CS3.301 Operating Systems and Networks

Networking - Introduction (Sockets and Networking Layers)

Karthik Vaidhyanathan

https://karthikvaidhyanathan.com

INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

SERC
Software Engineering Research Centre

Acknowledgement

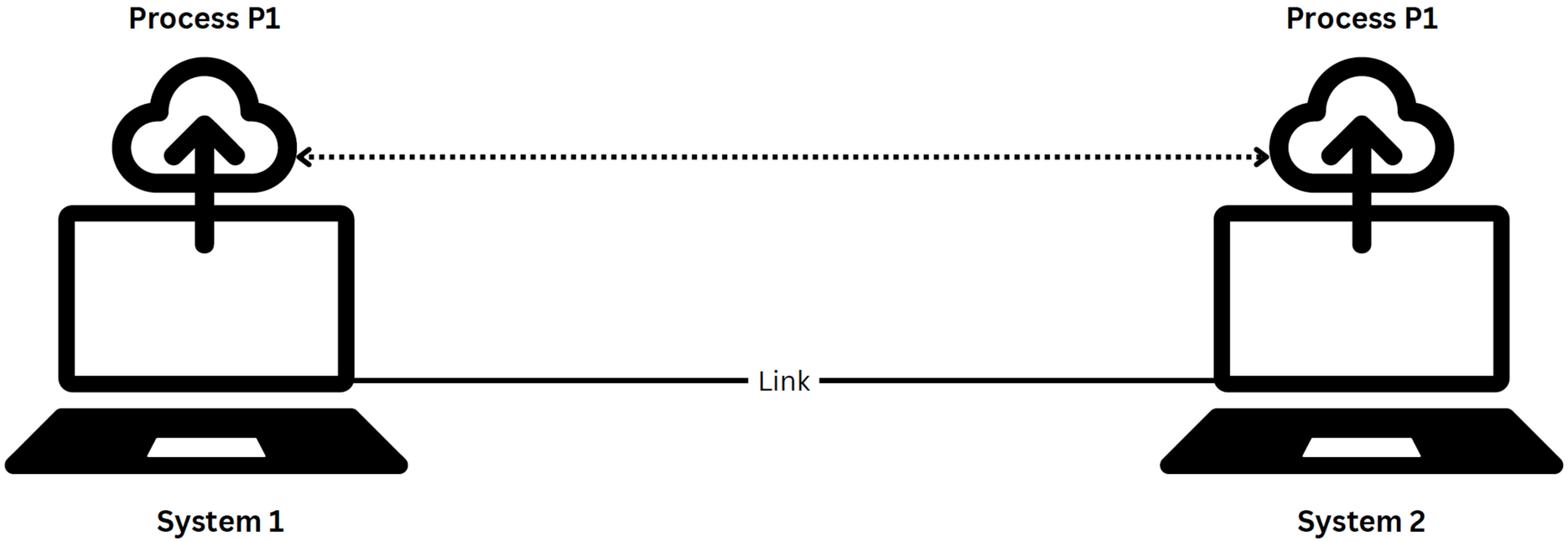
The materials used in this presentation have been gathered/adapted/generate from various sources as well as based on my own experiences and knowledge -- Karthik Vaidhyanathan

Sources:

- Computer Networks, 6e by Tanebaum, Teamster and Wetherall
- Computer Networks: A Top Down Approach by Kurose and Ross
- Computer Networking essentials, Youtube Channel
- Other online sources which are duly cited

What about processes in different machines?

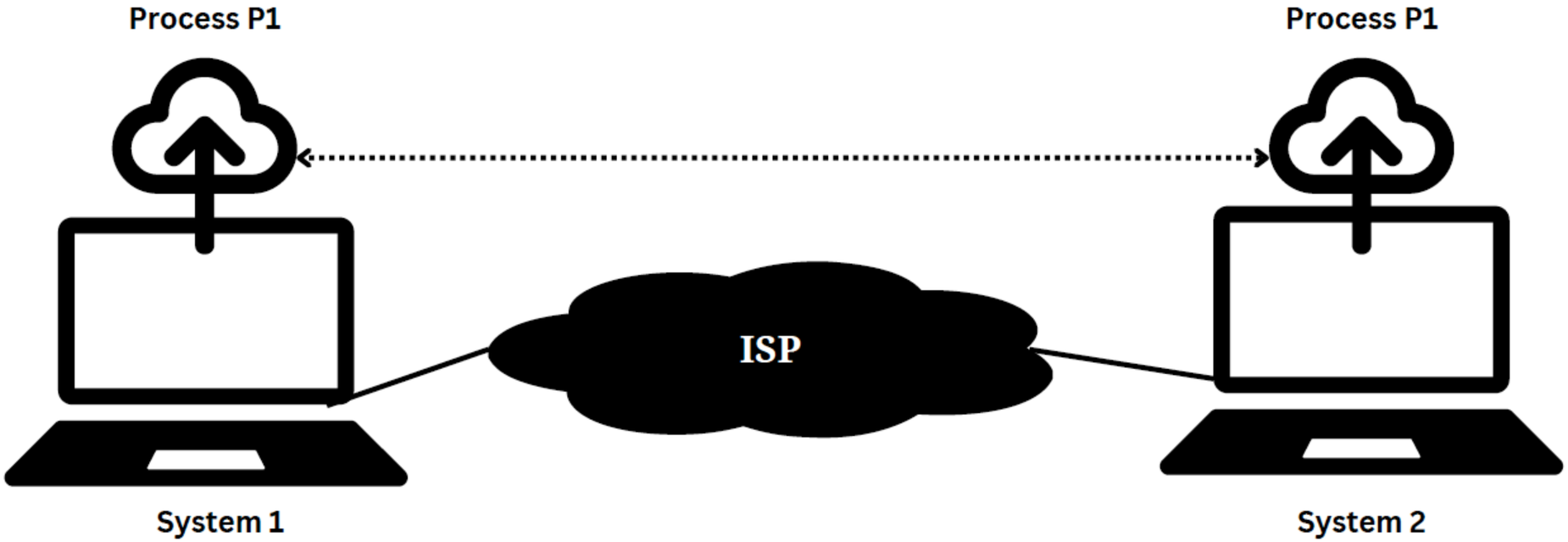
How can they communicate?



How does message/data from P1 in System 1 reach P1 in System 2?

What is the role of the OS in this and how does it contribute to the effectiveness?

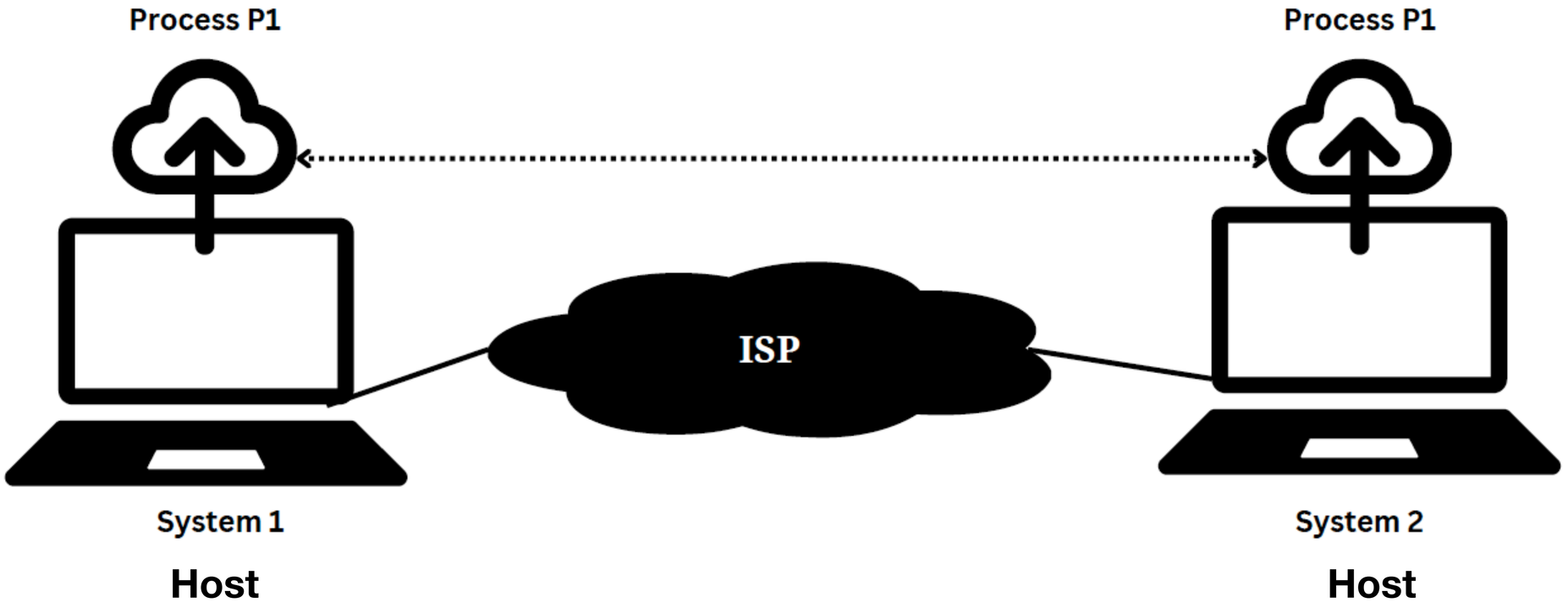
Let us expand it



- Between the process and network there needs to be an interface
- Between the network components there needs to be some interface

Network Components

Host

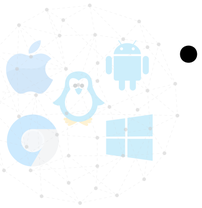


- Any device that send or receive traffic: Computer, laptop, smartwatch, phone, etc
- Host can be client or server
- Servers can sometime be clients too

How does host send data?

IP Address

- Host needs address to send the data
  - This address is known as **IP address**
  - When client sends data it provides both source IP and destination IP
  - IP addresses are 32 bits. Each bit can be 0 or 1
  - Total of 4 octets. Each octet ranges from **0-255 (8 bits)**
  - IP addresses are usually hierarchically assigned
  - **Eg:** 192.168.1.1



Sometimes we need more signal Strength

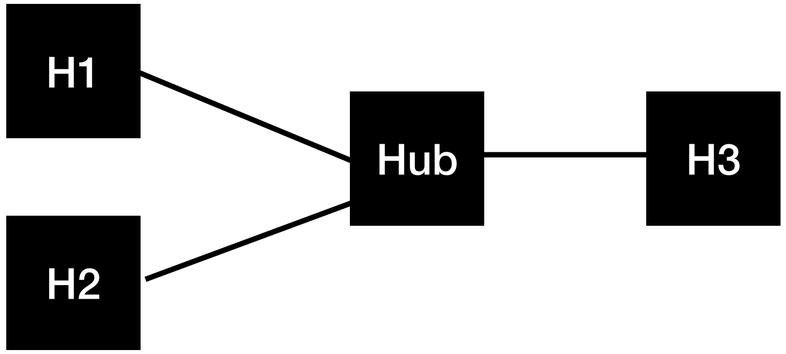
Repeater

- Repeater allows regeneration of signals for long distance communication
- Think of wifi in home
  - Signal strength may not be there
  - Repeater might be needed to transmit to longer ranges
- But we cannot just connect one host to another - **Not Scalable!**

Hubs and Bridges

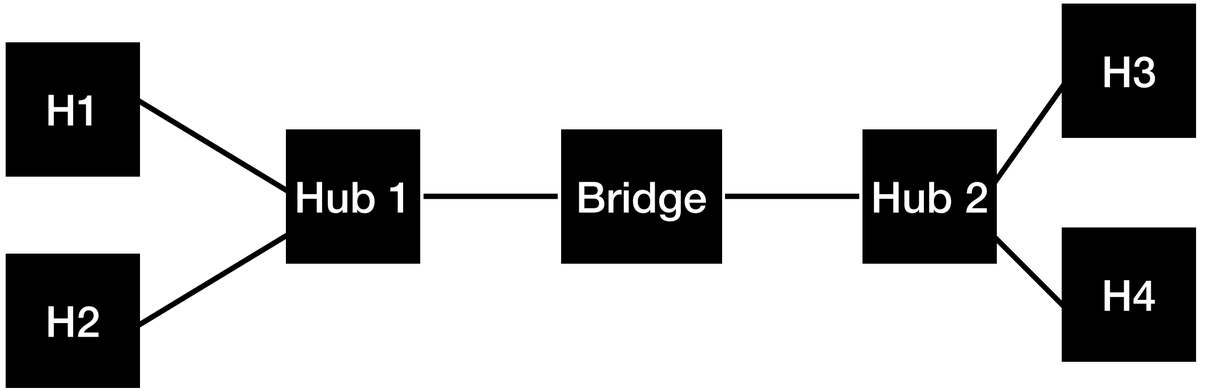
Hubs

- Multi-port repeaters
- Key issue: Everyone receives everyones data



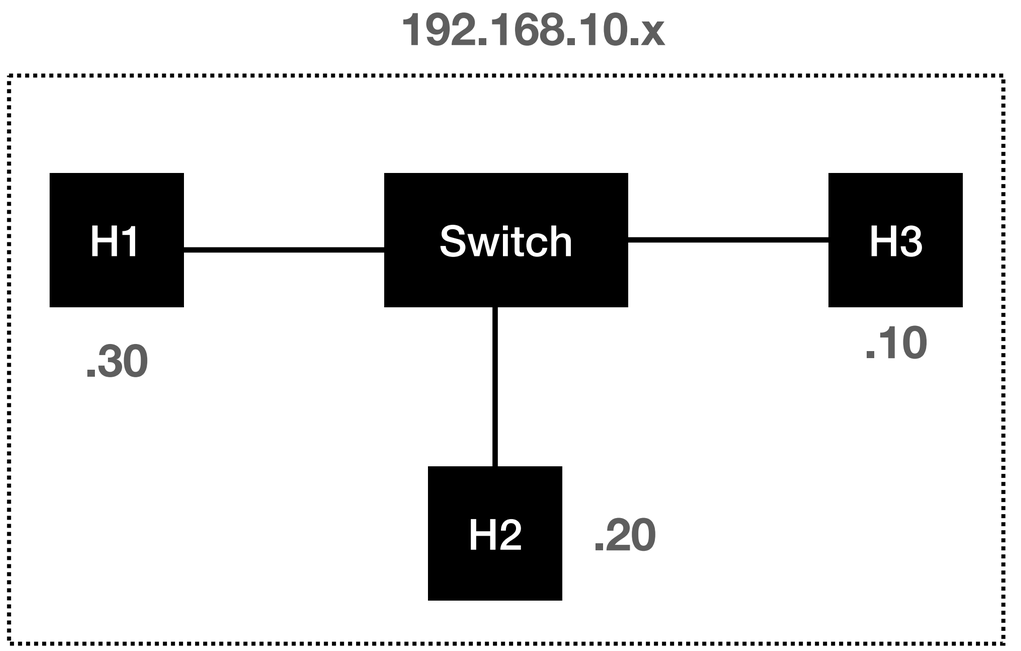
Bridges

- Sit between two hubs
- They have only two ports
- They learn which hosts are on either side (for routing)
- Eg: H1 wants to communicate with H2



Switches

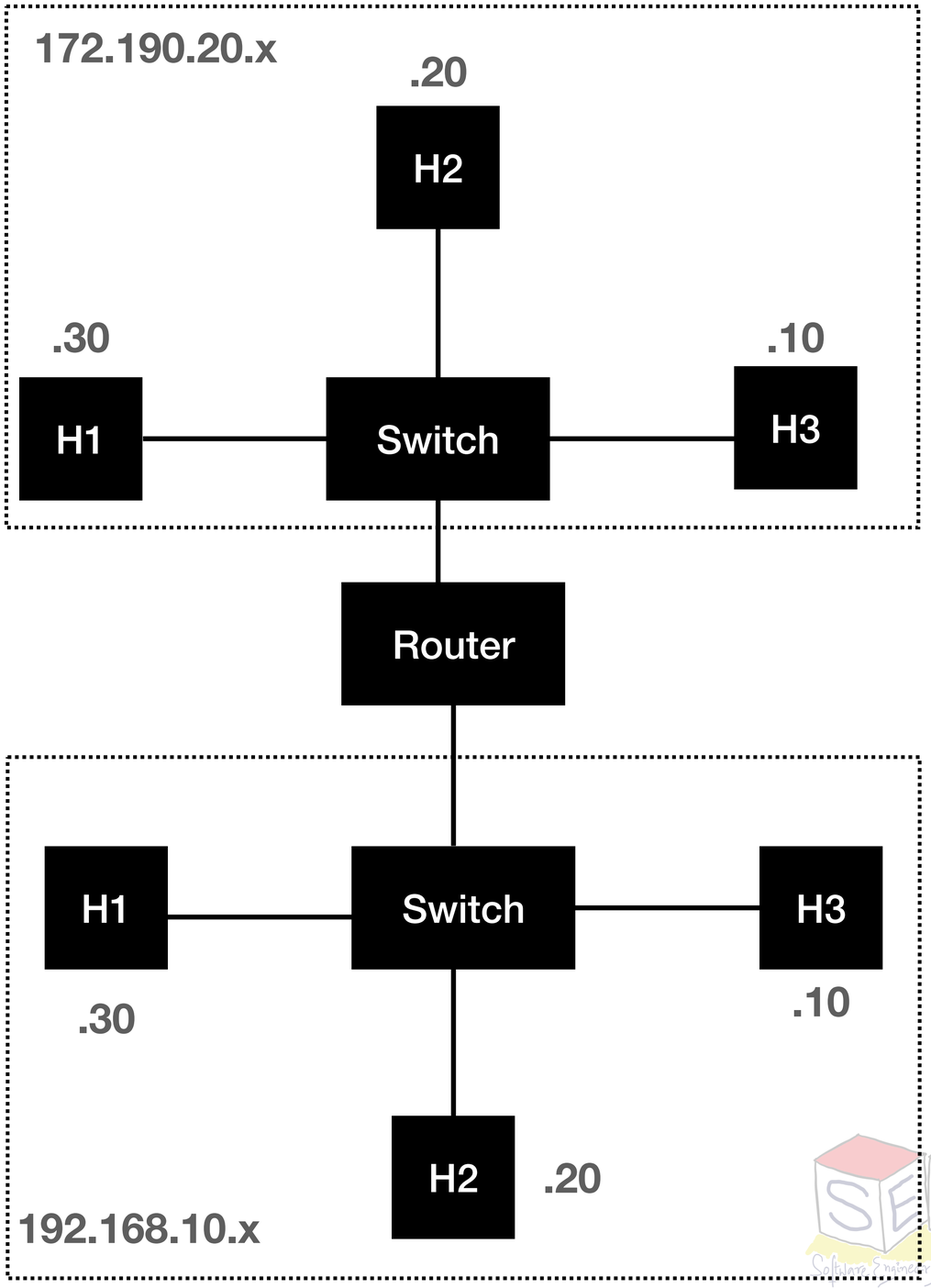
- Devices which facilitate communication within a network
- Combination of hubs and ports
- Knows or infers which hosts are on each port
- They have multiple ports
- Whatever connected to switch becomes part of one network



What if the host 192.168.10.20 wants to communicate with Another host in different network?

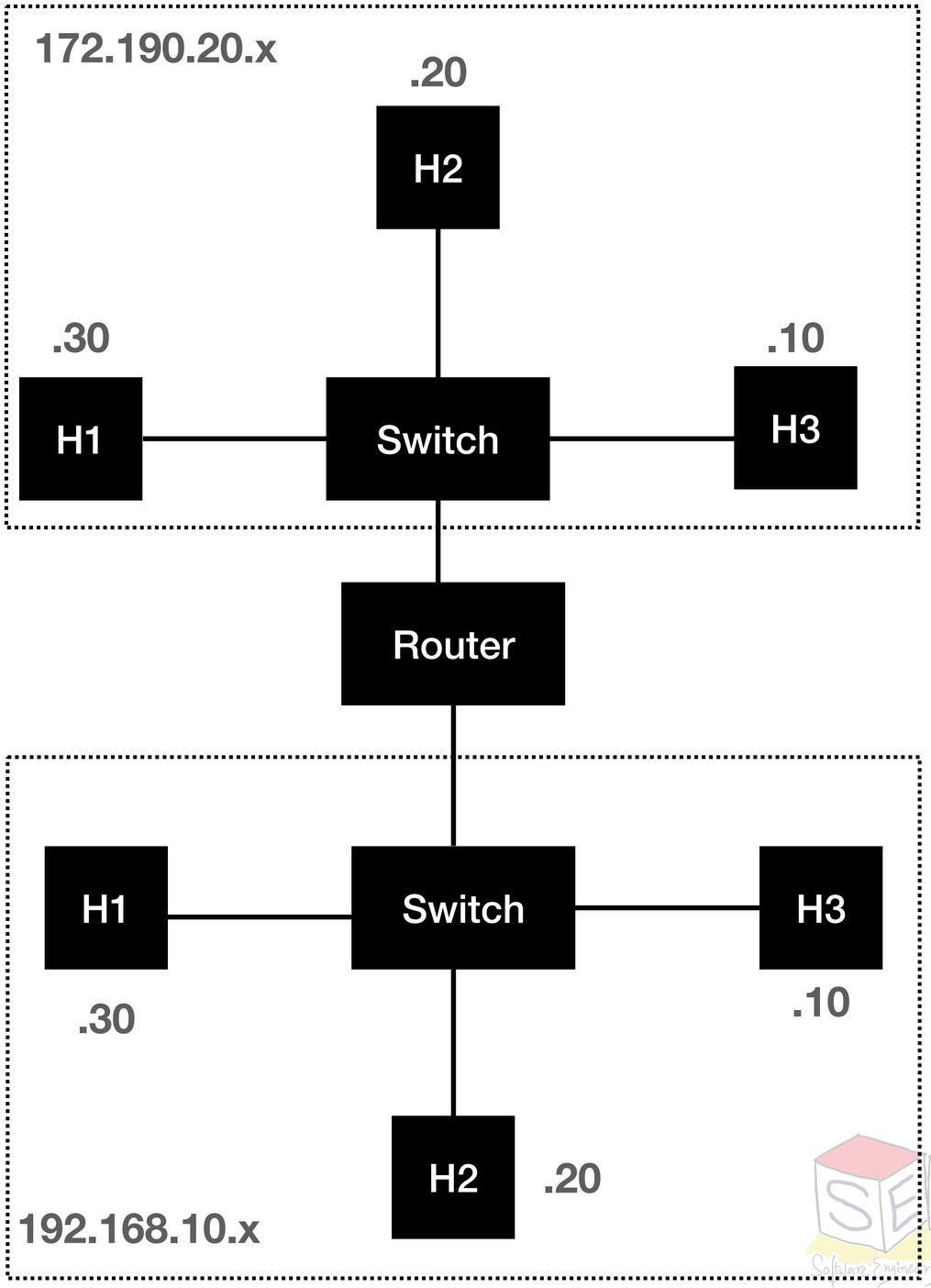
Routers

- Facilitate communication between the networks
- They provide like a traffic control point
  - Security, filtering, redirection
- Routers learn which networks they are attached to
  - Known as routes
  - Stored in a routing table
- Routers have their IP address in the network they are attached to

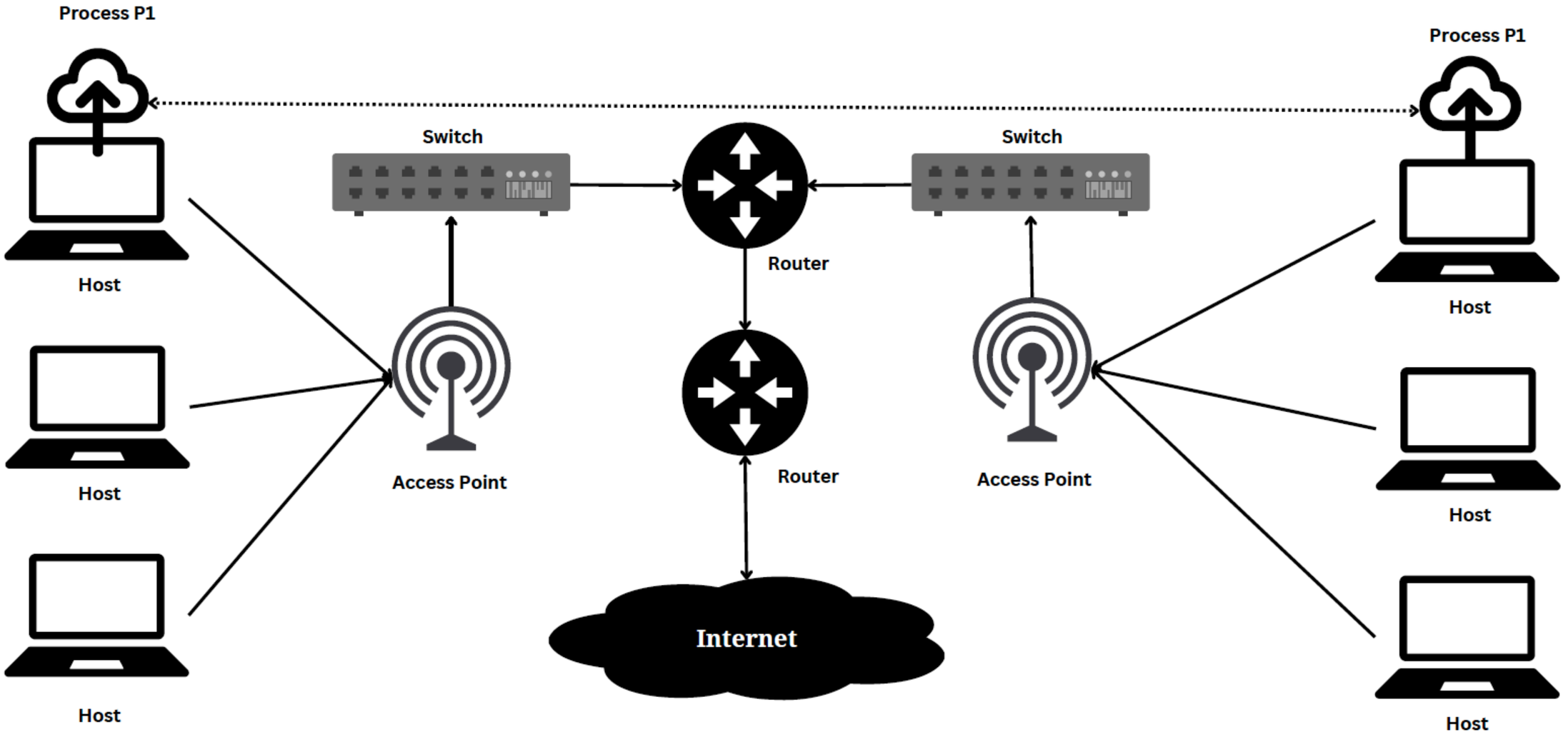


Routers

- Allows creation of hierarchy in the networks
- Every time hosts wants to go out of the network, it goes through router
- Internet is nothing but bunch of routers
- Gateway (IP address of router in the given network)
  - Becomes exit point of hosts outside their network

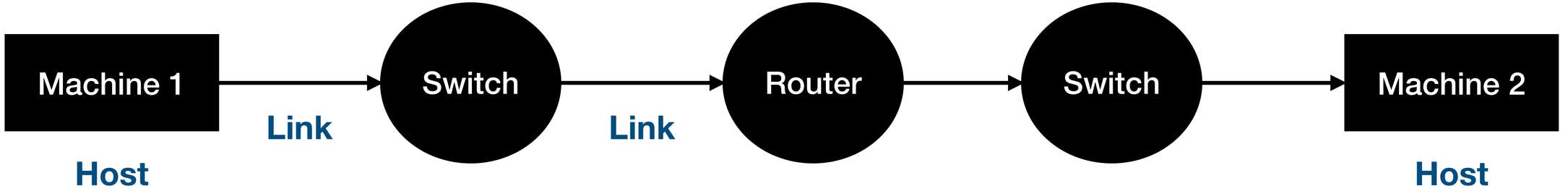


The Bigger Picture



What happens internally when one process wants to share/ receive data from another host?

Components of a network



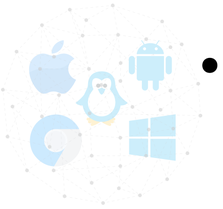
Process Communicating over network

- Process A (eg: Whatsapp) is executing in Host 1
- Process B (whatsapp) executing in Host 2
- Process A wants to communicate with Process B
  - Some system call is made to access the network
    - Leads to an interrupt
    - Process A should know where process B is
    - Hardware support is needed (some network device with drivers)

Network Types

Multiple types of networks exist

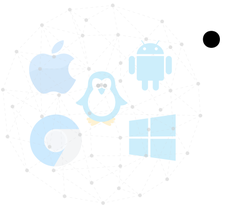
- **Personal Area Network - PAN**
  - Devices communicate over a very short range
  - Eg: Bluetooth (master slave paradigm)
- **Local Area Network - LAN**
  - Private network operating within and nearby a single building (home, office, factory, etc.)
  - Wireless LANs runs speed from 11 Mbps to 7 Gbps (1 Mbps is 1,000,000 bits per sec) - Power in 10 (not in terms of 2)
  - Wired LANs operate at speed ranging from 100 Mbps to 40 Gbps (low latency)
  - Eg: connecting personal computers and consumer electronics (eg: printer)



Network Types

We have come a long way!

- One large Physical LAN can be divided into smaller logical LANs (Virtual LANs)
- Earlier days it was about broadcasting on a single line!
  - At most one computer could transmit successfully at a time
  - Use static allocation techniques
    - Every machine gets some time to transmit or receive
    - Round robin was used for scheduling
  - Packet collision used to happen (Wait for some random time and try again)



Network Types

- **Metropolitan Area Network - MAN**
  - Covers a city (City wide networks)
  - Think of cable TV networks (Earlier Antenna on top of the house and from the top of the hill the communication used to happen)
  - Idea of cable TV was used for providing two services (Internet and TV)
- **Wide Area Network - WAN**
  - Spans a large geographical area (often country, continent, etc.)
  - Eg: Internet is a large WAN (Dedicated WANs also exist)
    - There can be WAN that connects offices of organisation in different locations
  - Higher latency and lower transmission speeds. Cost for dedicated ones can be high

An Illustrative Scenario

Sending Letter/Courier

Community 1

Local Post office

City Post Office

Community 2

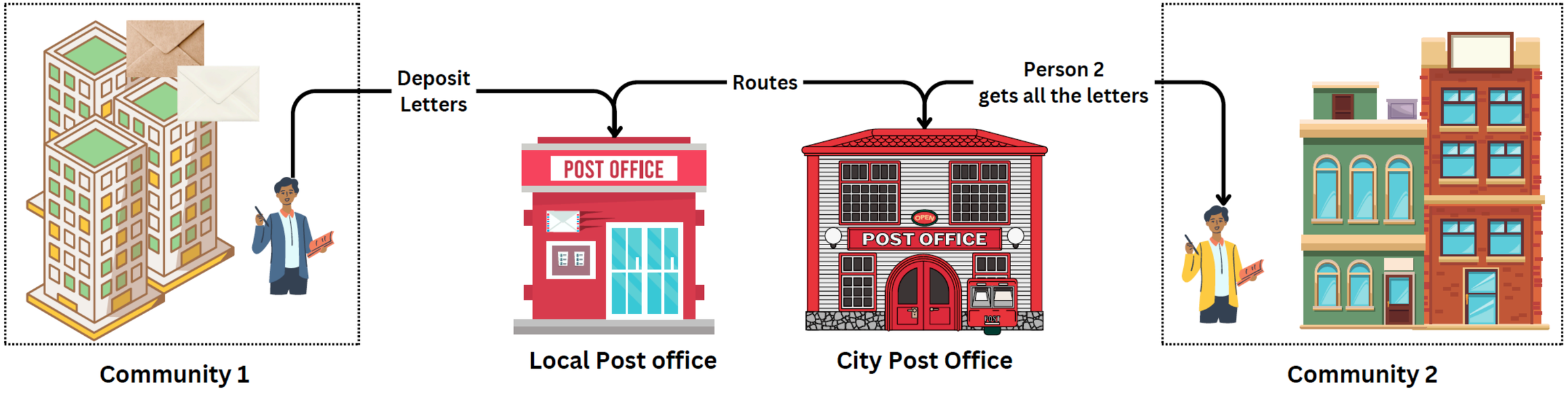
Two large communities in different parts of the city, two people in each community to collect and deliver the letters/couriers

An Illustrative Scenario

People in community send letters/couriers

One person is collecting all the letters/couriers

Person delivers the letter to each person

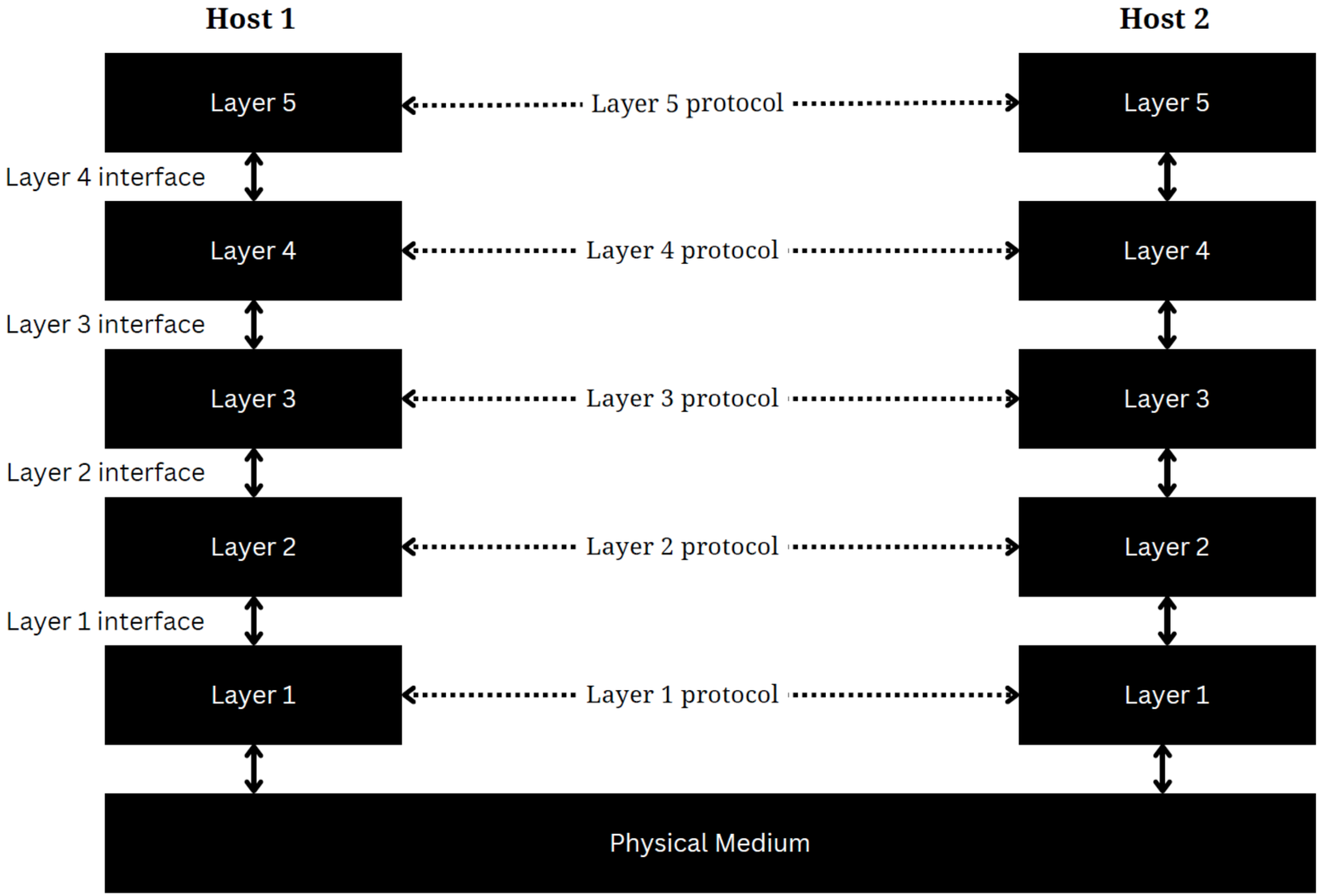


Key points: Door number, building number, Post office has an identifier, etc.

Lets take this to Process communication

- Process A (eg: Whatsapp) is executing in Host 1
  - Process B (Whatsapp) is executing in Host 2
- Host 1 will have an address, same is the case with host 2
- How to ensure the data reaches from Host 1 to Host 2?
  - What all needs to be considered?
  - Remember: There will be multiple processes that are executing in a host

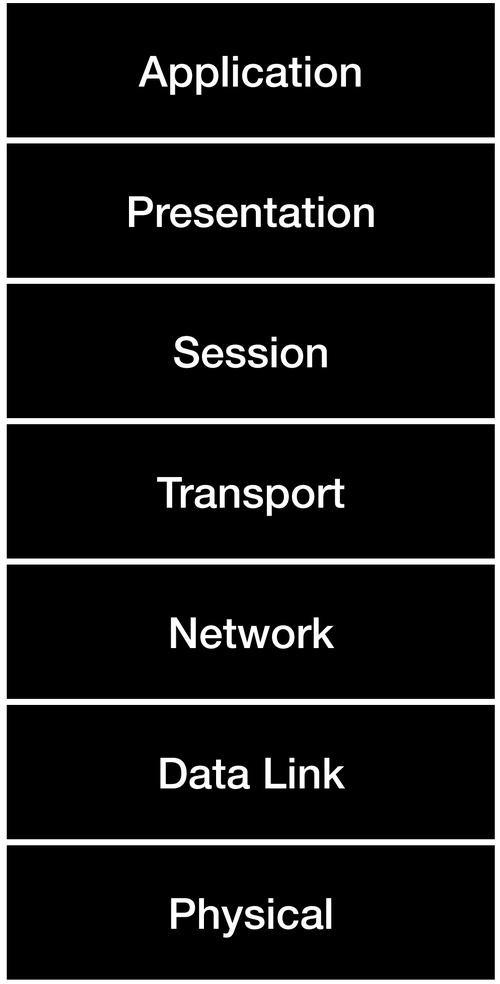
Networking Layers



Networking Layers

- Reduce design complexity, network organised a stack of layers or levels
- The layering provides abstraction in and to other layers
- Communication (in some sense) happens between the corresponding layers
  - Layer n one machine communicates with layer n of another using a **protocol**
  - Protocol is just like agreement between communicating practices
- Set of layers along with protocols => **Network Architecture**
- Between each pair of adjacent layer their is an **interface**
  - Defines the primitive operations and services the lower layer makes available

The OSI Model

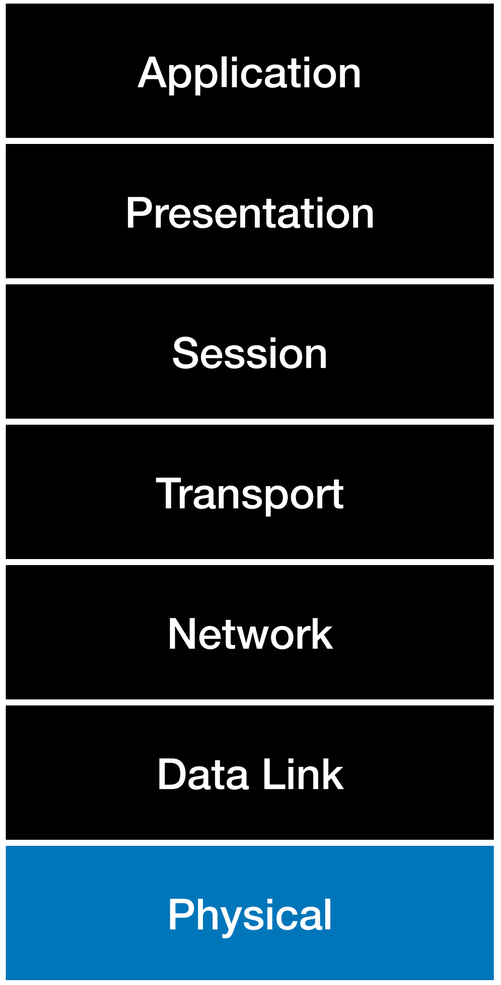


- Open System Interconnection (OSI)
- A Conceptual framework used to understand how communication works through different layers
- Divides the network communication process into seven layers
- Developed to facilitate interoperability between different technologies
- Each layer has a specific function. If they all do what they are supposed to do => sharing of data

Physical Layer (L1)

Ultimately everything is 0's and 1's

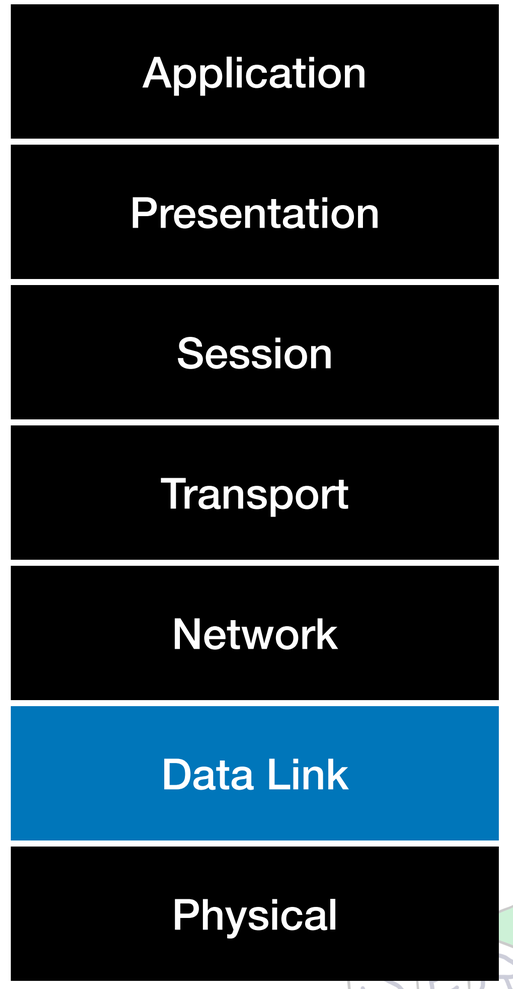
- Data is in the form of bits - 0s and 1s
- Something has to transport the bits from one machine to another - Physical layer
- Concerned with transmission of raw bits over physical medium, like a cable
- L1 technologies: Ethernet cables, Optical fiber, Coaxial cable, etc.
    - Even WiFi is L1 technology, hub, repeater, etc.



Data Link Layer (L2)

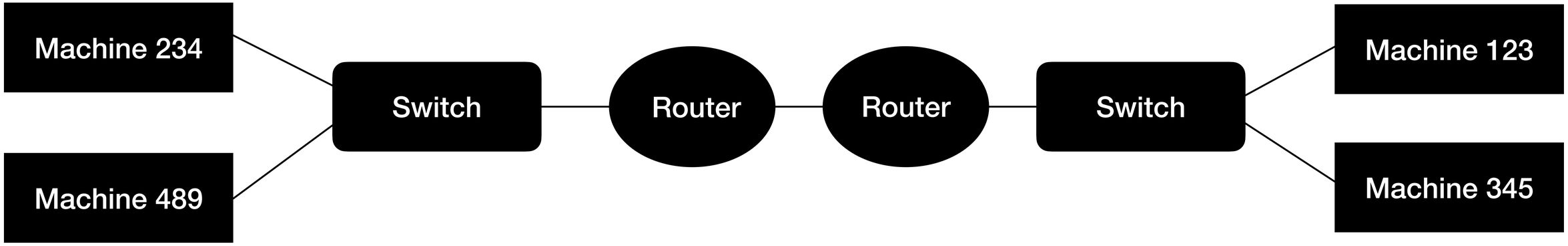
Hop to Hop connectivity

- Interacts with the physical medium
- Adds/takes data to/from L1 technology
- Responsible for creating a reliable link between two directly connected nodes, error correction, etc.
- L2's responsibility is mainly taking data from one hop to another
  - Uses an addressing scheme - MAC addressing
  - 48 bits represented as 12 hex digits
- L2 Technologies : NIC, WiFi access cards
- Switches are also L2 technology (help in moving data)



Communication is just more than Hop to Hop

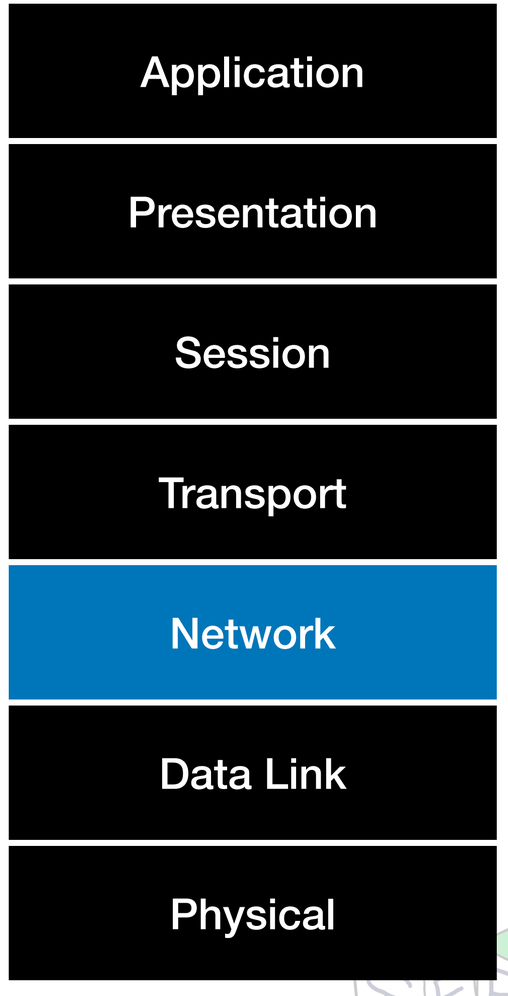
What about communication from 234 to 345?



- Hop to hop is guaranteed by L2
- What about end-to-end delivery?

Network Layer (L3)
End-to-end Communication

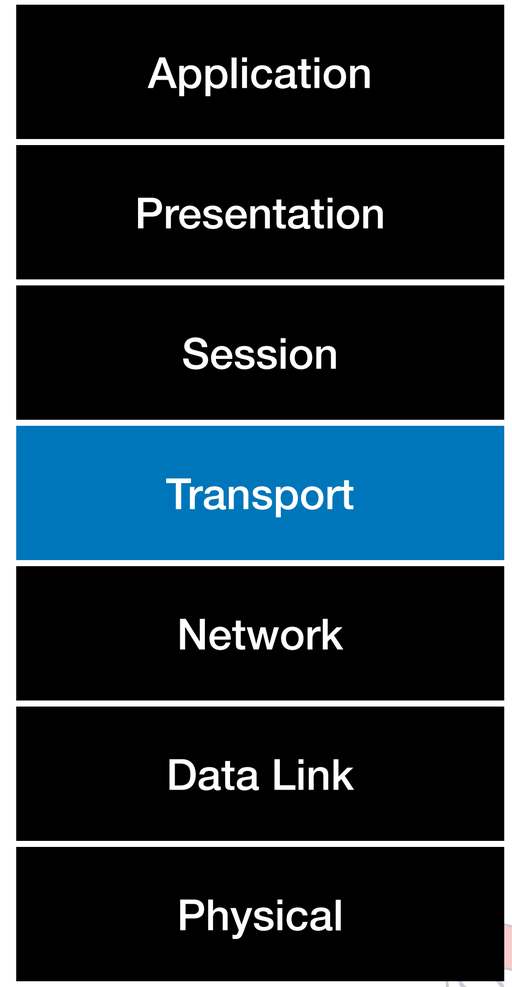
- Manages routing through different routes in a large network
- Uses an addressing scheme - IP addressing
  - 32 bits represented as 4 octets (IPv4)
- Performs functionalities such as Logical addressing (IP), Path selection and packet forwarding
- L3 technologies: routers, even hosts are L3, L3 switches



Transport Layer (L4)

Service to Service

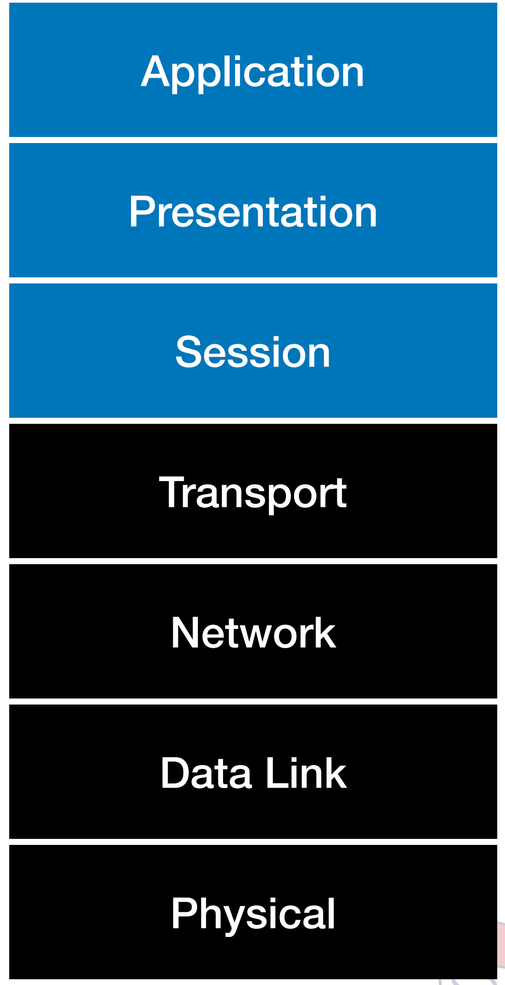
- How to ensure that the right process receives the data?
  - Many process will be executing or are waiting to execute?
- Ensures data transfer is reliable, sequential and free from others
- Manages flow control and error correction
- Layer 4 has an addressing scheme to guarantee message delivery
  - Ports! (0 - 65535), Privileged: 0-1023, Registered: 1024 - 49151
  - Every process will have a port through which sending or receiving data
- **L4 Technologies:** TCP, UDP



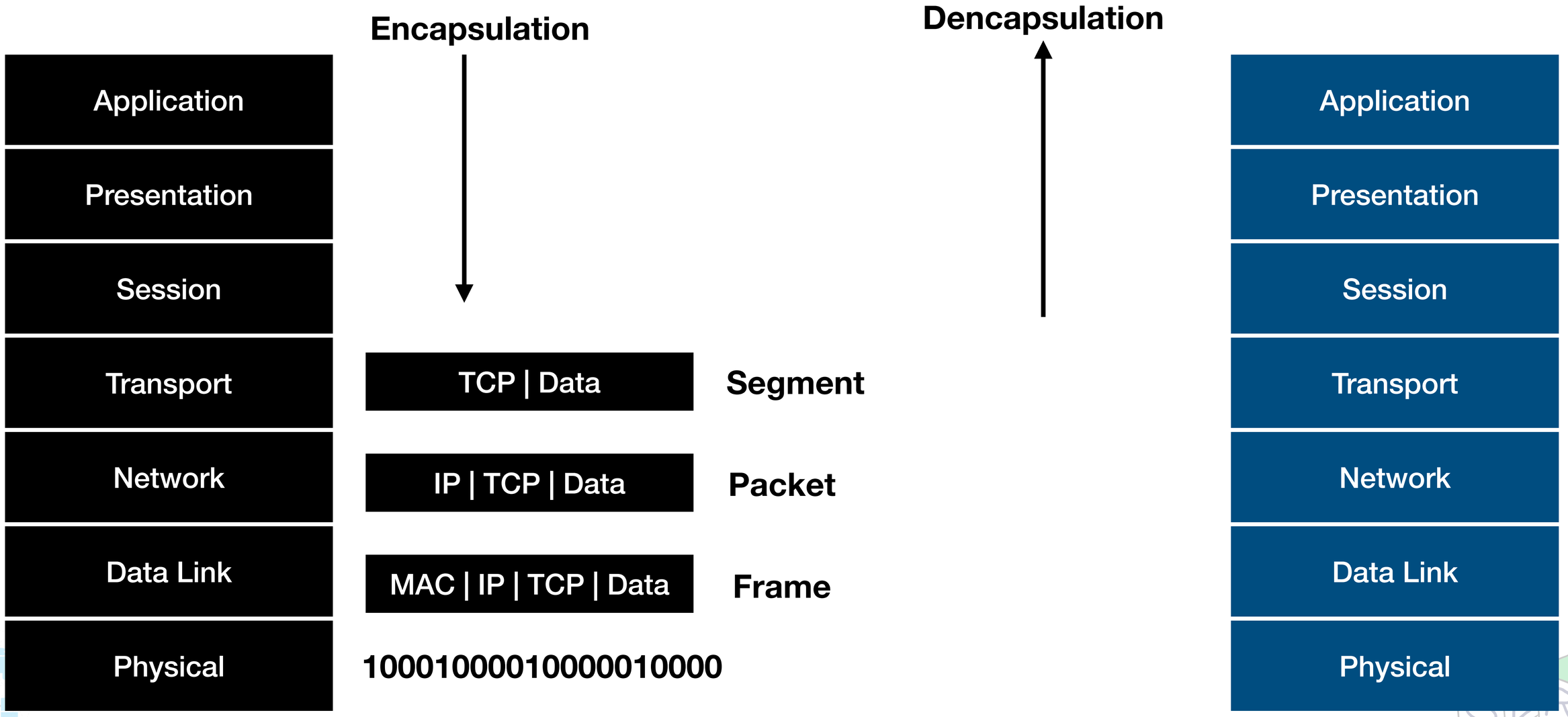
Session, Presentation and Application

Application to Application

- **Session Layer (L5)**
  - Manages connection between different devices
  - Establishing, maintaining and terminating connections
- **Presentation Layer (L6)**
  - Ensures that data is in format that sender and receiver can understand
  - Manages data encryption, compression
- **Application Layer (L7)**
  - Provides network services to the application processes
  - Eg: web browser, email clients, other softwares/apps



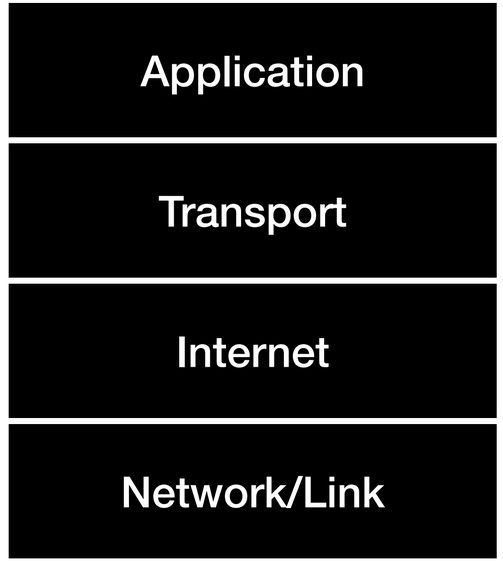
Putting It Together



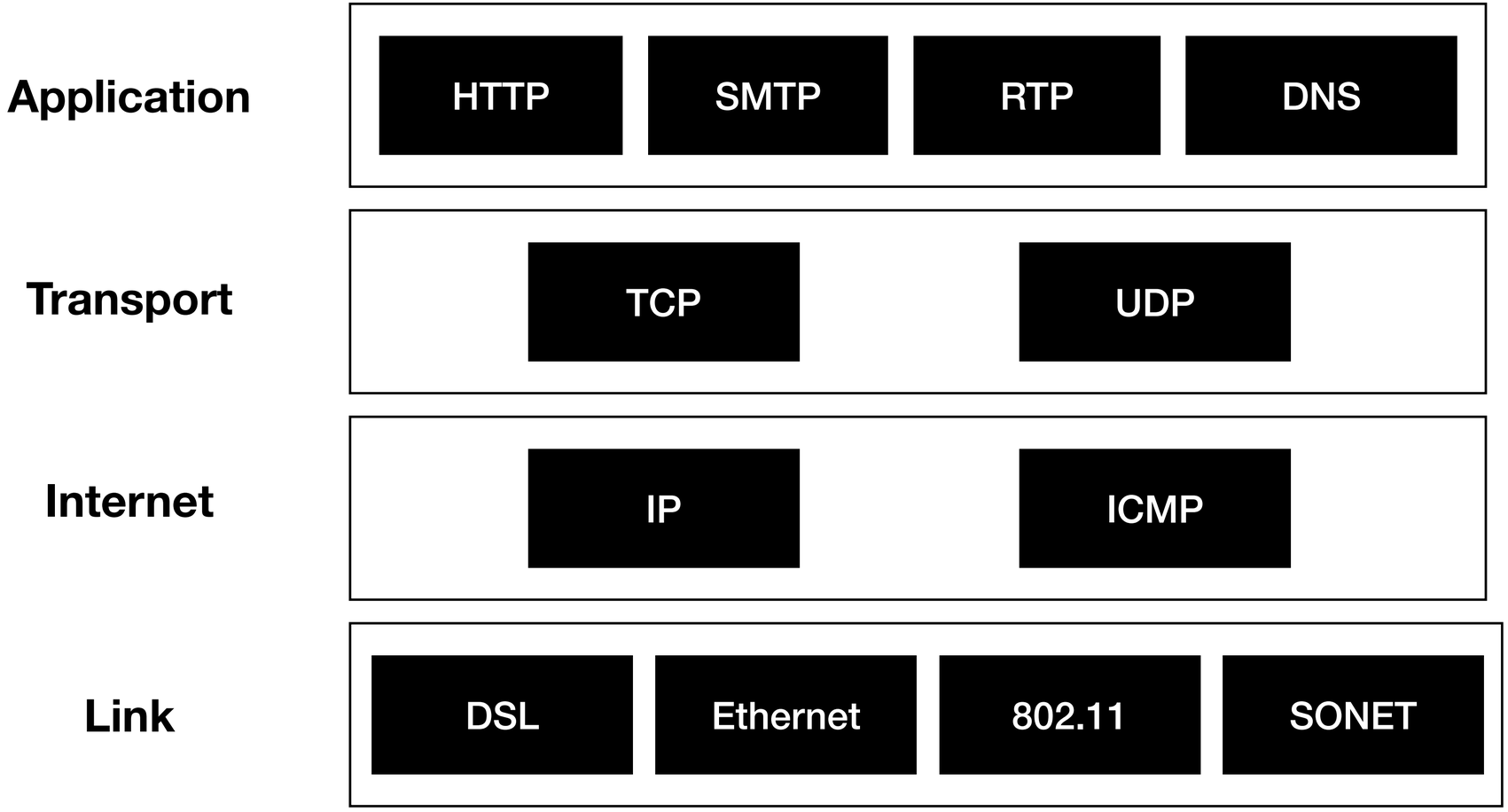
The 4 Layer Model

Internet Model or TCP/IP model,

- OSI model is more educational purpose
- 4 layer model more used in reality
- Application layer - Corresponds to application, presentation and session
- Transport layer - Transport layer of OSI
- Internet layer - Network layer of OSI
- Network - Physical and data link layers of OSI



Network Protocol Stack



Thank you

Course site: karthikv1392.github.io/cs3301_osn
Email: karthik.vaidhyanathan@iiit.ac.in
Twitter: @karthi_ishere