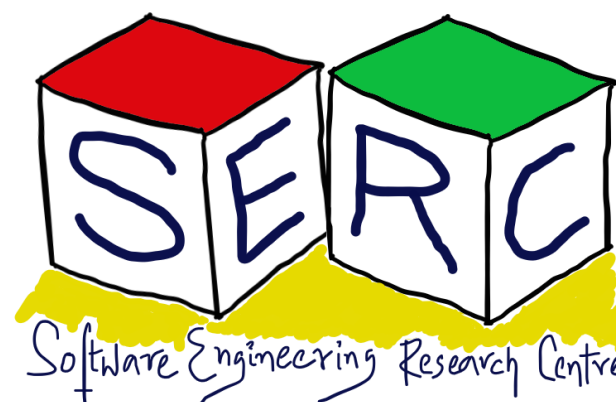


CS3.301 Operating Systems and Networks

Networking - Link Layer and MAC Addressing

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Acknowledgement

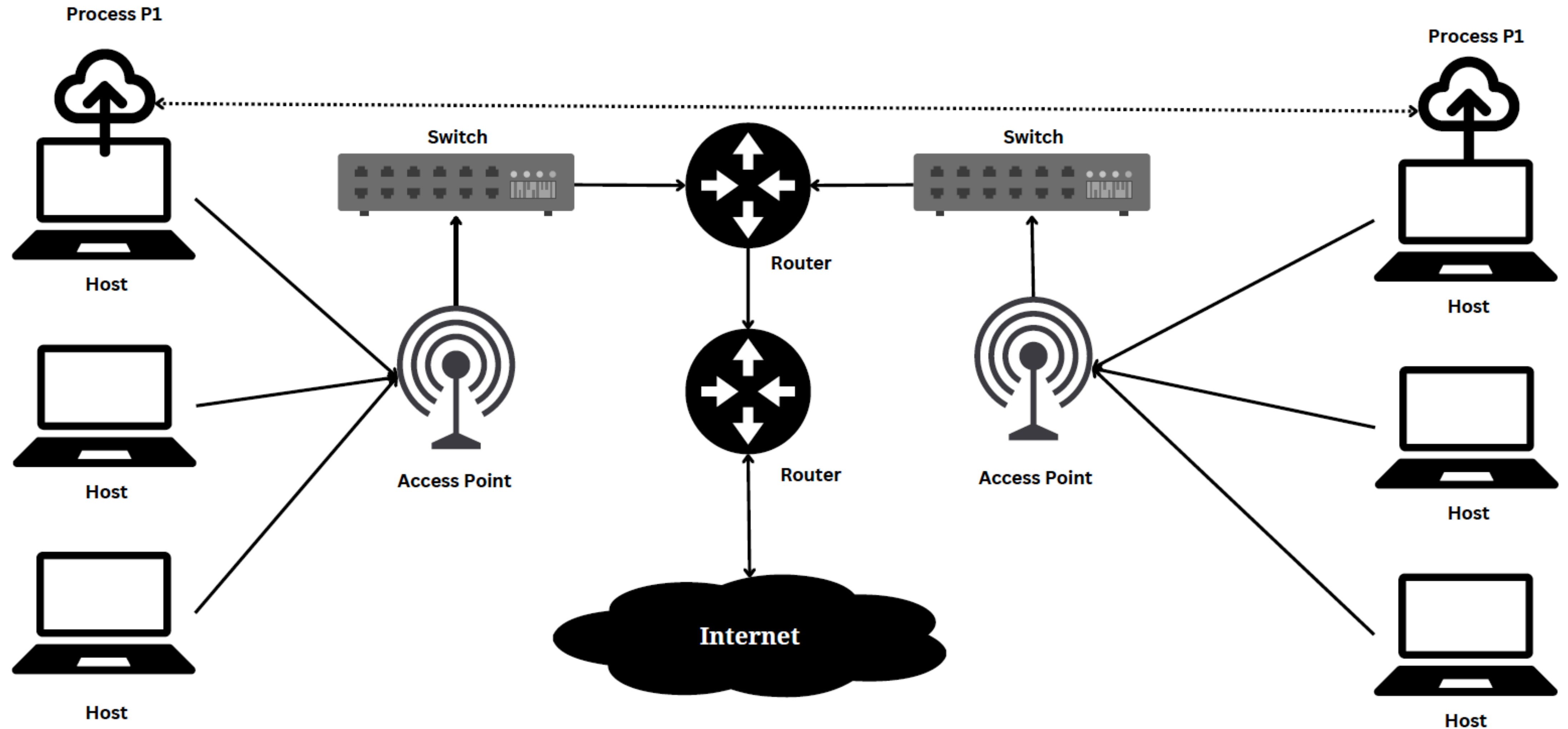
The materials used in this presentation have been gathered/adapted/generate from various sources as well as based on my own experiences and knowledge -- Karthik Vaidhyanathan

Sources:

- Computer Networks, 6e by Tanenbaum, 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



The Bigger Picture

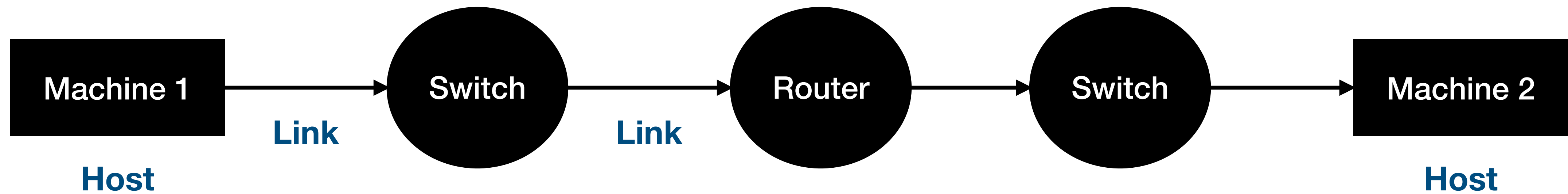


How does host to host communication work?

What's the contribution of the link layer?



Remember the Components?



What we have seen so far

- **Application layer**

- Provides support for end applications to format and manage data
- HTTP, DNS, SMTP, etc.
- In turn they make use of transport layer protocols

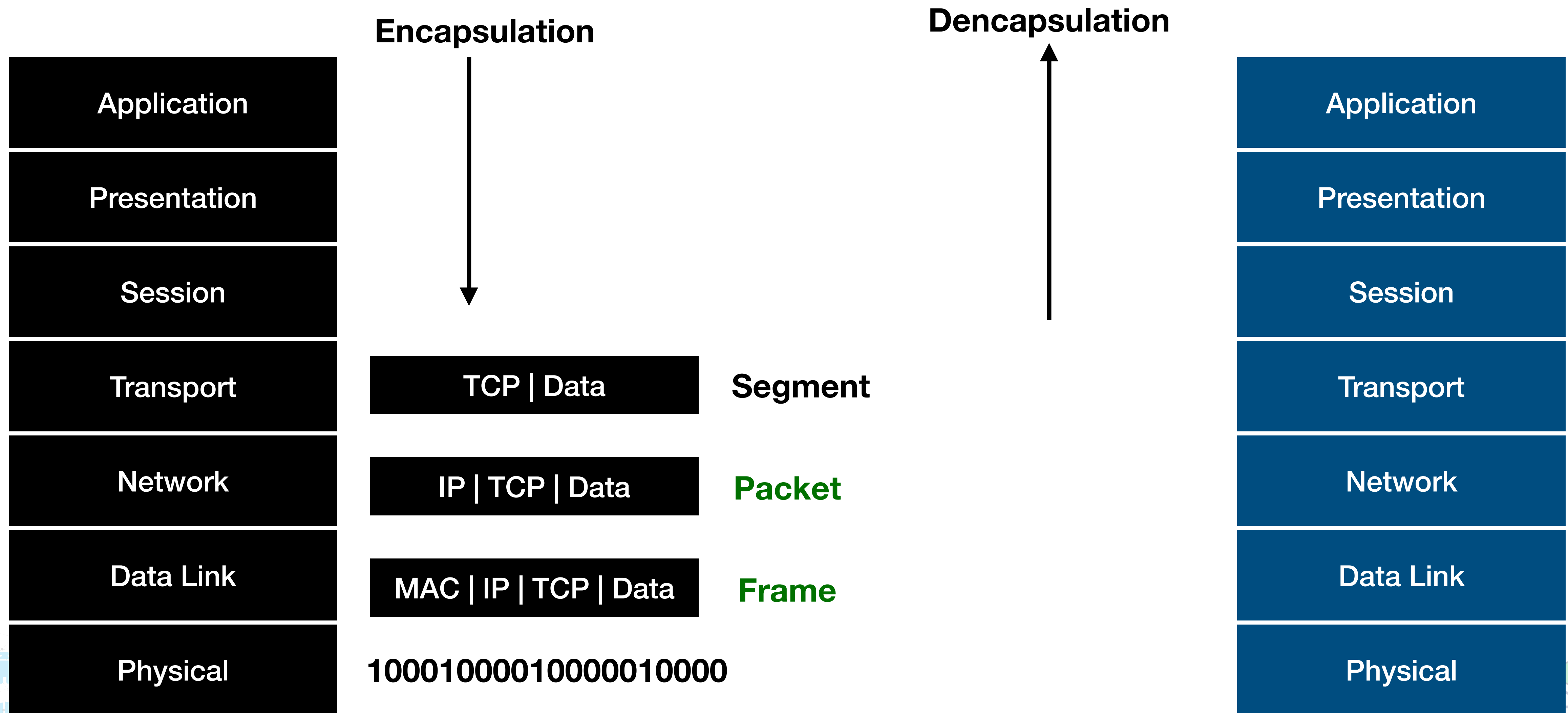
- **Transport layer**

- Provides support for communication between services
- TCP, UDP
- Ports helps in identifying the right services/process

- But transport layer by itself is not enough! - **Requires underlying support - Why?**

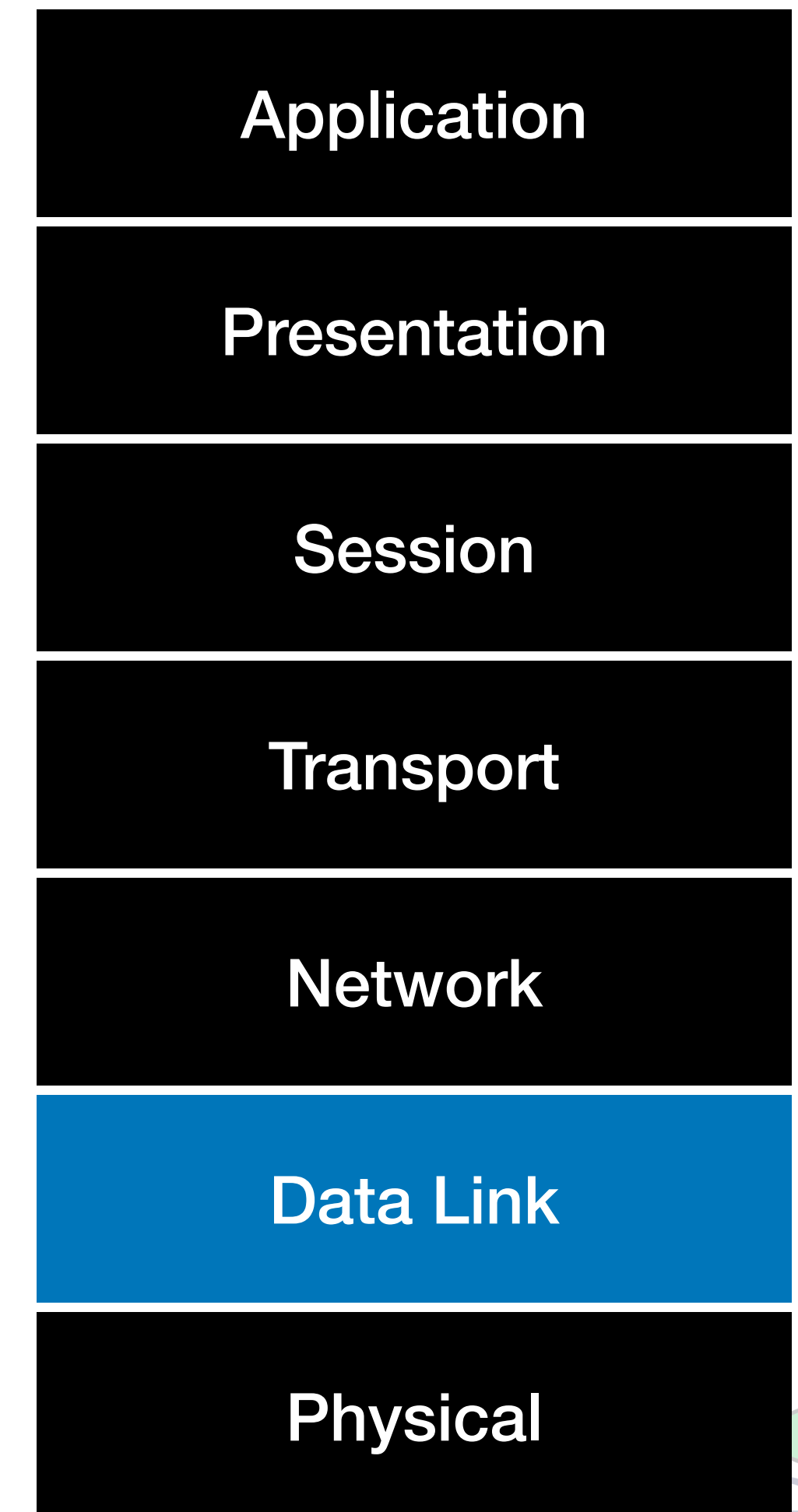


Putting It Together



Link Layer

- Responsibility of transferring datagram from one node to a **physically adjacent node** over a link (no intermediate L3 routers)
- Supports **hop-to-hop** communication
- Ensures reliable connection link between two directly connected nodes (flow control, error correction and detection, etc.)
- Supported by **Media Access Control (MAC)** addressing
- Addressing scheme: MAC addressing (48 bit address, 12 hex digits, 6 bytes)
 - Eg: **00:1A:2B:3C:4D:5E**
 - First three identify manufacturer (IEEE)
 - Next three are assigned by manufacturer and should be unique

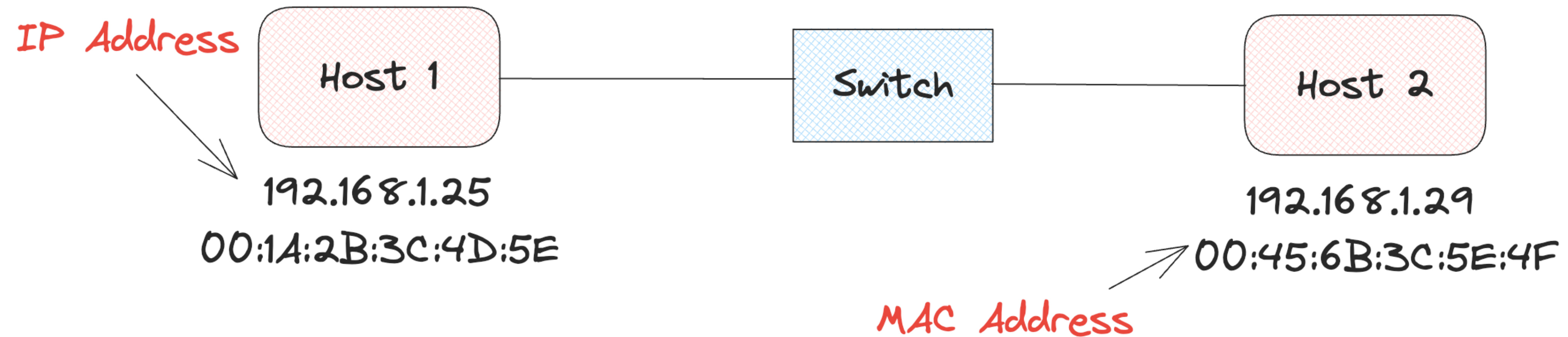


Two process want to communicate with each other

- Two main possibilities
 - Two processes are running in machines in the same network
 - Two processes are running in machines in two different networks
- Same network
 - Two machines are connected through switches
 - It can be a large intranet but the machines are still in same network



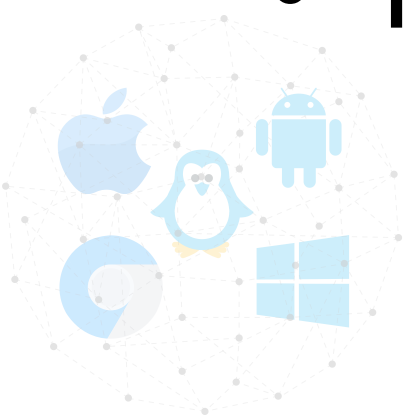
When machines are in same network



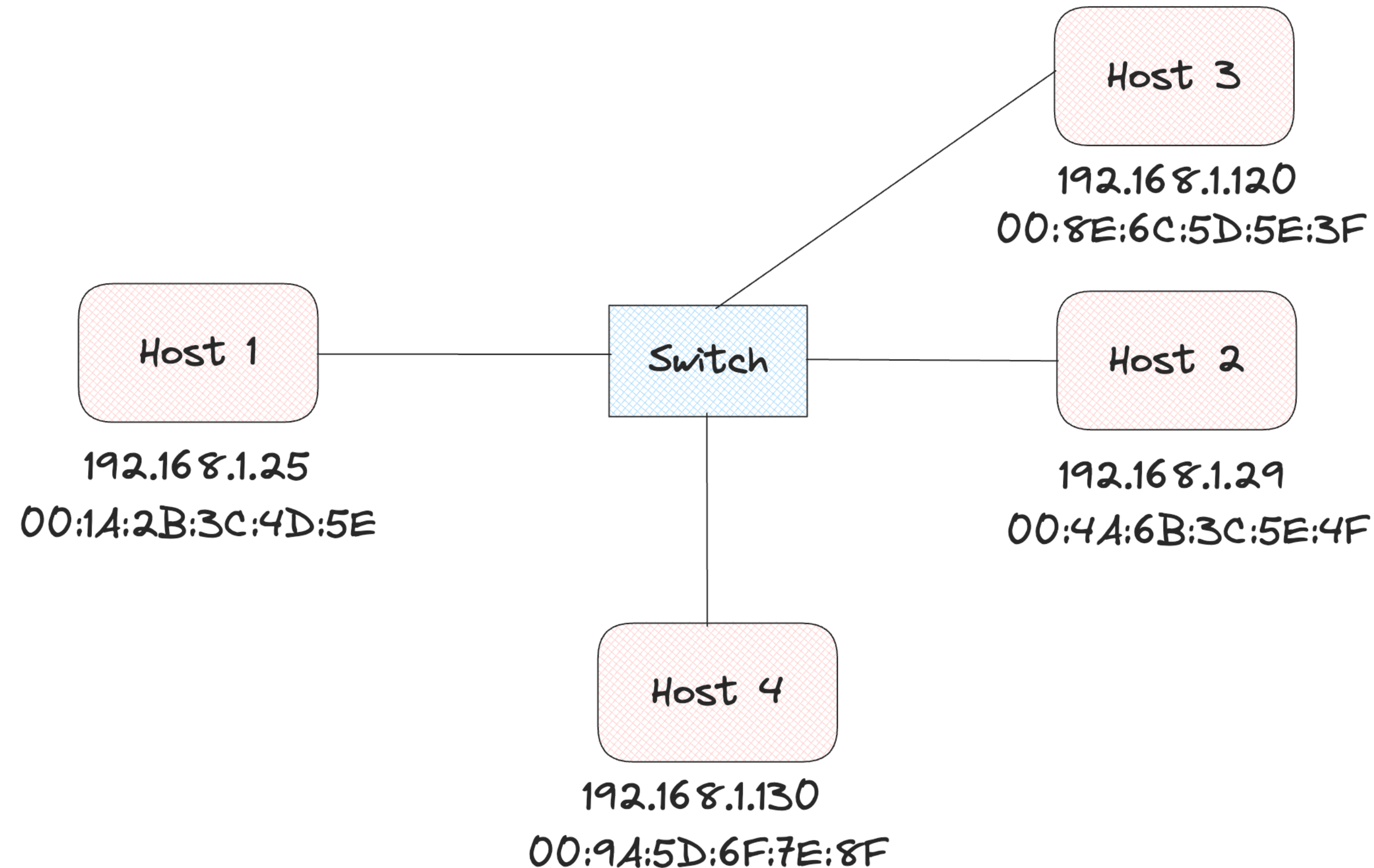
- Assume Host 1 wants to communicate to Host 2 known by domain host2.com
- Host 1 will know the IP address of Host 2 - **How?**
- IP address will help with L3 communication
- Will just the IP address suffice? What about L2? How to get the MAC address?

Why MAC and not just IP

- **Analogy:**
 - MAC address is like Aadhar card number
 - IP address is like Postal address
- **MAC address is unique to each interface**
 - Each interface on a LAN has globally unique MAC address
 - Each interface has a **locally unique IP address**
- How to determine interface's MAC address knowing its IP address?



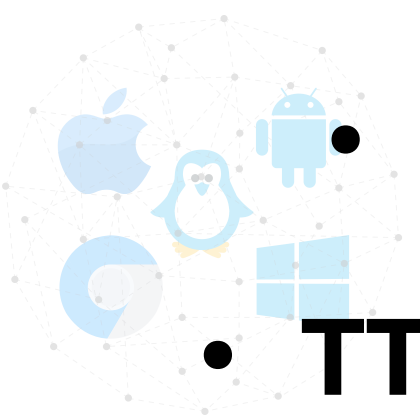
ARP - Address Resolution Protocol



- Each IP node (router, host) on the LAN has a table - **ARP Table**
- IP/MAC address mappings for some LAN nodes

- **<ip address, MAC address, TTL>**

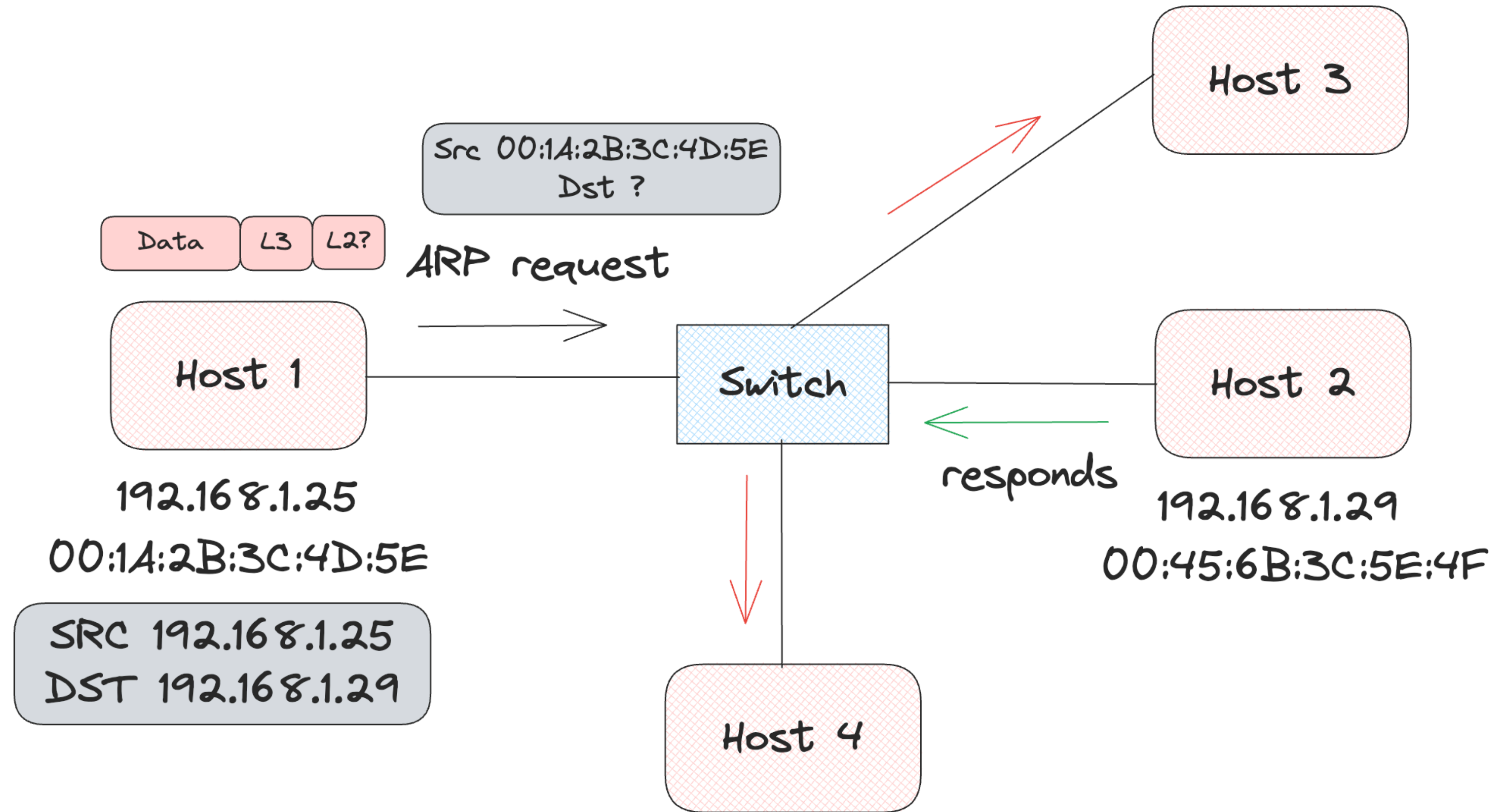
- **TTL:** Time to live, time after which the mapping will be forgotten (20 mins)



ARP - Address Resolution Protocol

ARP Table in Host 1

IP	MAC	TTL



- Host 1 wants to send data to Host 2
- Sends ARP request to all the hosts in the network and updates table

ARP Query

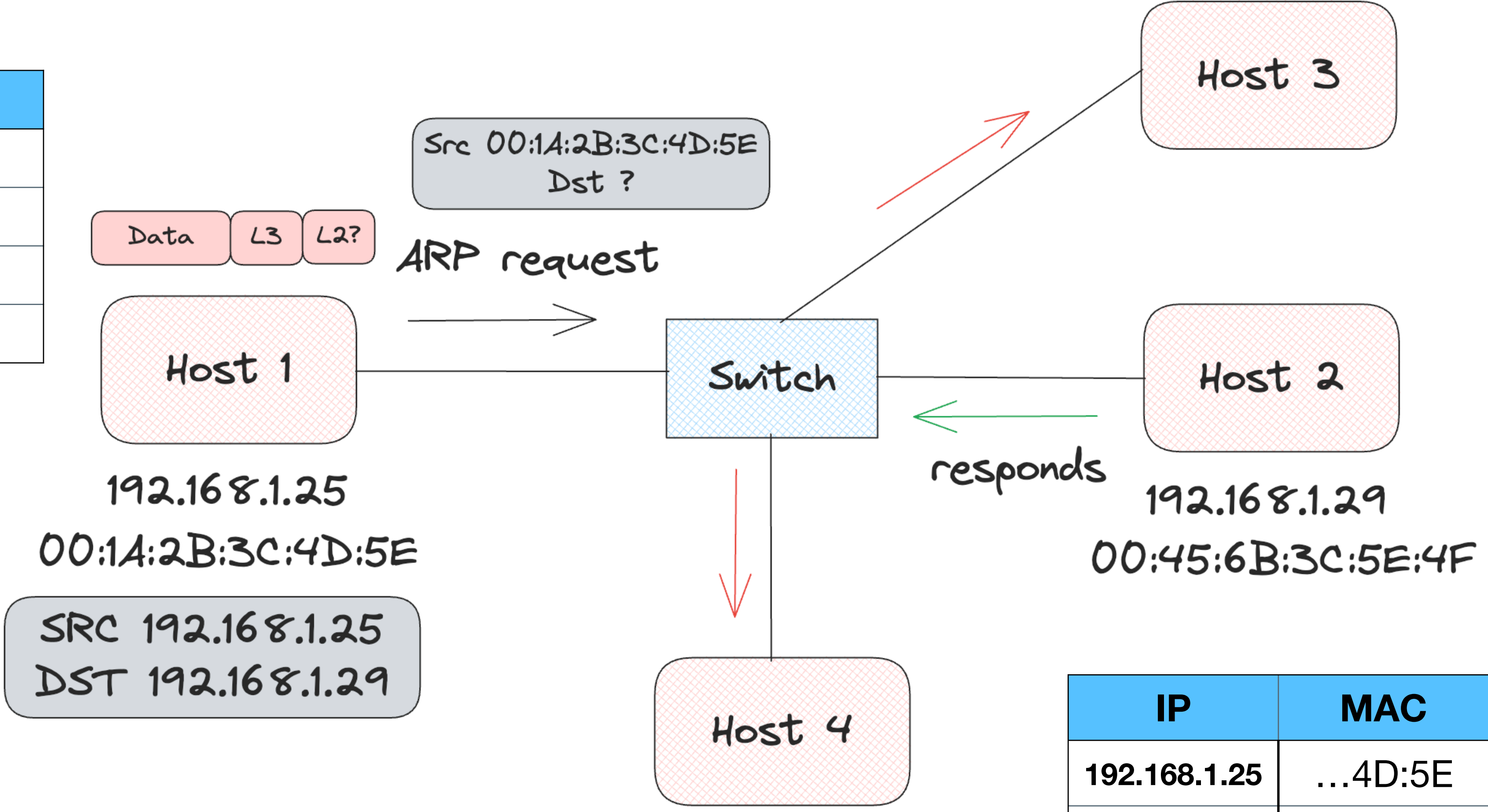
- When ARP query is sent initially, it is broadcast to all the nodes in the network
- The request includes senders IP address and MAC address
- It also includes the target IP address
 - Destination MAC is set as **FF:FF:FF:FF:FF:FF** (Reserved to send packet to all in the network)
- All the nodes will have an ARP cache or ARP table
 - It stores the mapping, when the initial request is send from one host, all other hosts stores the incoming mapping as well



ARP Table

IP	MAC	TTL
192.168.1.29	...:5E:4F	20

ARP Table at Host 1



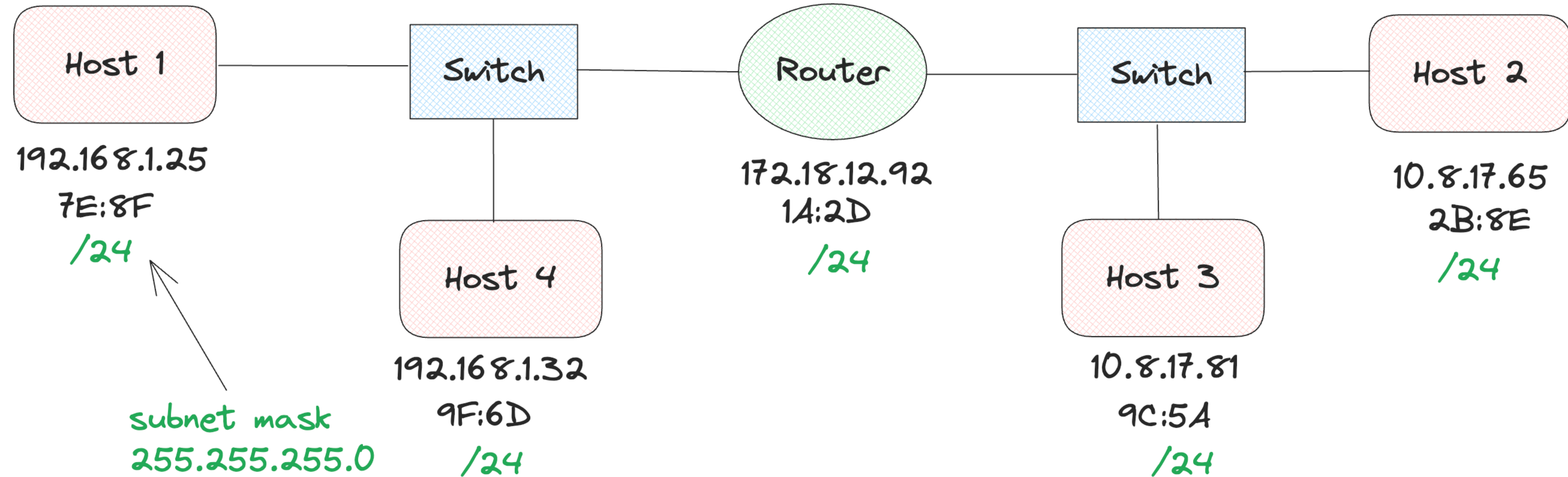
SRC 192.168.1.25
DST 192.168.1.29

IP	MAC	TTL
192.168.1.25	...4D:5E	20

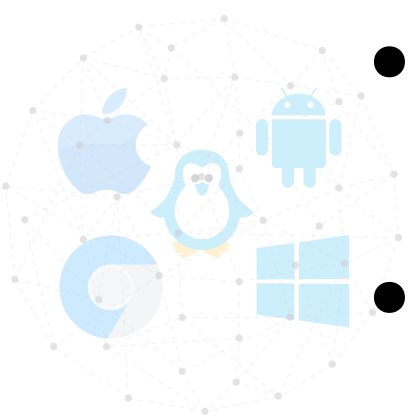
Host 2 is saving the MAC of Host 1 request in its ARP table



When Machines are in Different Network



- Host 1 wants to communicate to Host 2 - Knows the IP address
- Host 1 also knows that Host 2 is not in the same network? - **How?**
- /24 - Subnet mask, what do we mean by that?
- Router **bridges** the two different networks

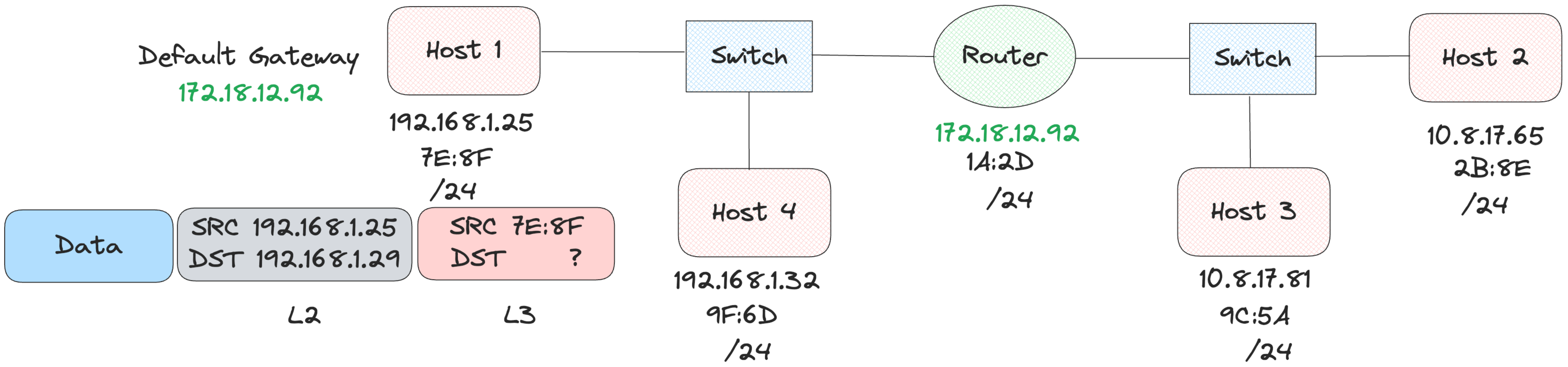


Subnets

- Practice of dividing a network into one or more networks is subnetting
- Allows to create hierarchy within an organisation
 - Think about 172.18.21.x (country.organization.department.machine)
 - Another set of IP within organisations 172.18.y.x
- Consider an IP address 172.18.21.0 with a subnet mask of 255.255.255.0 or /24
 - Implies one network that can contain 254 host addresses (only the last one can change)
 - /24 - CIDR Notation (Classless Inter domain routing) - Number of 1s in the address
- **What about subnet mask 255.255.0.0? Or /16?**



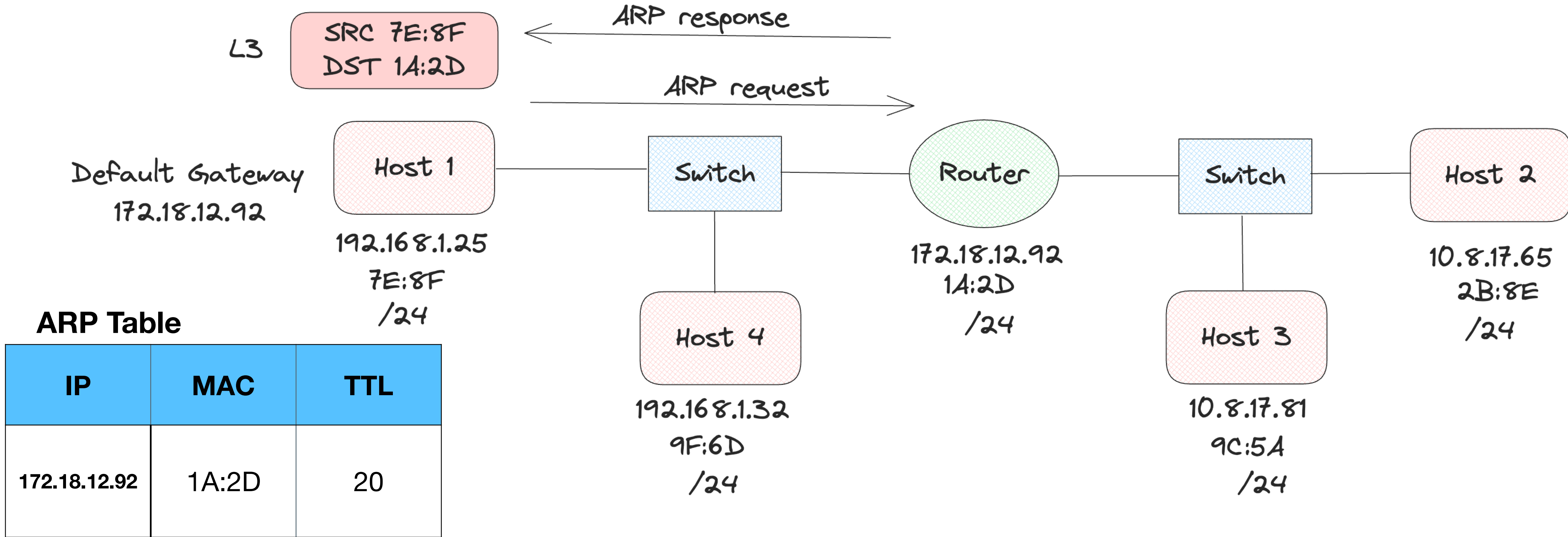
When Machines are in Different Network



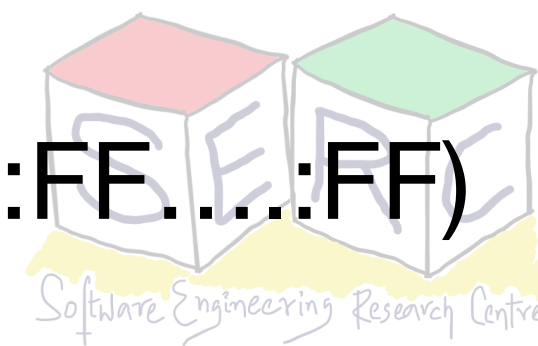
- Host 1 does not know the destination MAC address
- It need not broadcast to all MAC in the same network - **Why?**
- It can make use of the default gateway - IP address of the router



When Machines are in Different Network



- The ARP process needs to happen only once, since router is the gateway
- First step - Check if the IP of the receiver is in the same or different network
- If different network => Send ARP to gateway else, send ARP to all nodes in the network (FF:FF:FF:FF)



How does end-to-end communication work?

What is the role of the network layer?





Thank you

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