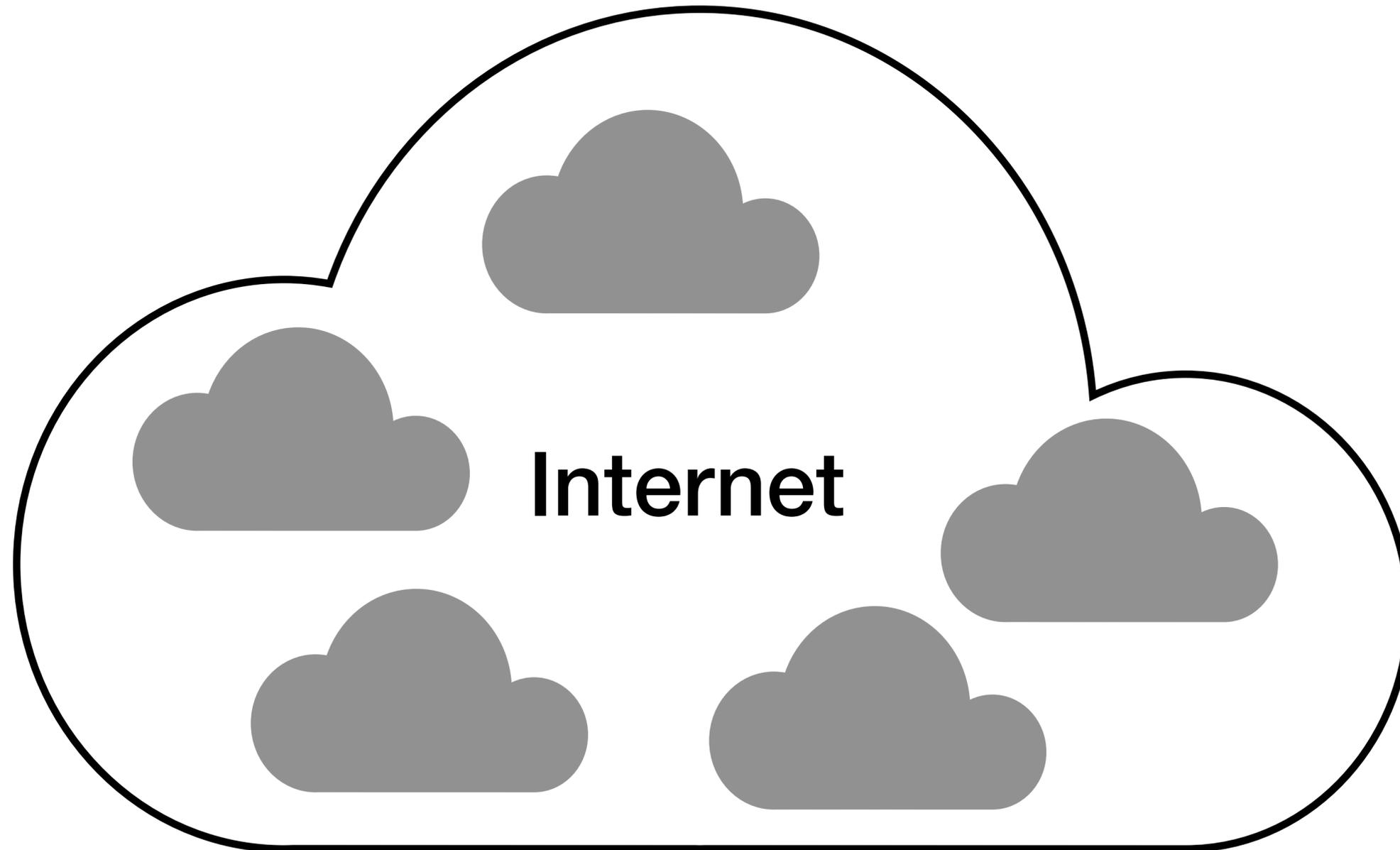


What is inside the Internet?



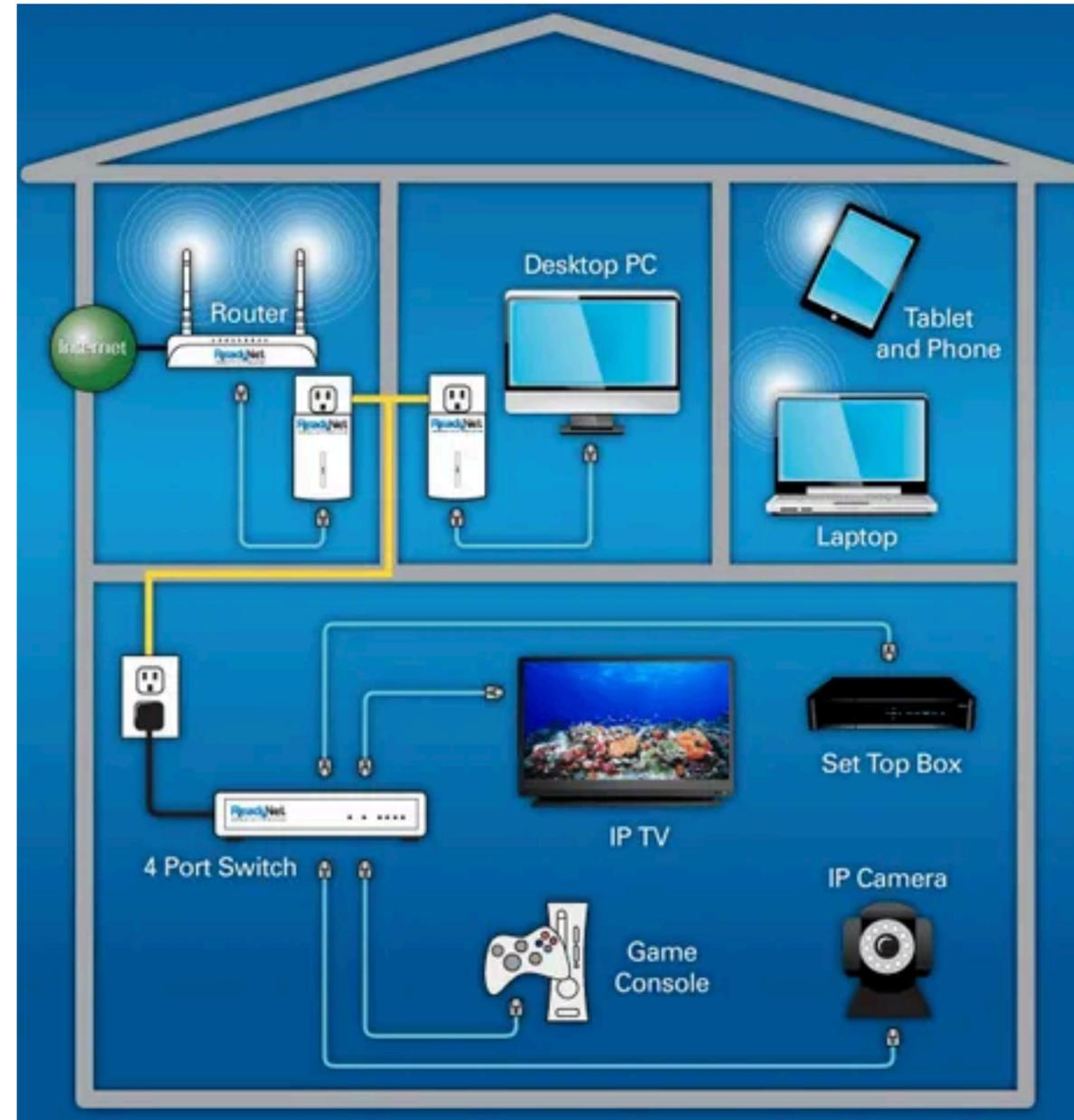
The Internet

- The Internet is a network of networks



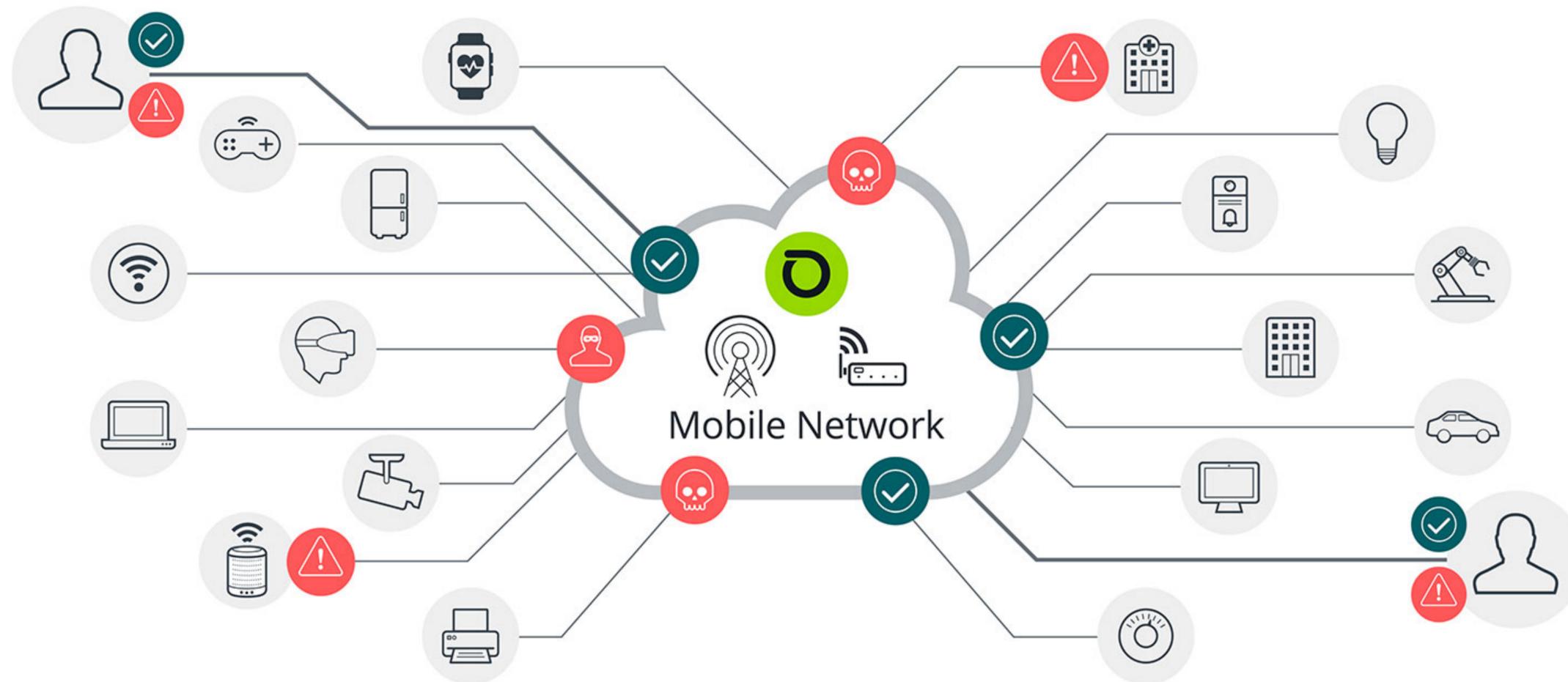
Home Network

- Provide Internet access for intra-house devices



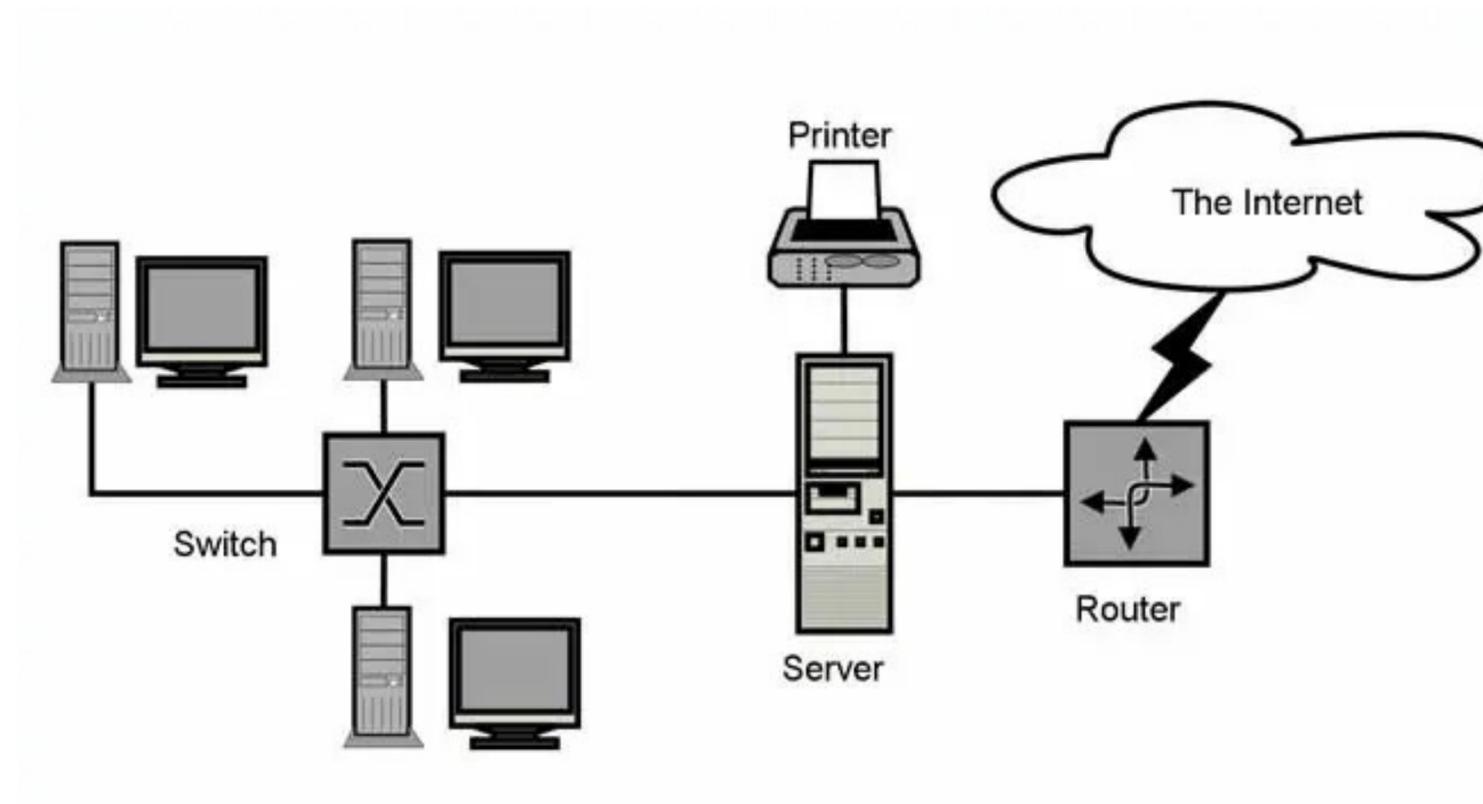
Mobile Network

- Provide Internet access for moving devices



Enterprise Network

- Provide Internet access for devices within an organization



Data Center Network

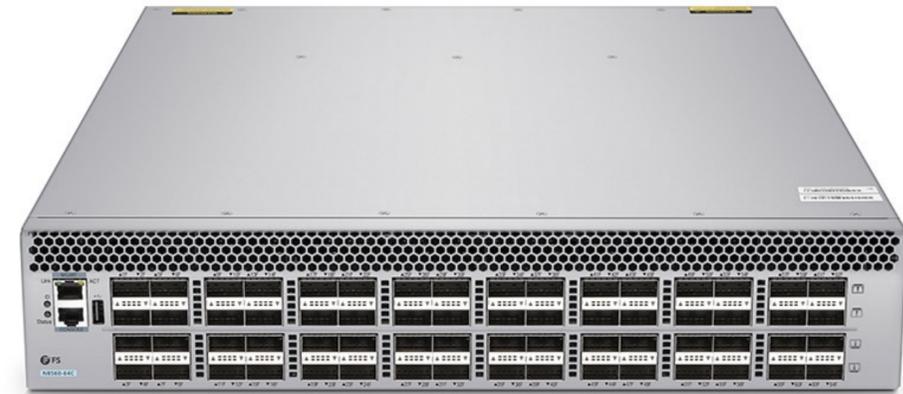
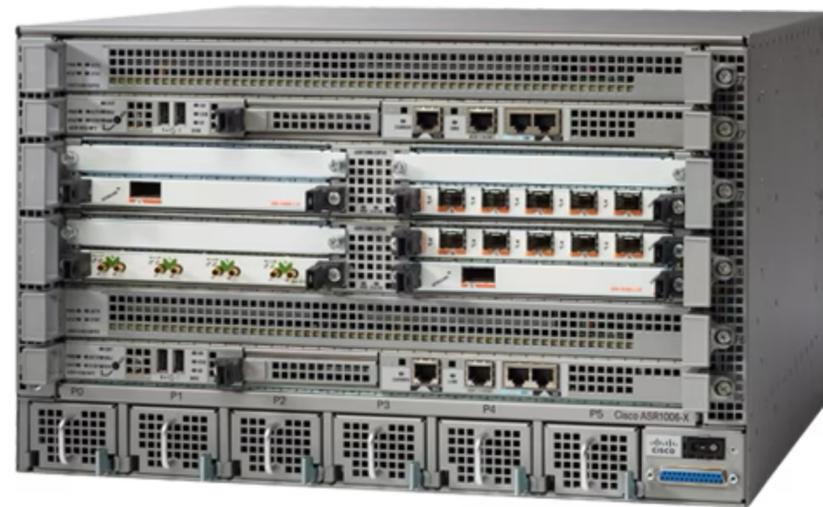
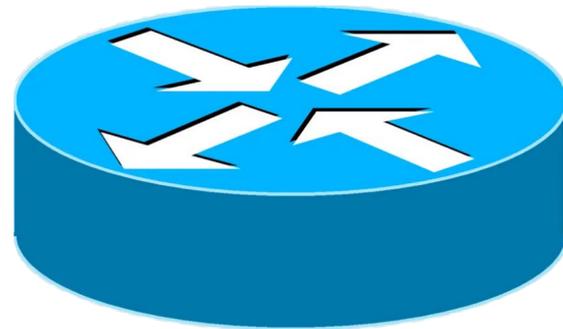
- Provide Internet access for devices within a data center



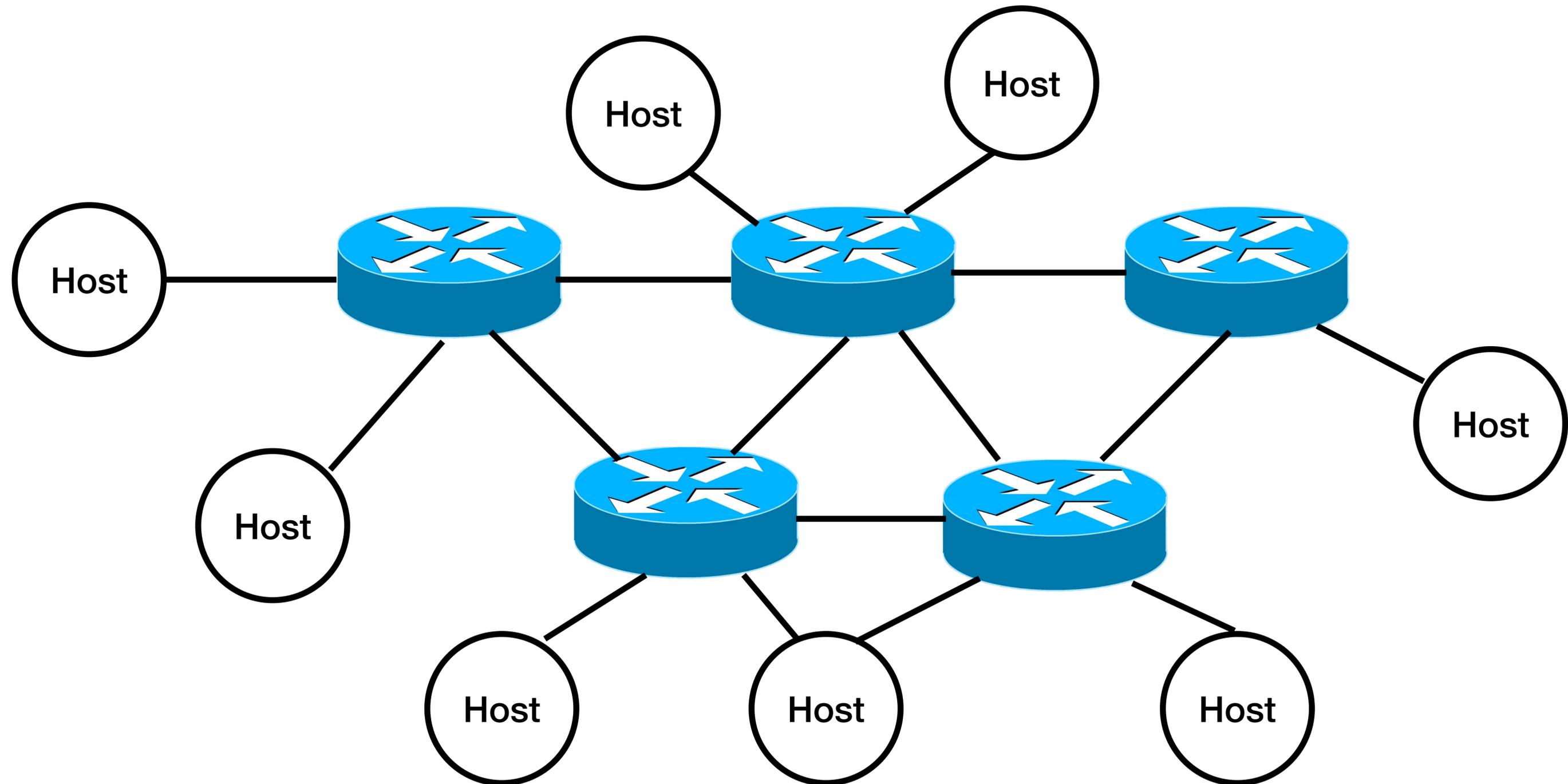
Inside a network, how do we connect multiple devices?

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)

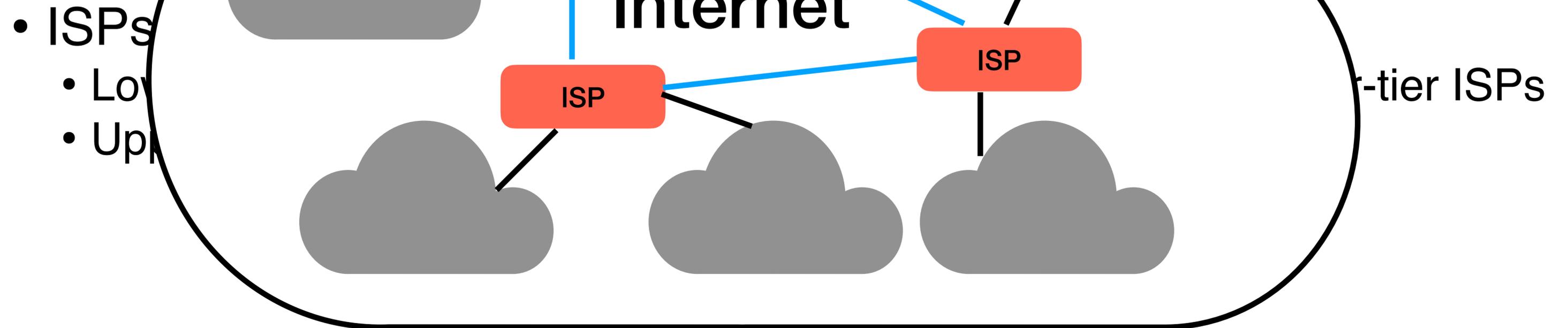
- An ISP is a vendor that offers Internet connection services
 - Residential ISPs —> home network
 - Corporate ISPs —> enterprise network
 - University ISPs —> university network
 - Cellular data ISPs —> mobile network
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- ISPs are hierarchical and multi-tier
 - Lower-tier ISPs are connected via national or international upper-tier ISPs
 - Upper-tier ISPs are connected directly to each other

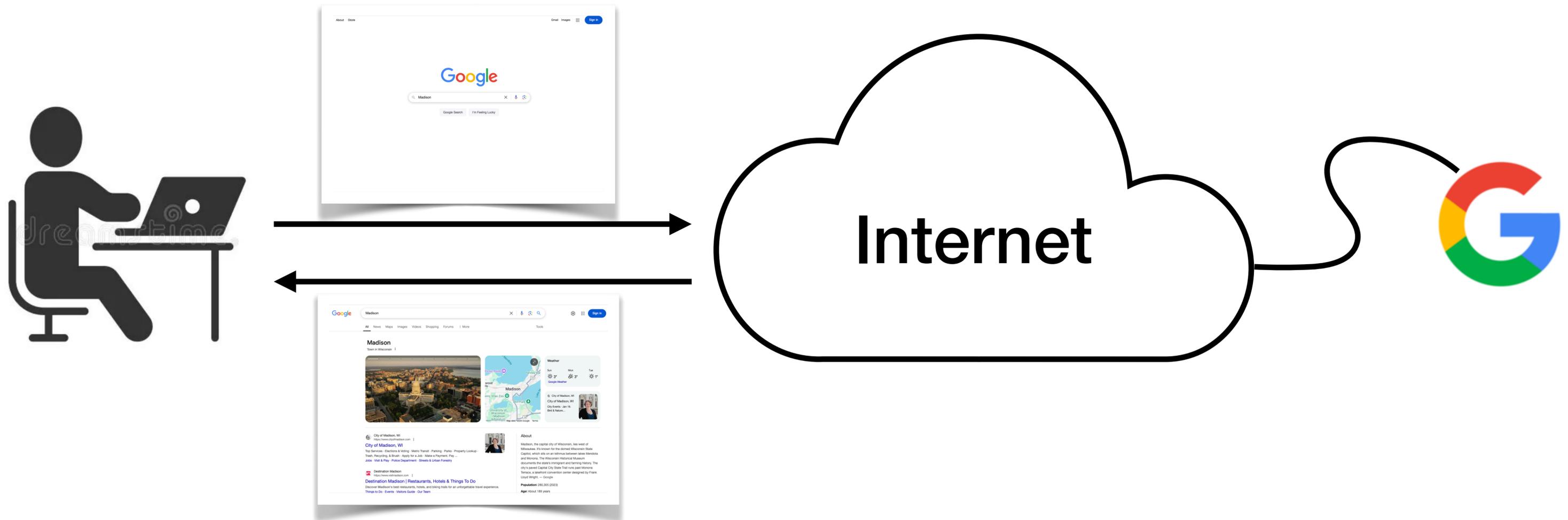
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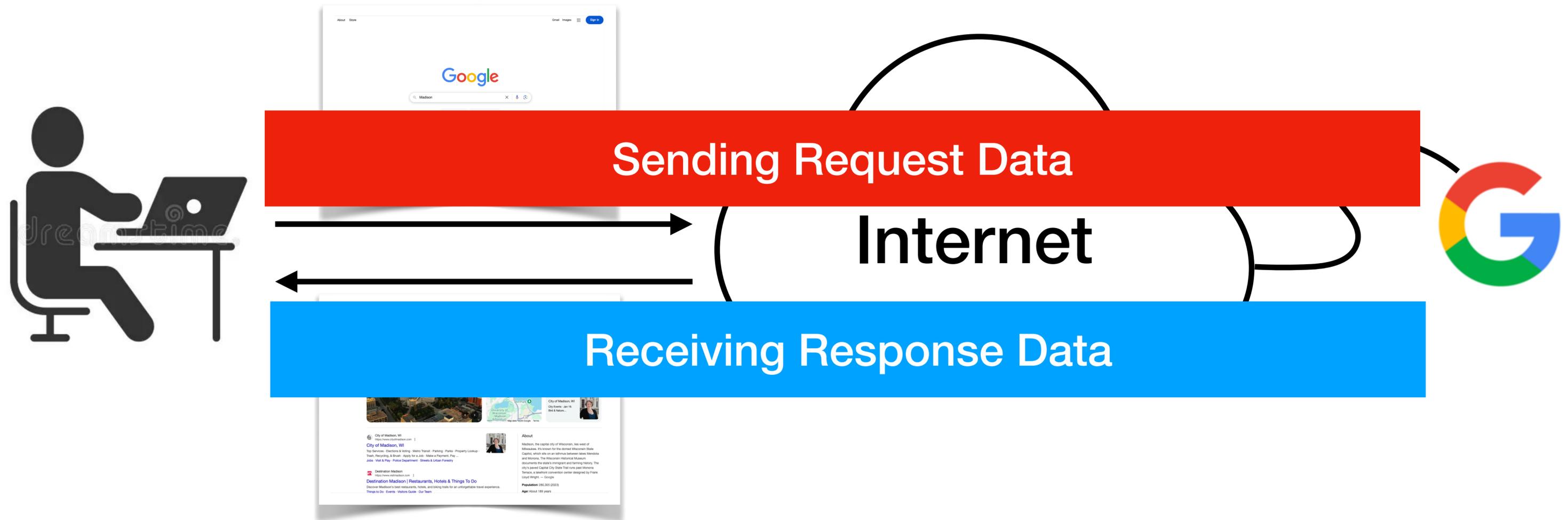
Using the Internet

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



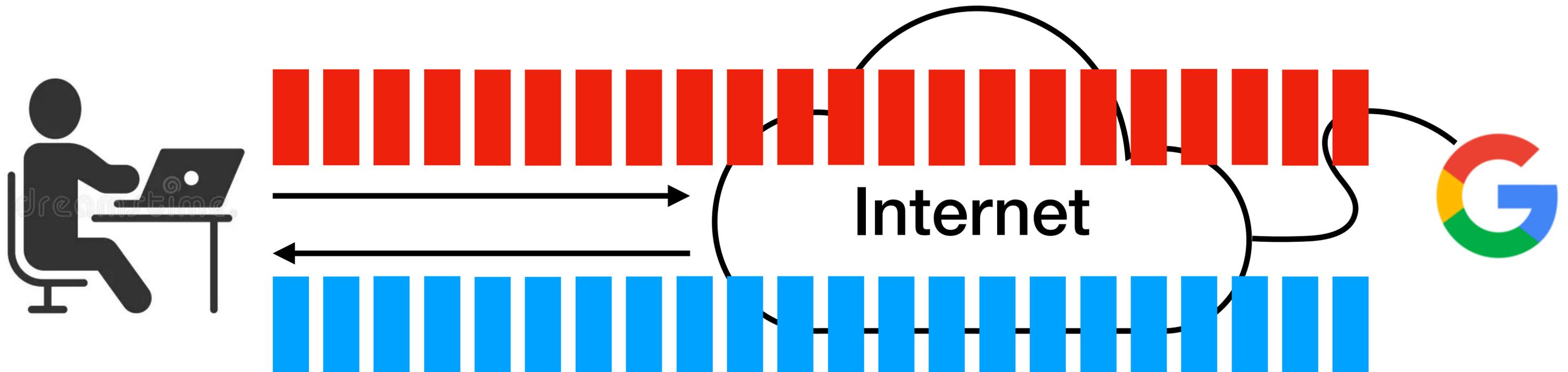
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Data as Packet

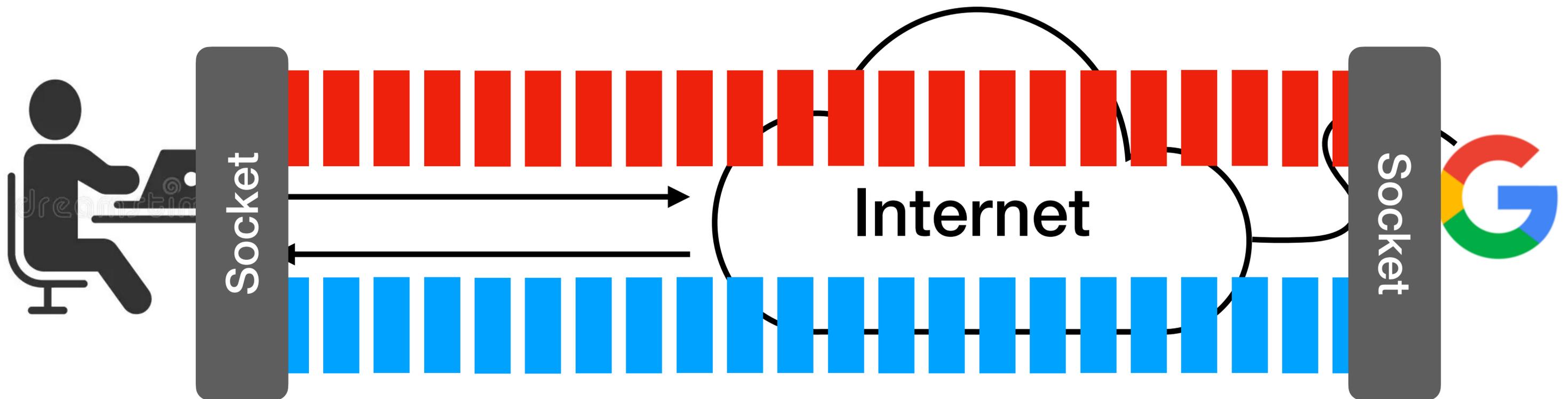
- A packet is the smallest unit of data that traverses the network
 - Consist of header and payload
 - The sender divides data and encapsulates them as packets
 - The receiver decapsulates packets and rebuilds the data



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

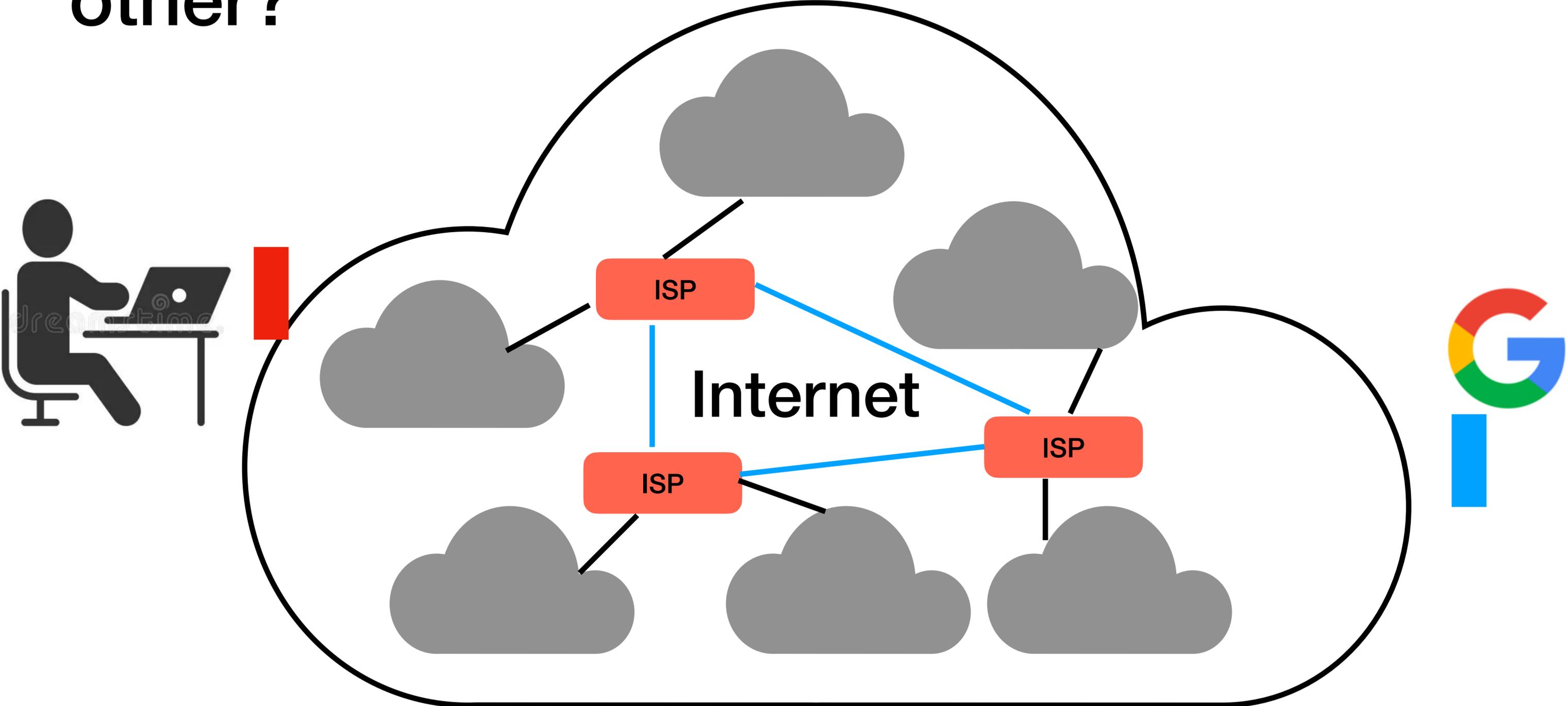
Communication Interface

- 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



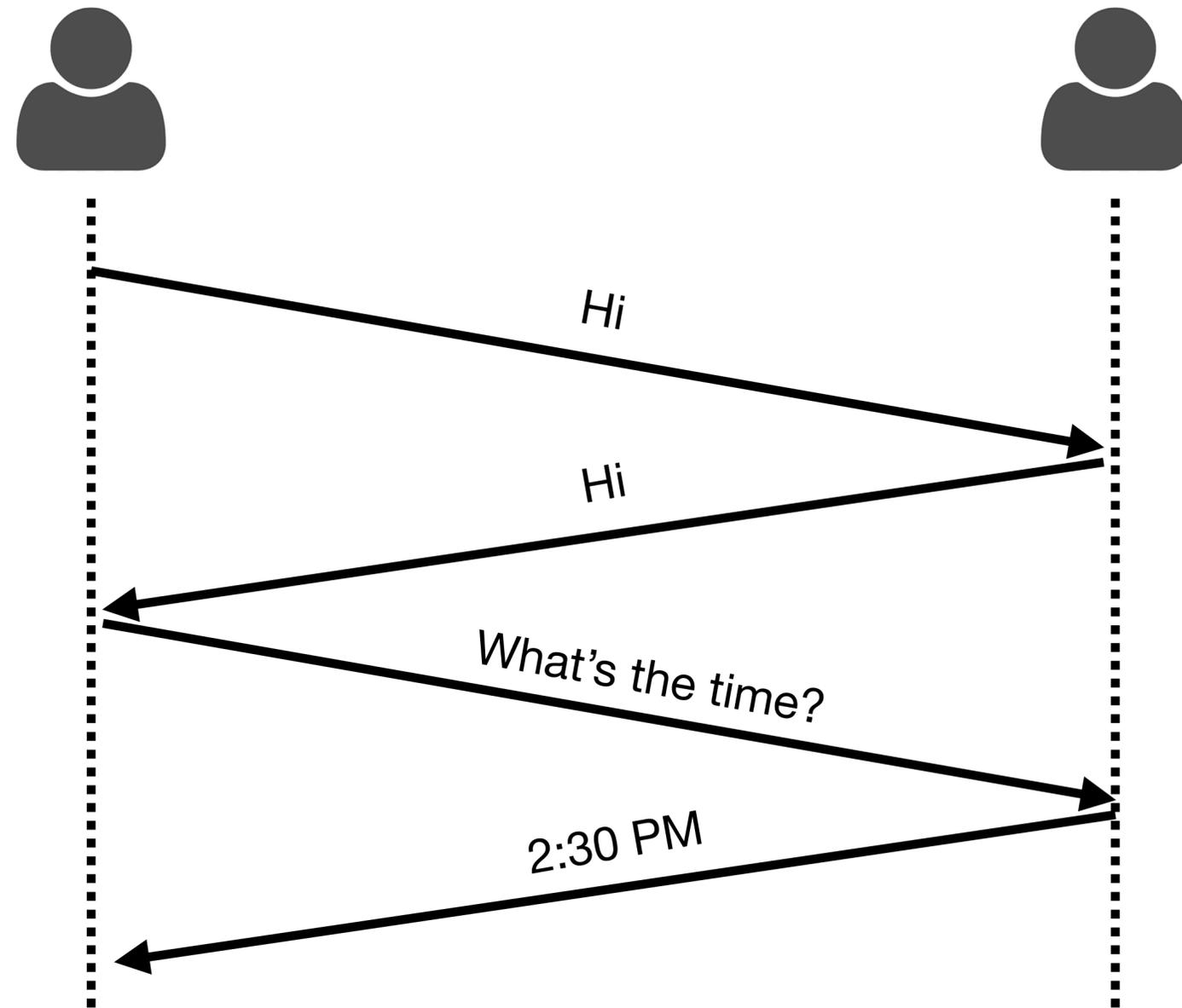
How do different devices understand each other?

How do different devices understand each other?



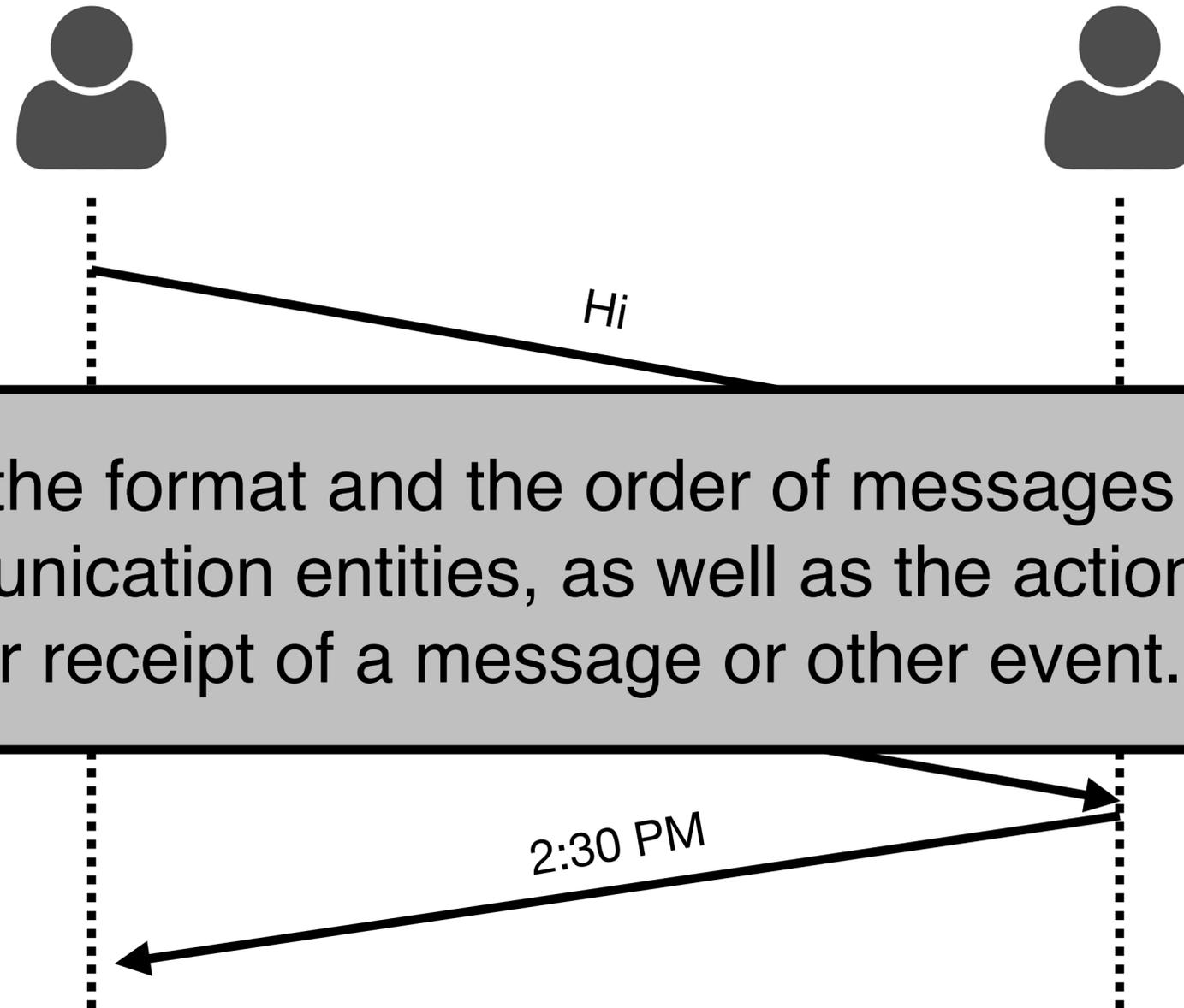
Protocol

- A protocol defines the communication standards



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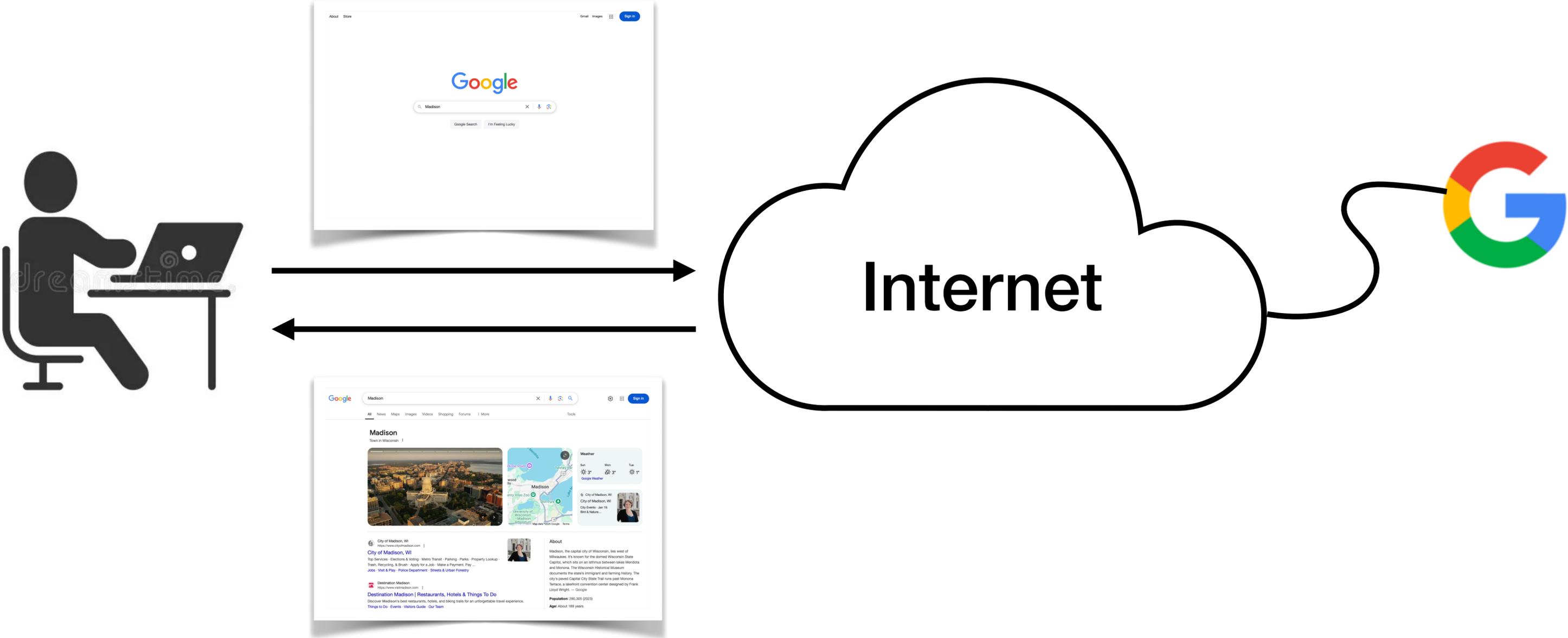
What are computer networks?

What are computer networks?

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

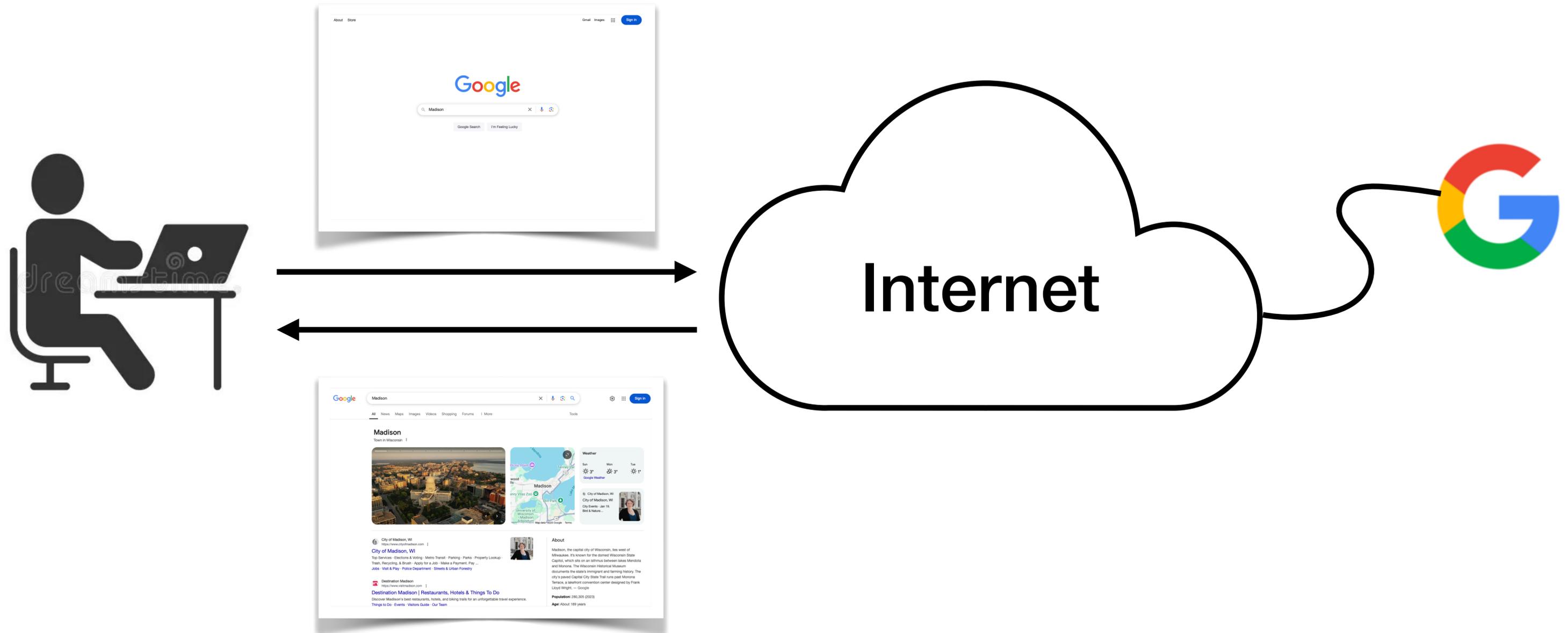
What are the design requirements of computer networks?

Design Requirements



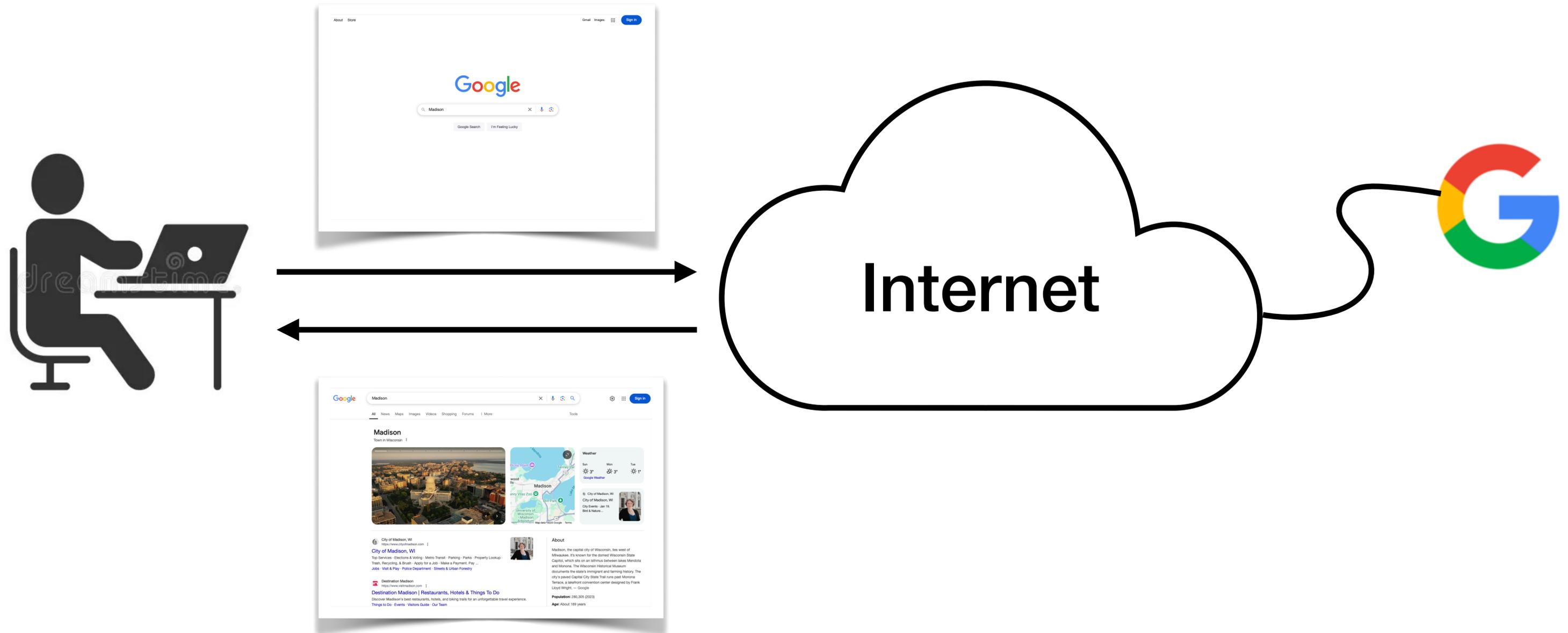
Design Requirements

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



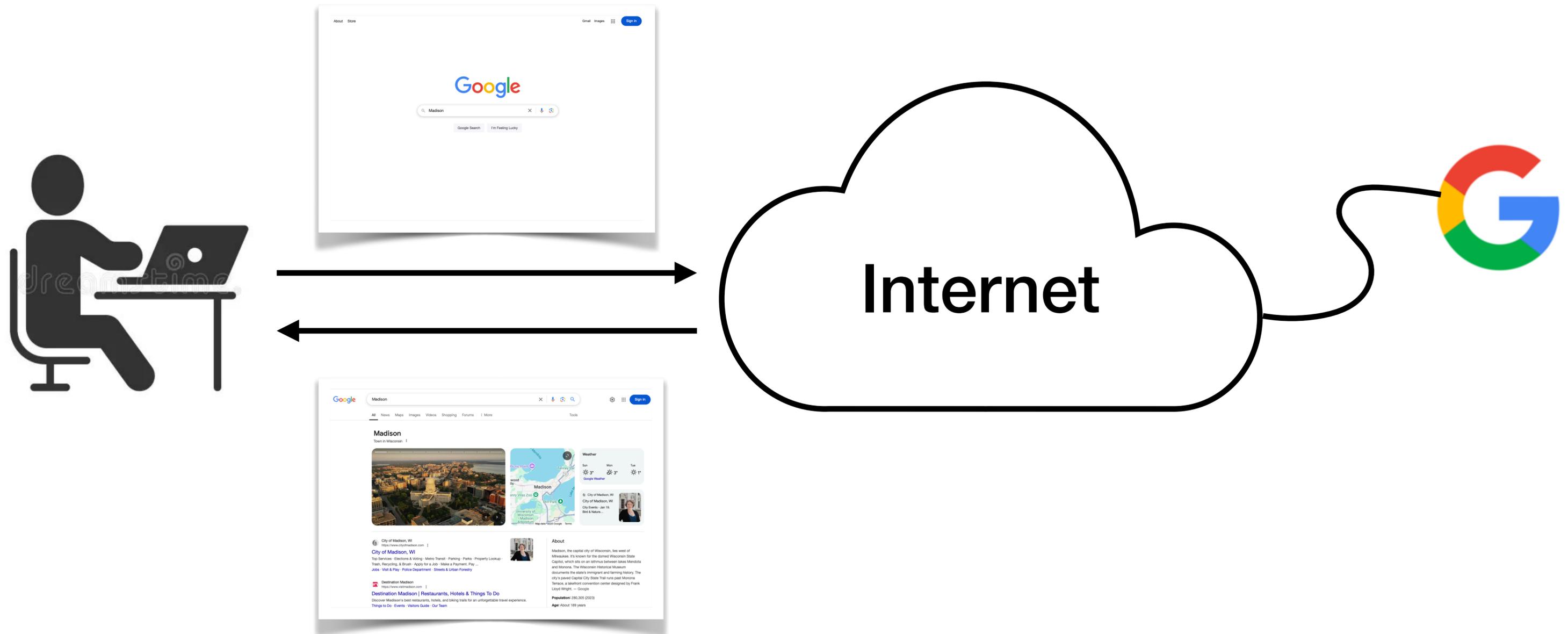
Design Requirements

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



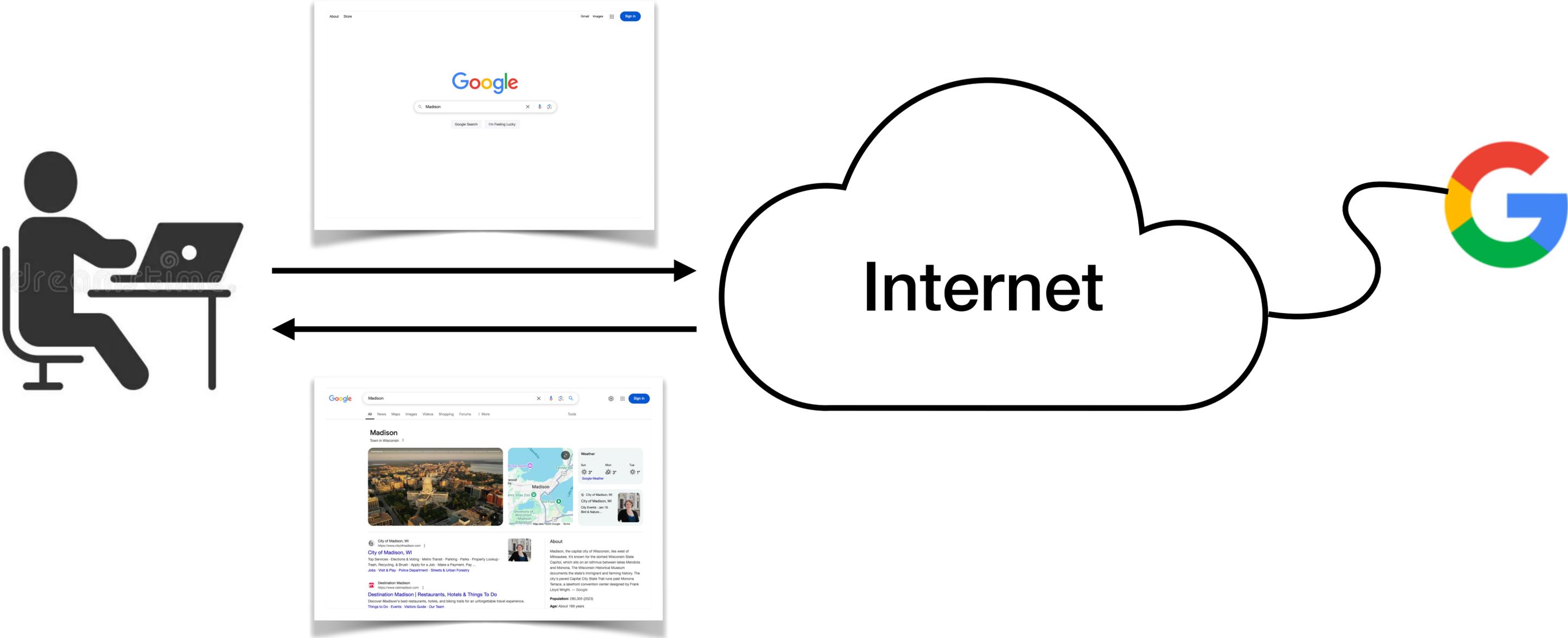
Design Requirements

- #3: Reasonable **performance**



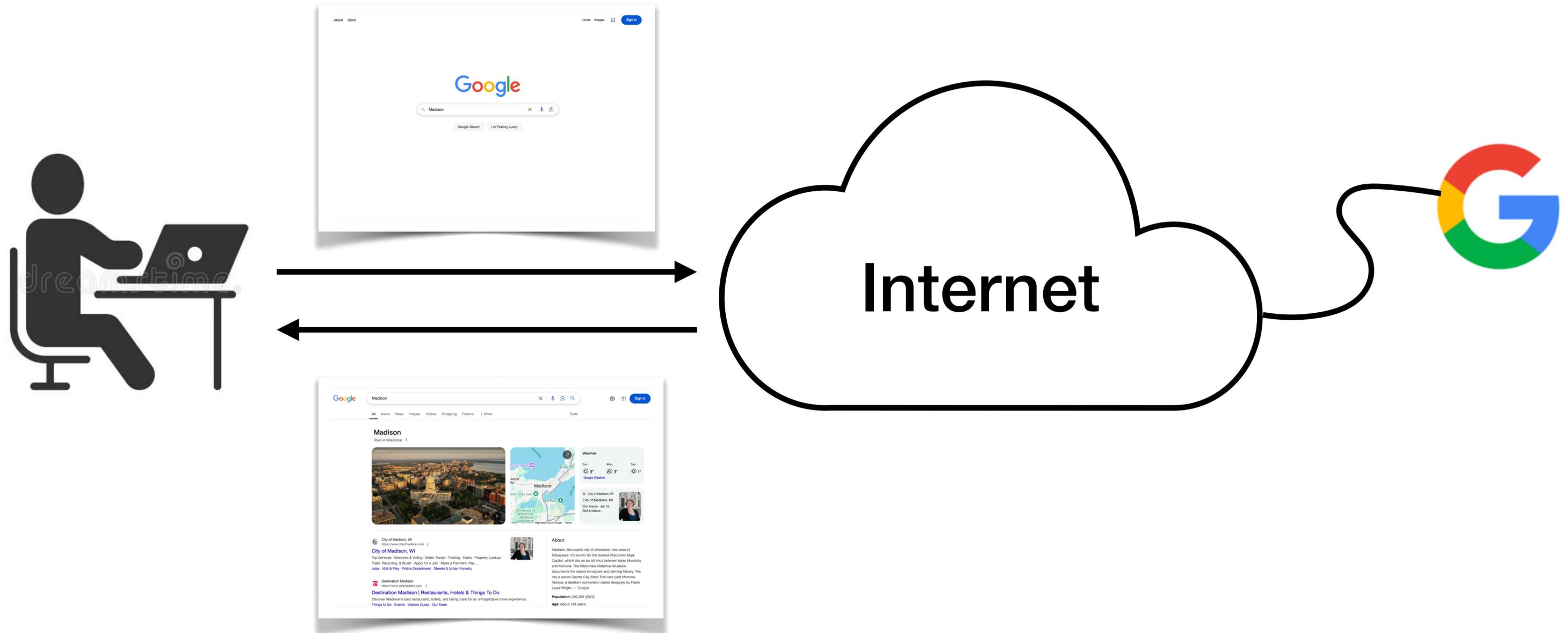
Design Requirements

- #4: Low **cost**



Design Requirements

- #5: Tolerable **security**



What are the design requirements of computer networks?

#1: Anytime and anywhere **connectivity**

#2: Always-on **correctness**

#3: Reasonable **performance**

#4: Low **cost**

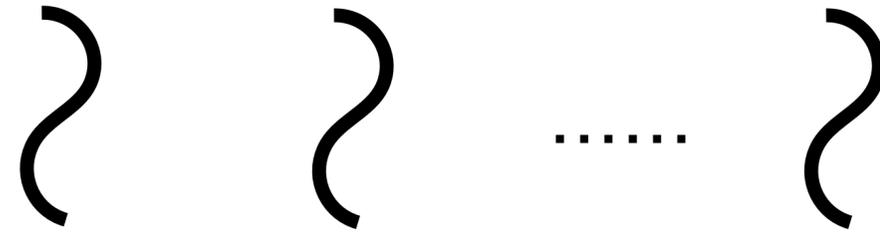
#5: Tolerable **security**

Computer networks are a system that provides cross-host communication for information exchange.

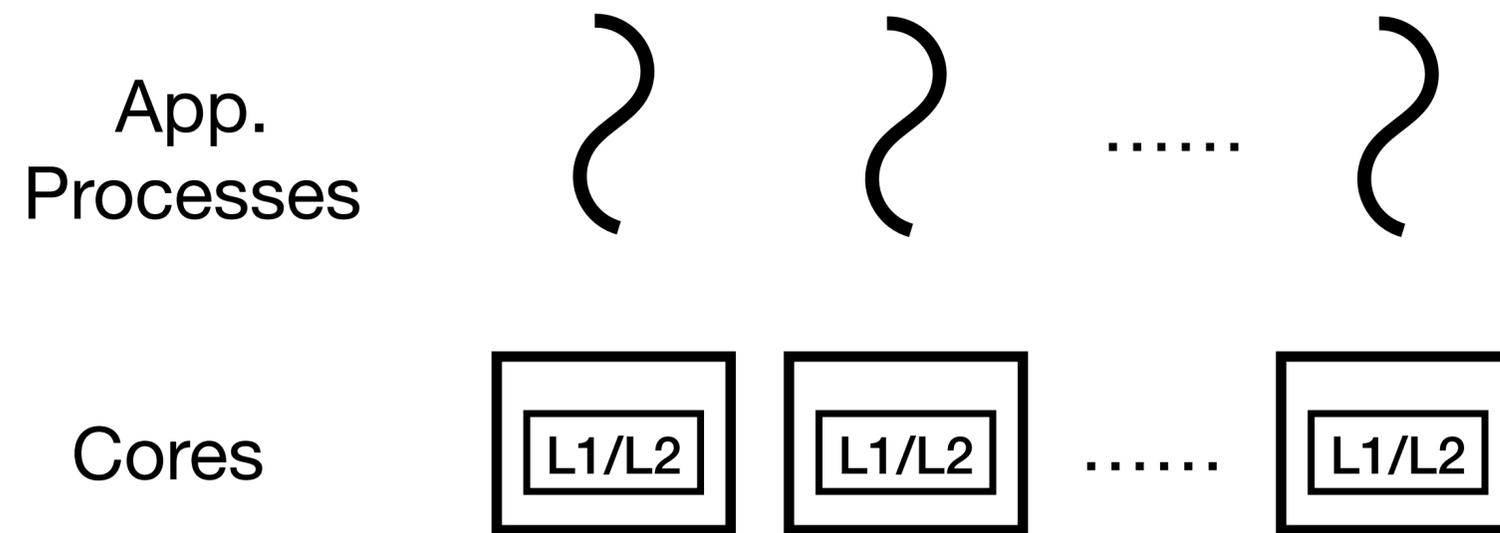
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How do intra-host communications work?

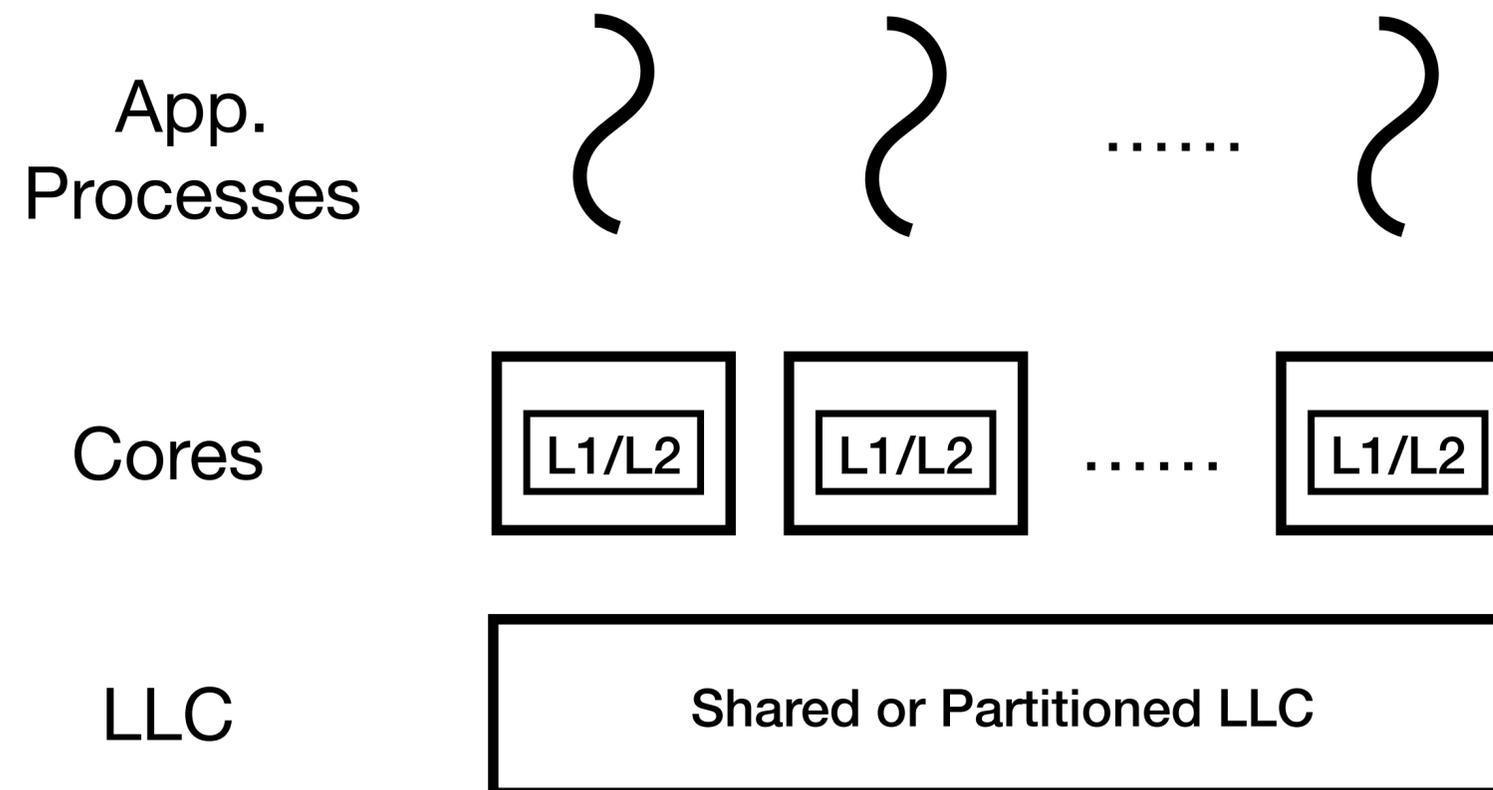
App.
Processes



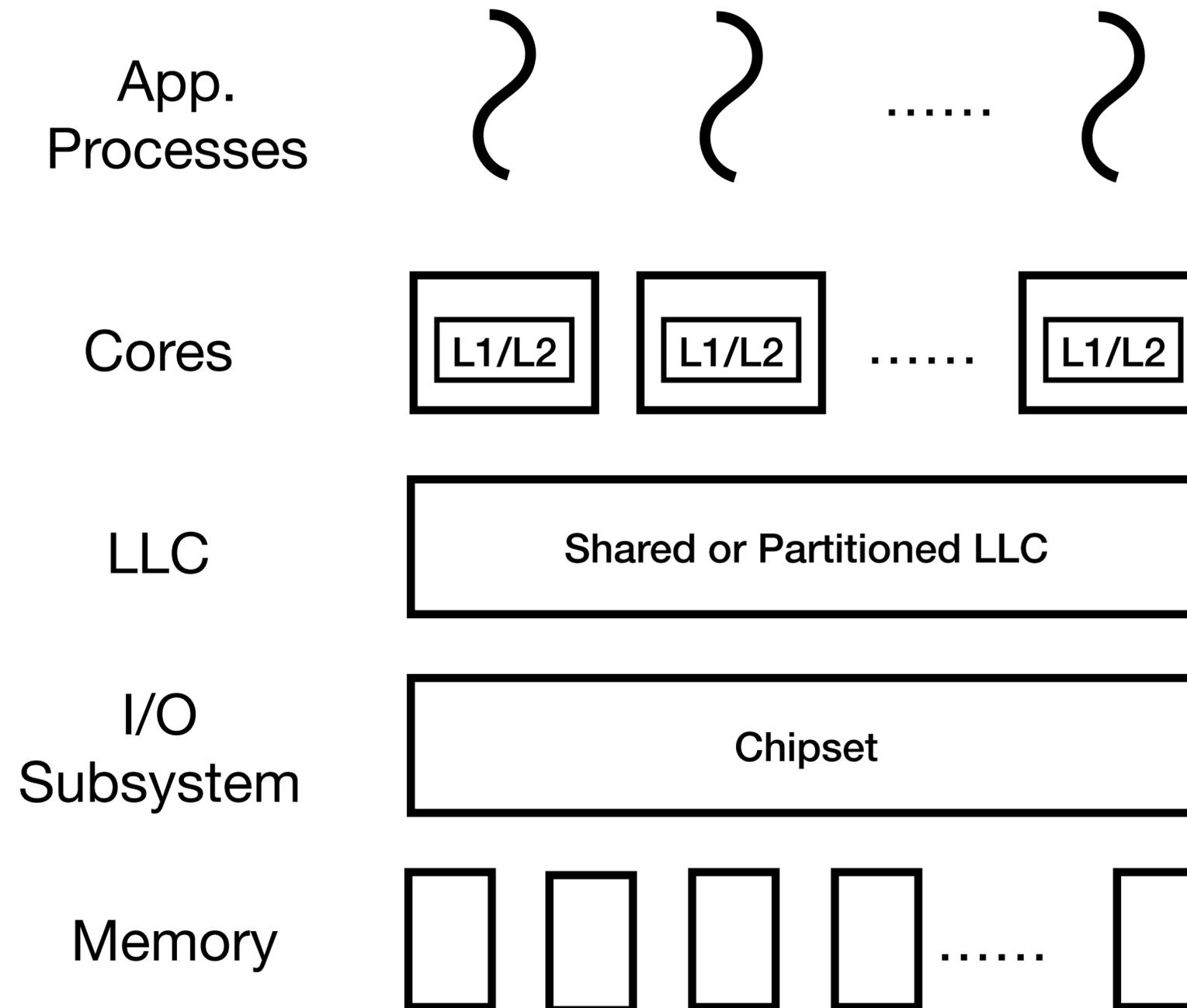
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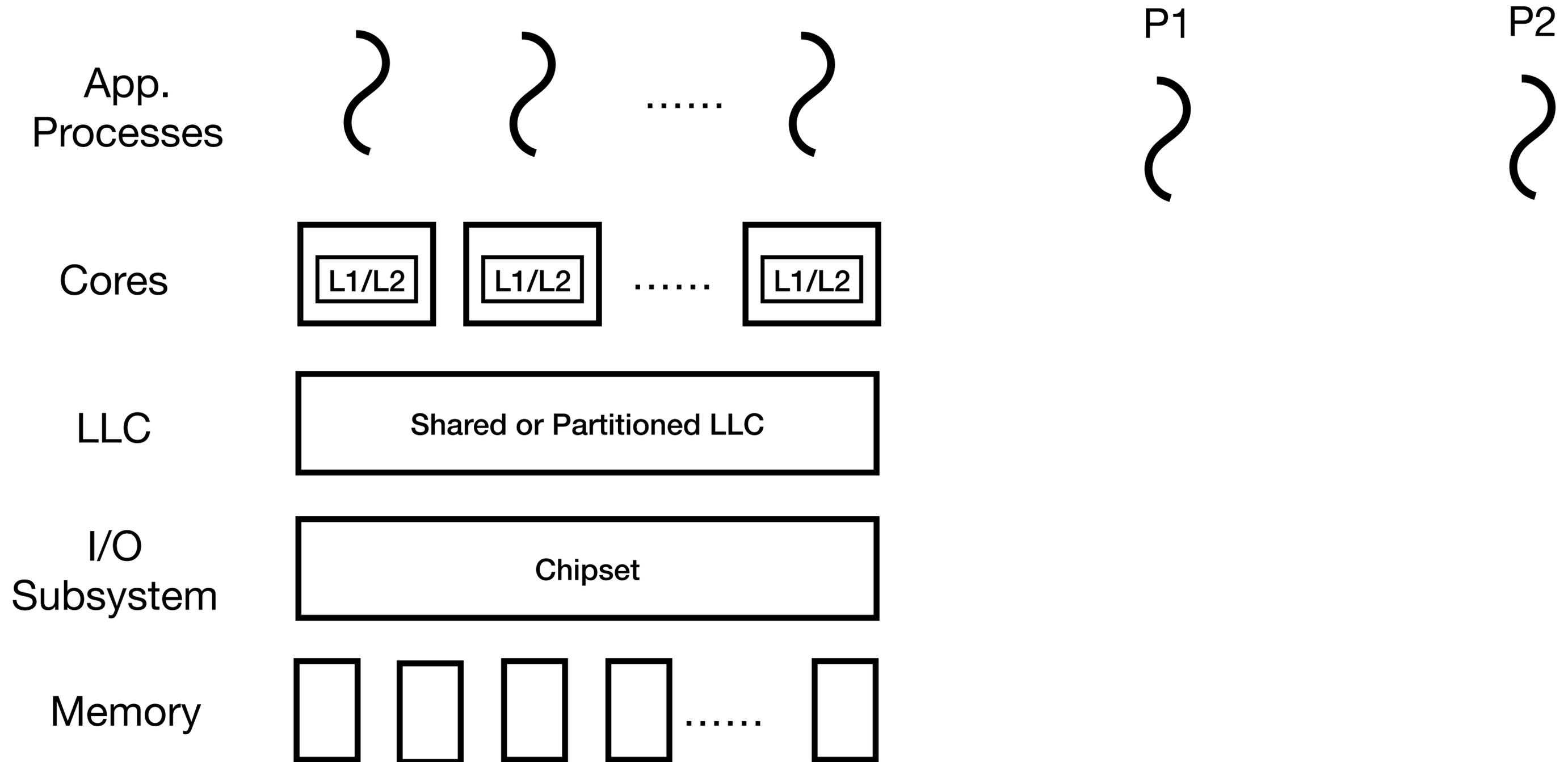
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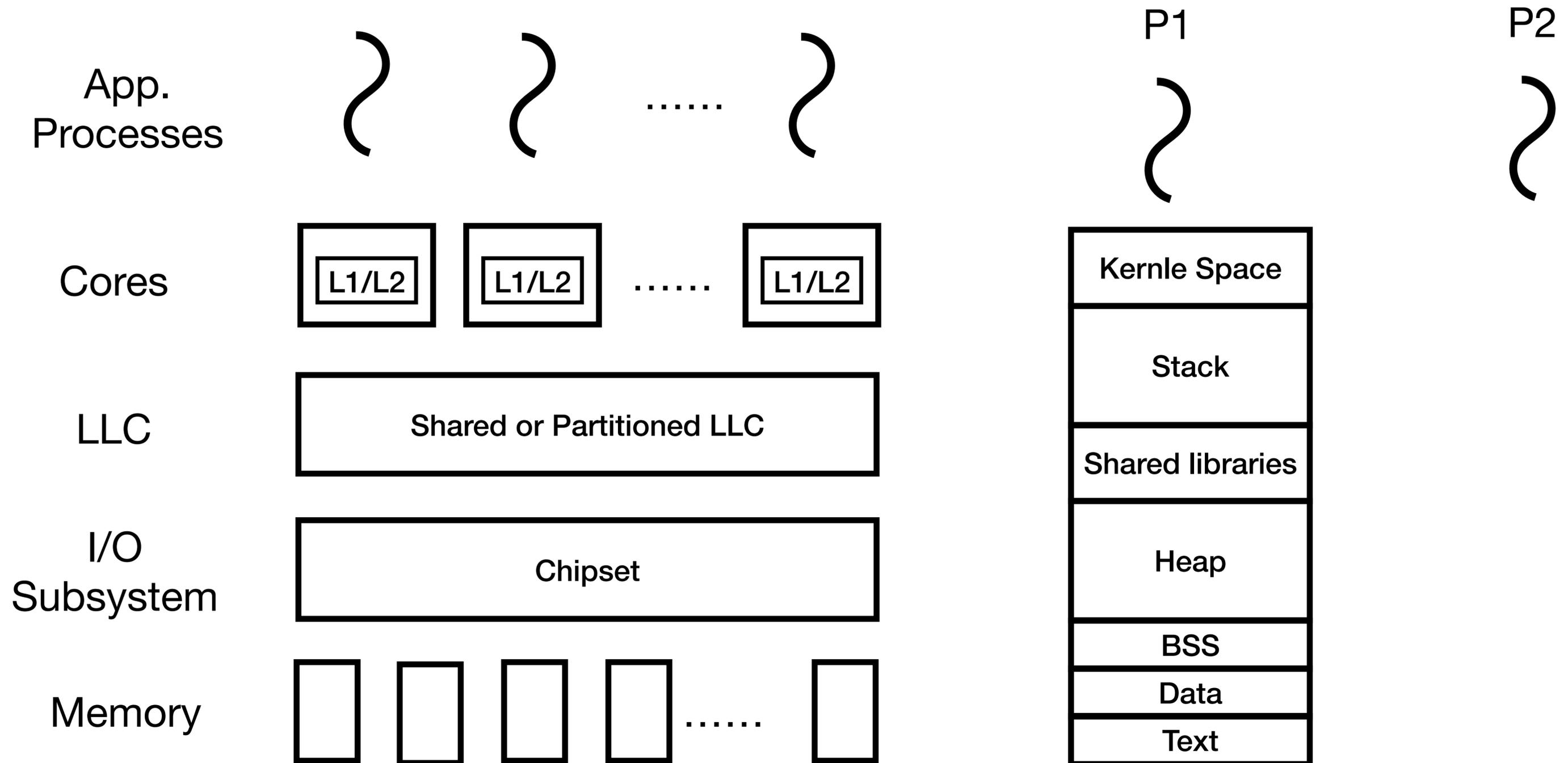
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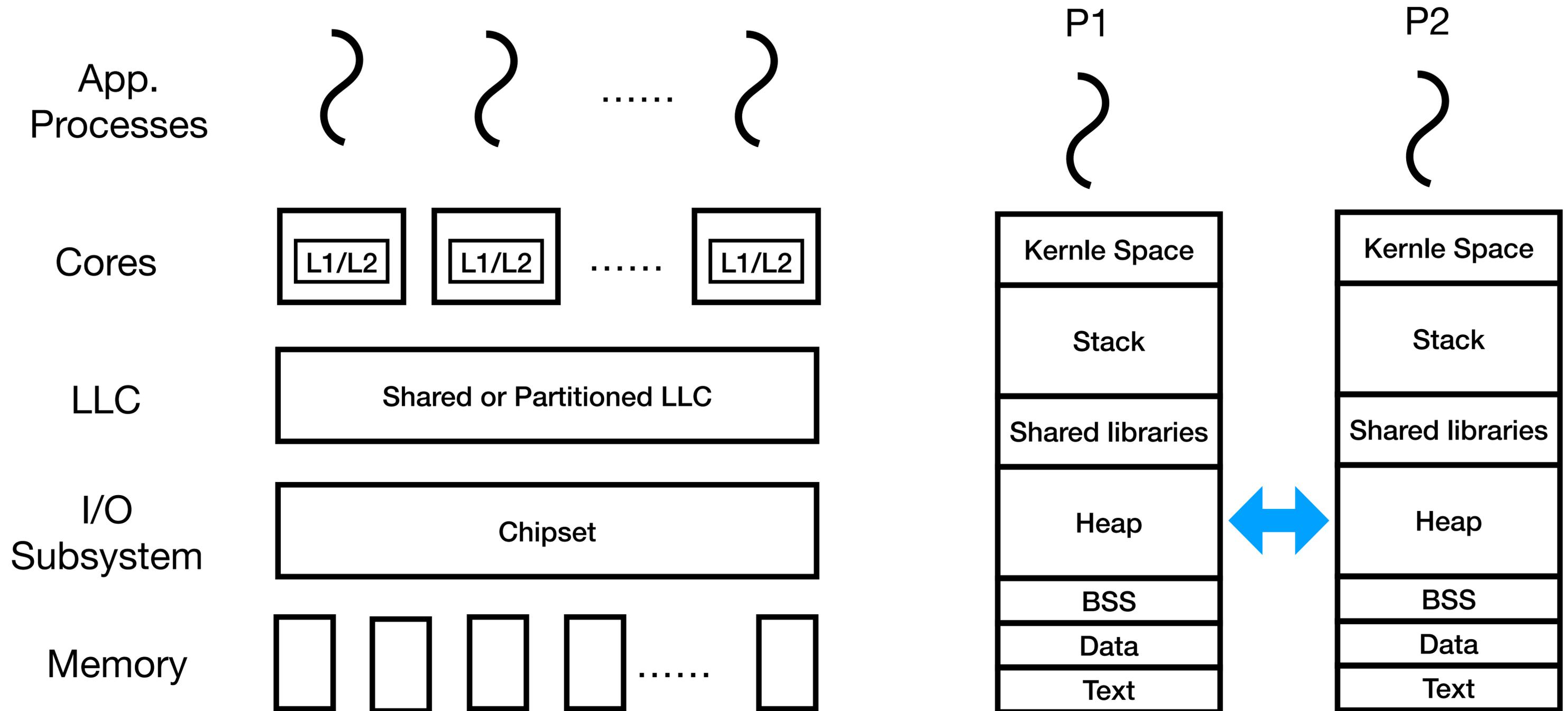
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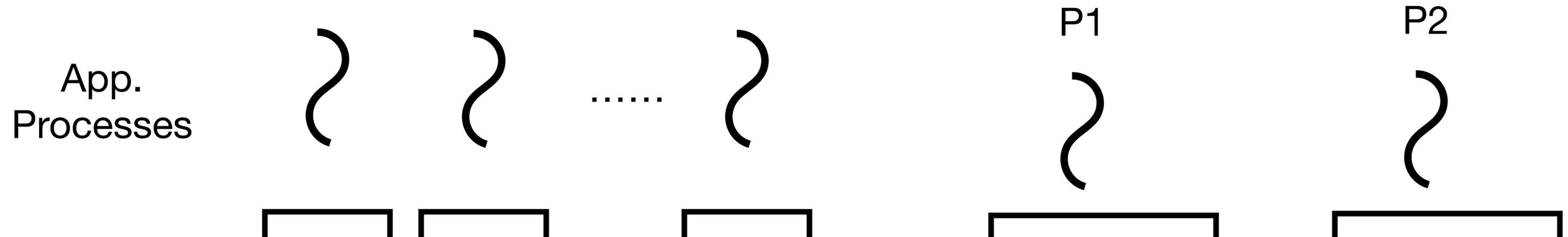
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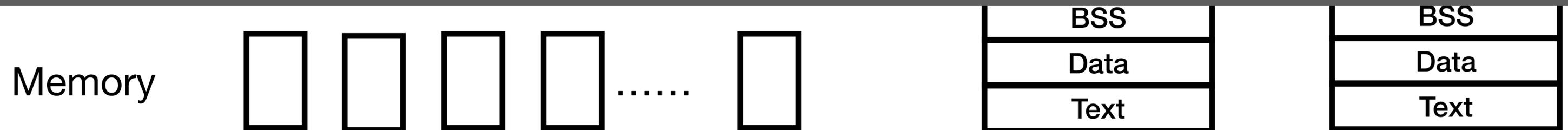


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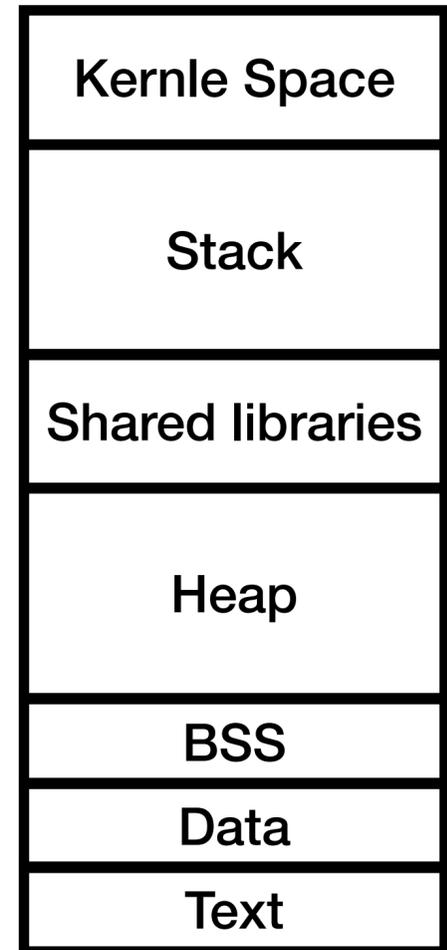
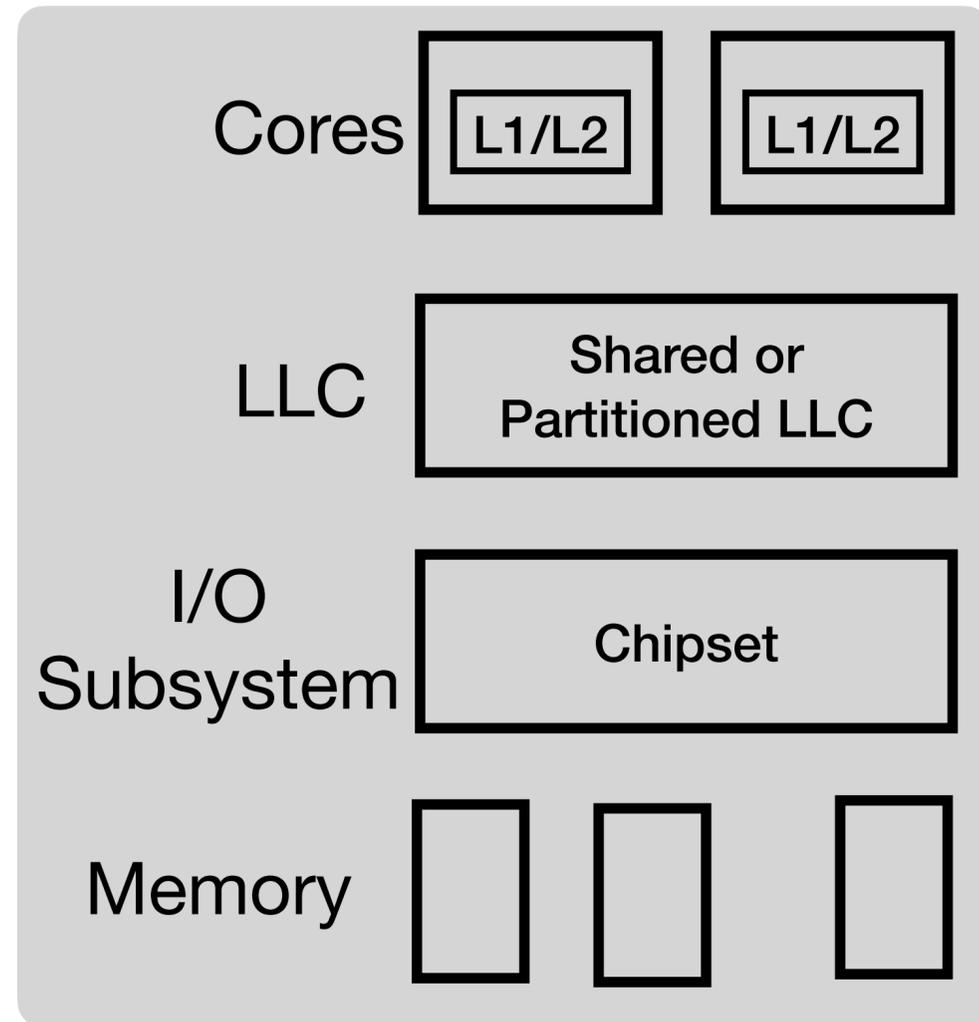
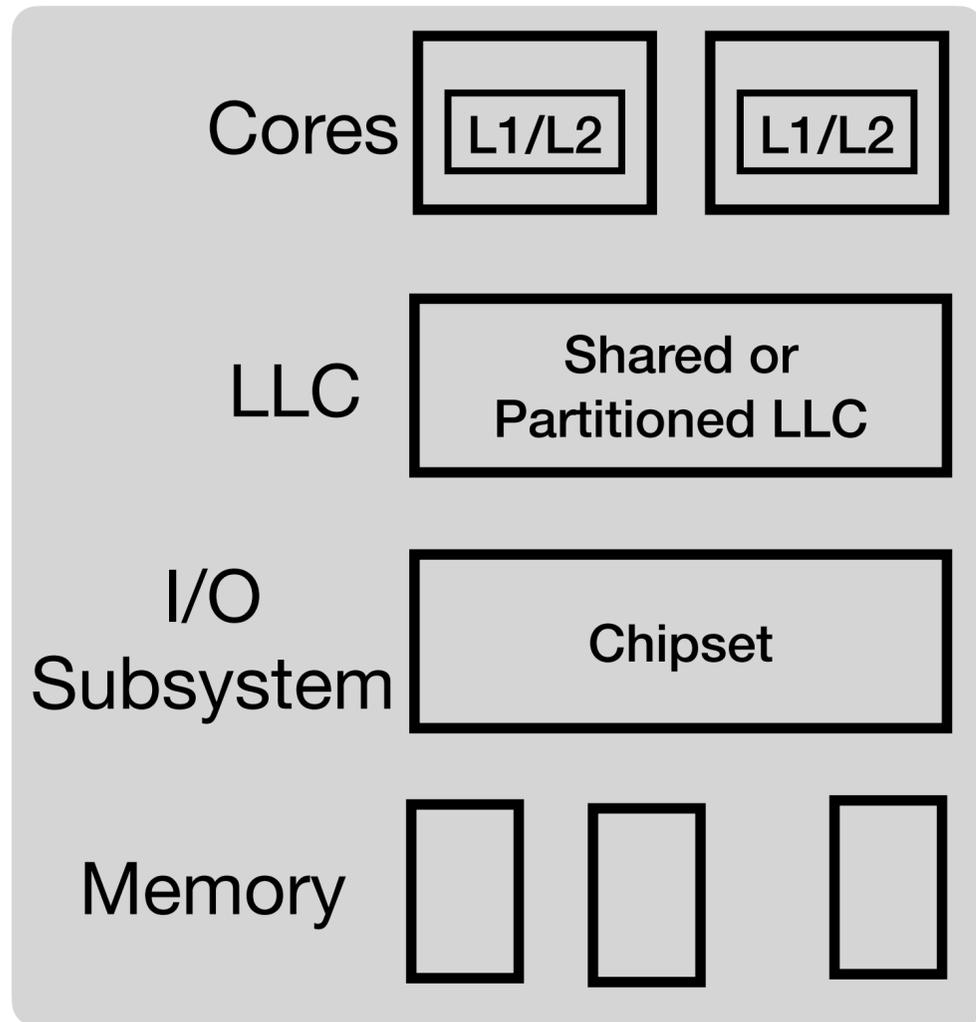
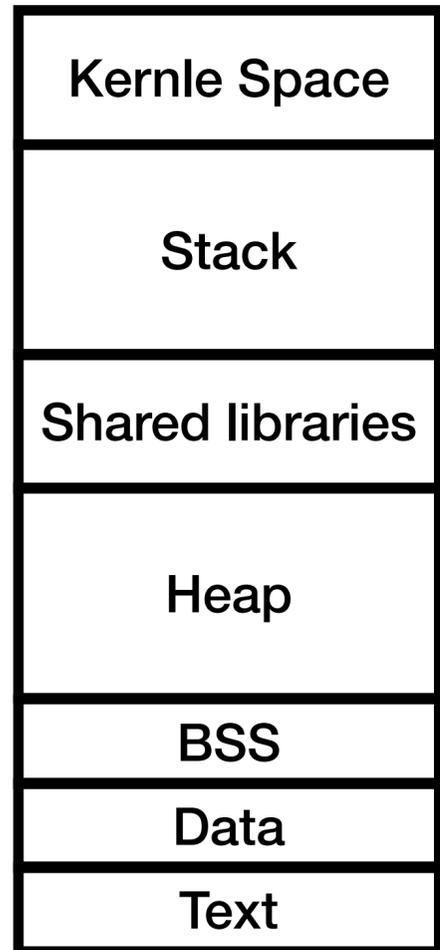


Inter-Process Communication of the Operating Systems

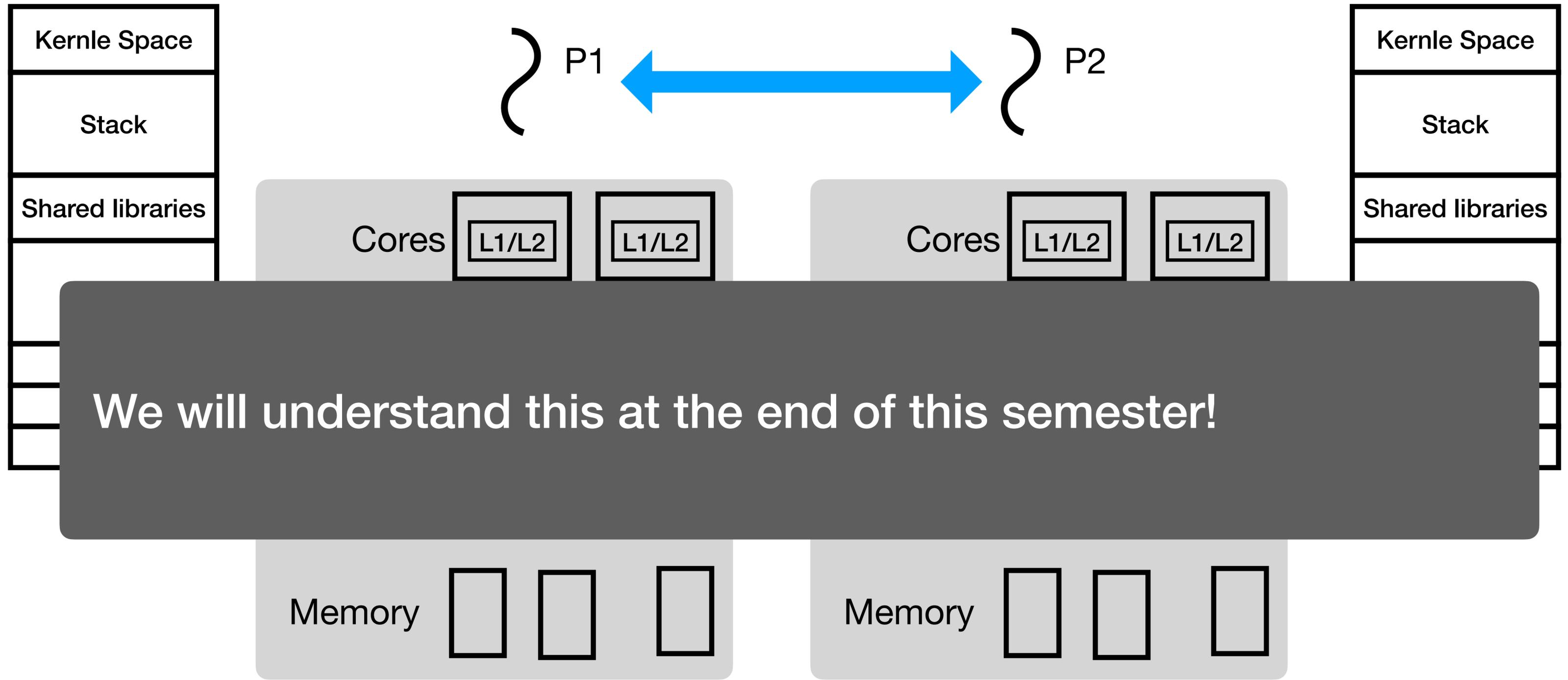
- Pipes: a unidirectional data channel
- Shared memory: mapping physical memory to the virtual address space
- Semaphore: synchronization primitives
- Sockets: a bidirectional channel for both intra-/inter- communications



Intra-host v.s. Inter-host



Intra-host v.s. Inter-host



We will understand this at the end of this semester!

Summary

- Today
 - Computer networks basics and design requirements
 - Intra-host v.s. Inter-host communication
- Next lecture
 - Computer networks: hardware and software