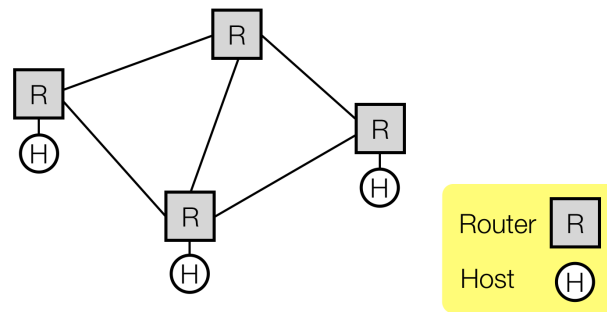


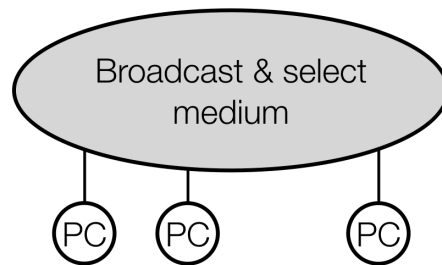
Networking Fundamentals (I)

A Brief History

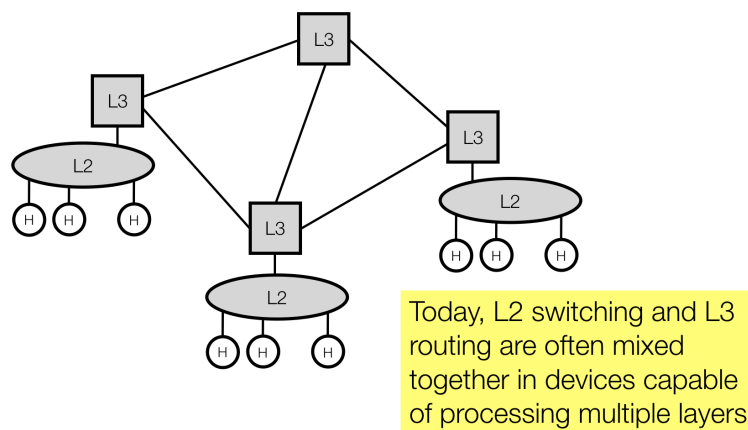
- Bell Labs Invents Modem (1958)
 - Digital signals to analog/electrical signal
 - enabled the communication between computers
- The **first paper on packet switching** theory by Leonard Kleinrock at MIT in July 1961 (**one of the two key steps to make computers talk together**)
 - A message is **broken into a number of parts** that are **sent individually** over the optimum path for each part, which allows the **same data path shared among many users** in the network.
 - **Circuit-switched**:
 - networks for **regular voice telephone** network
 - communication **circuit (path)** for the call **is set up and dedicated to the participants** in that call.
- “Galactic Network” concept by J.C.R Licklider of MIT in August 1962
 - first recorded description of social interactions that could be enabled through networking
 - envisioned a globally interconnected set of computers through which everyone could quickly access data and programs from any site
 - very much like the Internet of today, in spirit
- The first computer network was built in 1965 (**the other key step**)
 - to explore Kleinrock’s theory,
 - connected the **TX-2 computer in MA and the Q-32 in CA** with a low speed dial-up telephone line
 - first WAN ever built
 - confirmed that packet switching offers the most promising model
- The **ARPANET** (Advanced Research Projects Agency Network)
 - the study of ARPANET starts from 1967
 - an early network used to study packet switching
 - the **first network implemented the TCP/IP** protocol suite (1982)
 - the network grew to 23 hosts by 1972
 - many countries started to build their own ARPANET (e.g., France 1972) and connected to other countries (e.g., the first international connection to the ARPANET is made by University College of London (England) via NORSAR (Norway), 1973; around 1980’s continents: US-Europe, Asian-Internet)
- Therefore, **Packet-switched networks became popular** (70’s - 80’s)
 - the networks were long-distance point to point (leased / low-speed dial-up telephone line) lines
 - but allows the same data path shared among many users in the network
 - hosts by then were typically large room-size computers



- **Local area networks** (late 80's, early 90's)
 - smaller personal computers gradually replaced the large room-size computers
 - so, the personal computers at a site were connected together based on broadcast & select medium



- more and more PCs join the broadcast & selected medium. To better support and manage network, Ethernet (L2) switches are introduced to L2 broadcast & select medium.
- **Internet** - a network **INTER**connect **NET**works (today)

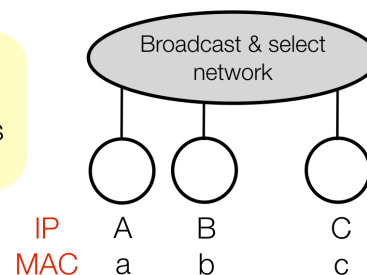


REF: <https://www.internethalloffame.org/internet-history/timeline>

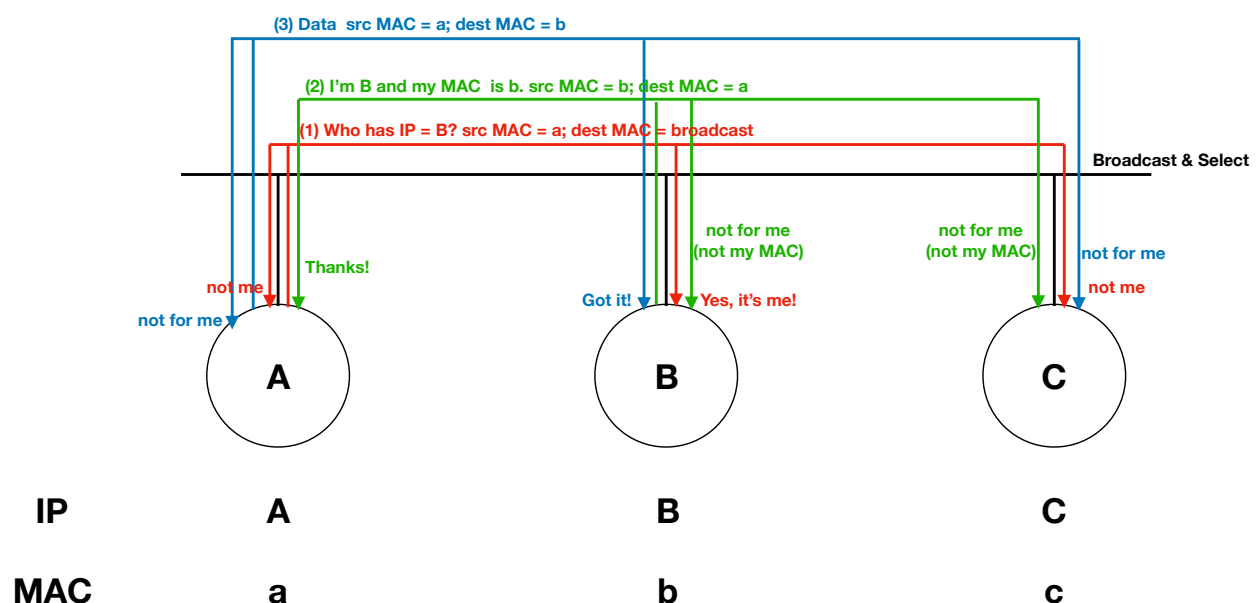
Address Resolution

- Packet transmission in a L2 broadcast & selected network is based on the MAC address. Suppose you are on dori and want to send a message to your friend on kili. You know the hostname kili, which can be mapped to its IP address. But **how can dori tell the MAC address of kili?**
- When dori transmits a packet, it will consult its arp table first.
 - What is the arp table?
 - It's a table maps MAC addresses to IP addresses, maintained by the computer.
 - How do you check the arp table of your computer?
 - Use command line `arp -a`
- If the IP address exists in the table, then packet is sent to another machine in on the same subnet. Otherwise, the system will use **ARP - Address Resolution Protocol**.
 - How does ARP work?
 - Suppose a L2 network with three nodes shown in the figure below. A wants to send a packet to B. A knows B's IP but has no idea about its MAC address.

A has a packet with IP destination address B, A needs B's MAC address to deliver the packet



- The way ARP works is demonstrated in the figure below.



- The broadcast MAC address is a reserved MAC address, FF-FF-FF-FF-FF-FF. When using broadcast MAC address, every node in the L2 network is the destination for that packet.
- After knowing the MAC address of B, A will update its arp table including the record for B into the table.
 - Suppose kili was not in dori's arp table initially. After you ping kili from dori and check dori's arp table again, you will find the entry for kili in the updated arp table.
- Please note that if the destination IP is not in the updated arp table, the packet will be sent to the router, the default gateway.

Disclaimer: Notes adapted from the textbook and online resources.