IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES

COMPUTER NETWORKS AND INTERNET PROTOCOLS

Protocol Stacks – OSI and TCP/IP

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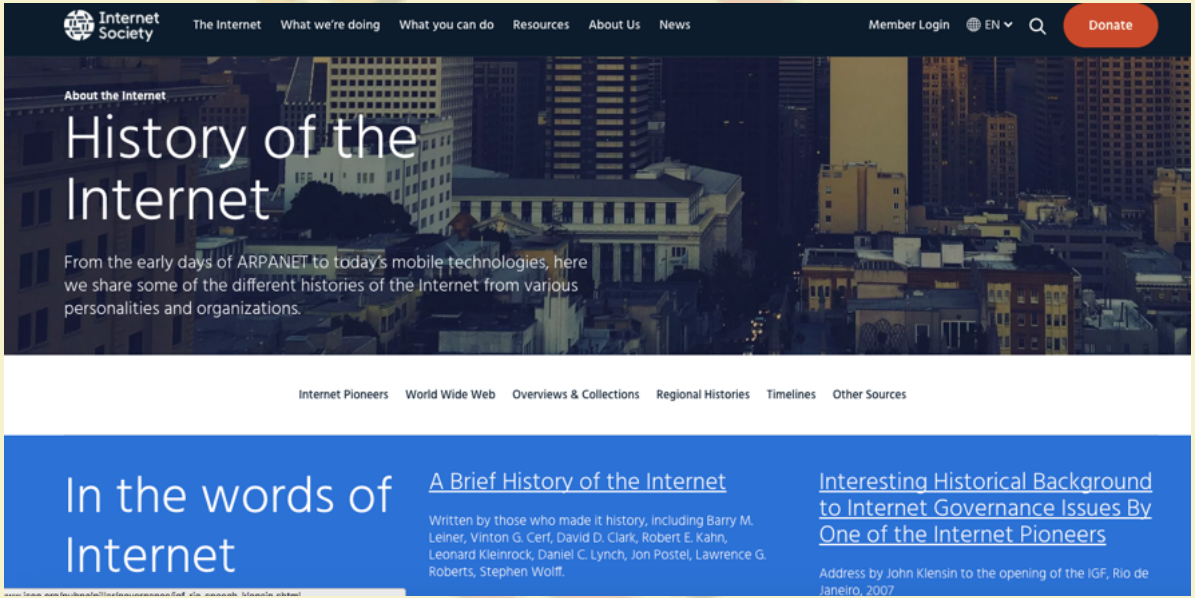
History of Computer Networks

- https://www.youtube.com/watch?v=9hlQjrMHTv4



https://www.internetsociety.org/internet/history-internet

History of Internet

Year	Event
1836	*Telegraph* by Cooke and Wheatstone Revolutionized human (tele)communications. Morse Code a series of dots and dashes used to communicate between humans. This is similar to how computers communicate via (binary 0/1)
1858-1866	*Transatlantic cable*. Allowed direct instantaneous communication across the Atlantic. Today, cables connect all continents and are still a main hub of telecommunications.
1876	*Telephone*. Alexander Graham Bell Exhibits. Telephones exchanges provide the backbone of Internet connections today. Modems provide Digital to Audio conversions to allow computers to connect over the telephone network.
1957	The US forms the *Advanced Research Projects Agency (ARPA)* within the Department of Defense (DoD) to build US skills in computer technology. U.S.S.R. launches Sputnik.
1962	ARPA's contracts from the private sector to universities and laid the foundations for what would become the *ARPANET*.

History of Internet

Year	Event
1962-1968	*Packet-switching* (PS) networks developed The Internet relies on packets to transfer data. Data is split into tiny packets that may take different routes to a destination.
1969	ARPANET commissioned by DoD for research into networking. Four (4) nodes: (i) Univ of California, Los Angeles (UCLA); (ii) Stanford Research Institute (SRI); (iii) Univ of California, Santa Barbara (UCSB); (iv) Univ of Utah
1971	Ray Tomlinson of invents *Email* program to send messages across a distributed network. 15 nodes (23 hosts) on ARPANET
1973	Global Networking becomes a reality. First international connections to the ARPANET: University College of London (England) and Royal Radar Establishment (Norway)
1974	Packets become mode of transfer Transmission Control Program (TCP) specified. Packet network Intercommunication -- the basis of Internet Communication. Telenet, a commercial version of ARPANET, opened -- the first public packet data service.

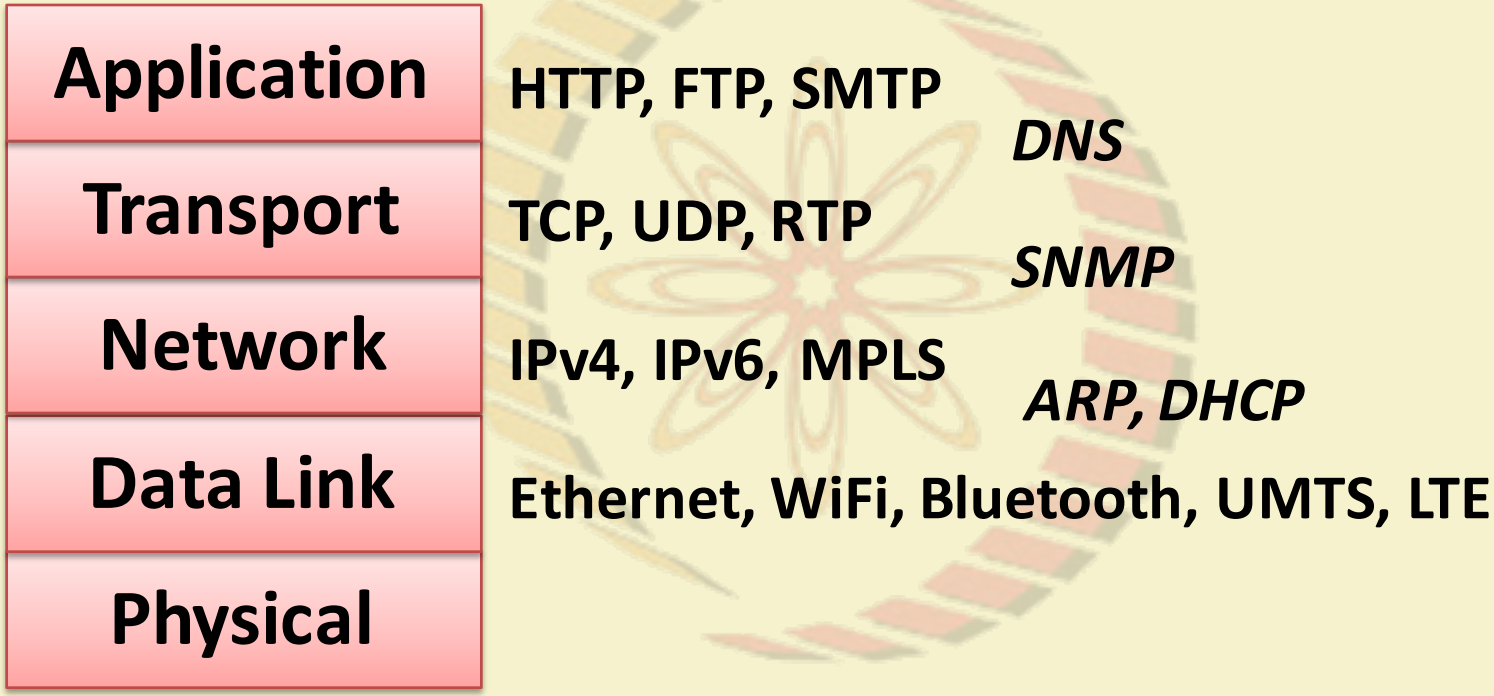
History of Internet

Year	Event
1977	E-mail becomes a reality Hosts: 100+
1979	News Groups formed. USENET established using UUCP - A collection of discussions groups, news groups.
1982	Transmission Control Protocol (TCP) and Internet Protocol (IP) are proposed, as the protocol suite, commonly known as TCP/IP, for ARPANET. TCP/IP defines future network communication.
1983	Name server developed.
1984	Domain Name Server (DNS) introduced. Hosts: 1,000+ NSFNET created - NSF establishes 5 super-computing centers to provide high-computing power for all -- This allows an explosion of connections, especially from universities.
1987	Commercialization of Internet. UUNET is founded with Usenix funds to provide commercial UUCP and Usenet access. Hosts: ~30,000.

History of Internet

Year	Event
1989	First relays between a commercial electronic mail carrier and the Internet Hosts: 100,000+ WWW concept by Tim Berners-Lee
1990	First search-engine (Archie) 300,000 Hosts. 1,000 News groups ARPANET ceases to exist. First browser/editor program.
1991	User Friendly Interface to Internet established Gopher released by Paul Lindner and Mark P. McCahill from the U of Minnesota. Text based, menu-driven interface to access internet resources.
1992	Multimedia changes the face of the Internet Hosts: 1+ Million. News groups 4,000 The term "Surfing the Internet" is coined by Jean Armour Polly.
1993	The WWW Revolution truly begins Hosts: 2 Million. 600 WWW sites. The Mosaic Web browser is released on the Net

Network Management and Control – Cross Layer Protocols



Web exploded…

- 1994 – 3.2 million hosts and 3,000 websites
- 1995 – 6.4 million hosts and 25,000 websites
- 1997 – 19.5 million hosts and 1.2 million websites
- January 2001 – 110 million hosts and 30 million websites
- Expansion continues….

Some Facts

- 1994 – Hotmail starts web based email
- 1994 – World Wide Web Consortium (W3C) was founded
- 1995 – JAVA source code was released
- 1996 – Mirabilis (Israel) starts ICQ
- 1998 – Google is founded

Protocols

- Protocol is a controlled sequence of messages that is exchanged between two or more systems to accomplish a given task.
- Protocol specifications define this sequence together with the format or layout of the messages that are exchanged.

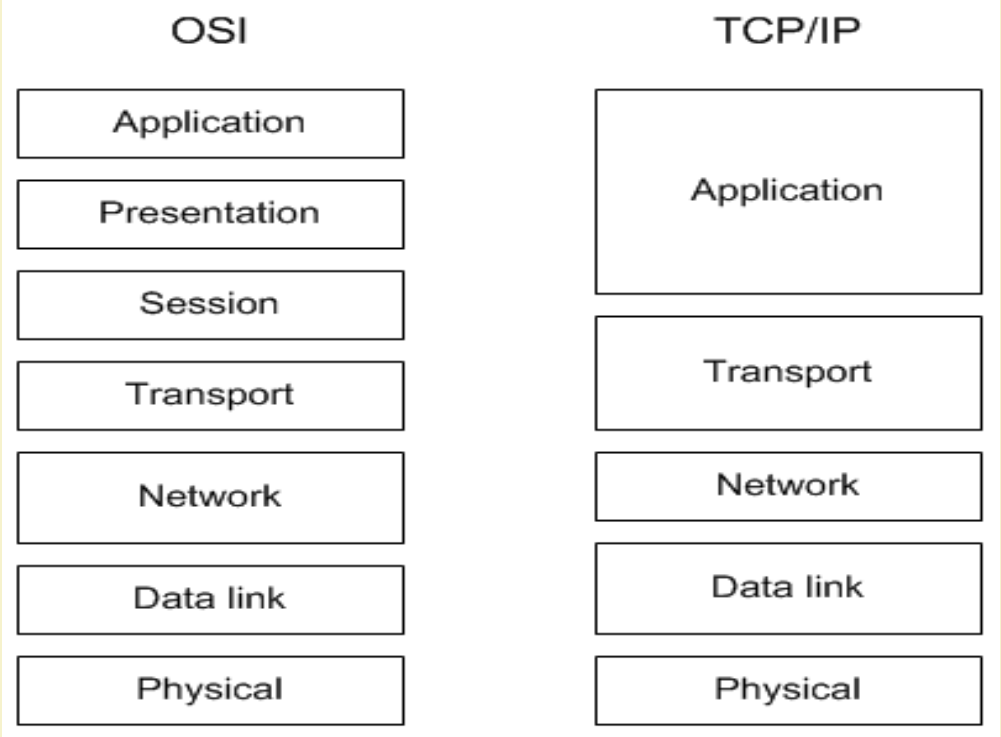
OSI Model Layers

OSI layer	Function provided
Application	Network applications such as file transfer and terminal emulation
Presentation	Data formatting and encryption
Session	Establishment and maintenance of sessions
Transport	Provision for end-to-end reliable and unreliable delivery
Network	Delivery of packets of information, which includes routing
Data Link	Transfer of units of information, framing, and error checking
Physical	Transmission of binary data of a medium

Transmission Control Protocol / Internet Protocol (TCP/IP)

- Transmission Control Protocol/Internet Protocol (TCP/IP) suite of protocols has become the dominant standard for inter-networking.
- TCP/IP represents a set of public standards that specify how packets of information are exchanged between computers over one or more networks.

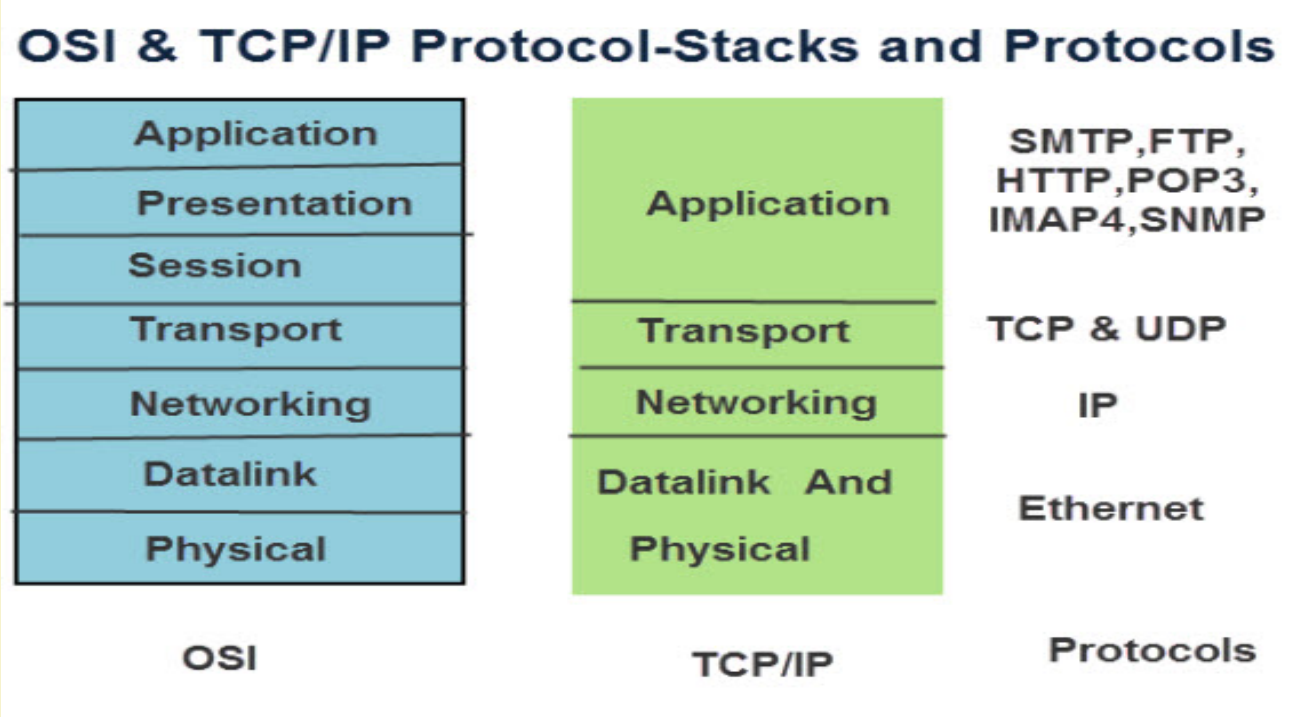
OSI and TCP/IP



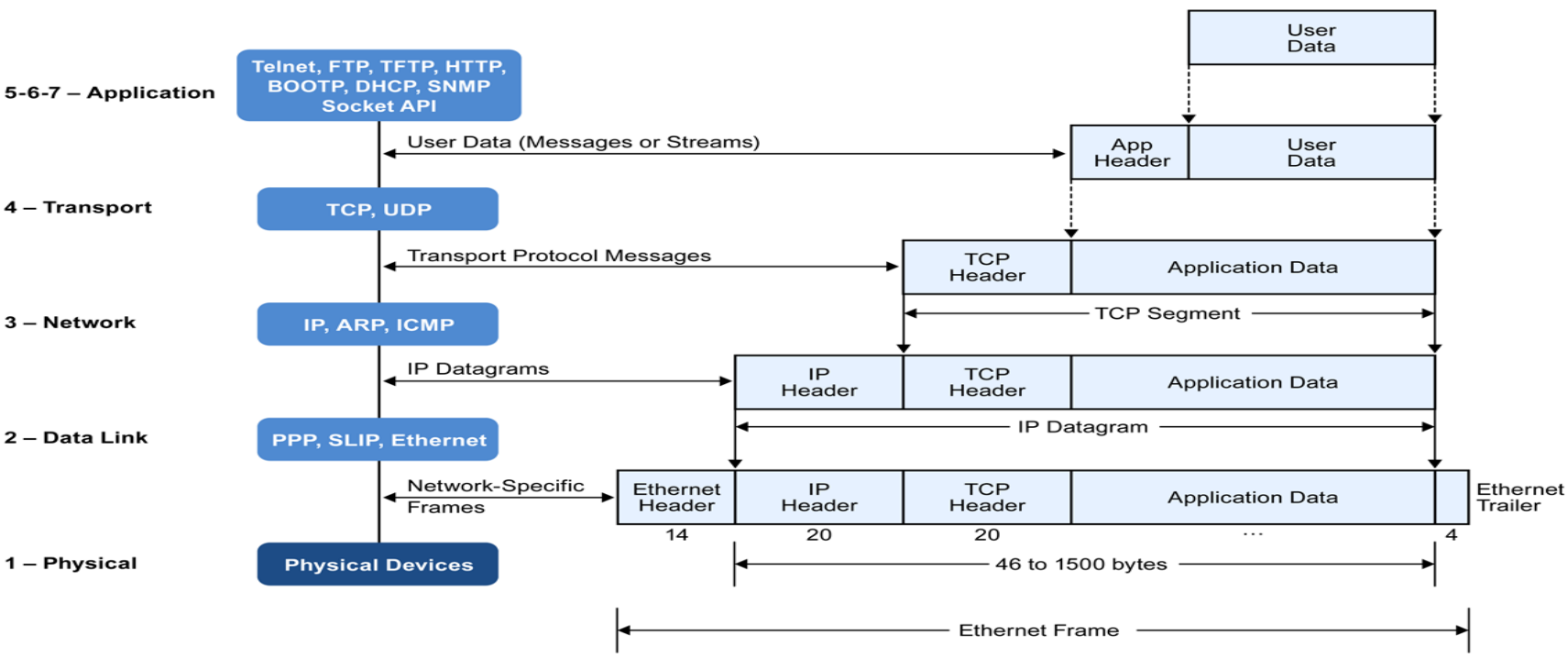
TCP/IP

<table>
<tr><td rowspan="2">Application
(Host To Host Layer)</td><td>Ping</td><td>Telenet &
Rlogin</td><td>FTP</td><td>SMTP</td><td>SNMP</td><td>Trace-
route</td></tr>
<tr><td>DNS</td><td>TFTP</td><td>BOOTP</td><td>RIP</td><td>OSPF</td><td>etc.</td></tr>
<tr><td>Transport</td><td colspan="2">TCP</td><td colspan="2">UDP</td><td colspan="2">ICMP</td></tr>
<tr><td>Network</td><td colspan="6">IP</td></tr>
<tr><td rowspan="2">Data Link</td><td colspan="2">LLC</td><td colspan="2">HDLC</td><td colspan="2">PPP</td></tr>
<tr><td>Ethernet</td><td>802.3</td><td>X.25</td><td>Token Ring</td><td>Frame Relay</td><td>ATM</td><td>SMDS</td><td>etc.</td></tr>
<tr><td>Physical</td><td colspan="2">Fiber Optics</td><td>UTP</td><td>Coax</td><td>Microwave</td><td>Satellite</td><td>STP</td></tr>
</table>

OSI and TCP/IP



TCP/IP – Packet Encapsulation



Local Area Network (LAN) – Typical Components

- Clients – workstations
- Servers – usually have more computing resources
- Network devices
  - Repeaters
  - Hubs
  - Transceivers
  - NICs
  - Bridges
  - Switches
  - Routers

Wide Area Networks

- A WAN is a data communications network covering a large geographic area.
- Unlike LANs , a WAN connection is generally rented from a *service provider*.
- WANs connect various sites at different geographic locations so that information can be exchanged.

Evolution of LAN Devices

- NICs, Repeaters, & Hubs
- Bridges
- Switches
- Routers

NIC Specifics

- NICs provide hosts with access to media by using a MAC address.
- MAC stands for Media Access Control
- NICs operate at Layer 2 !!

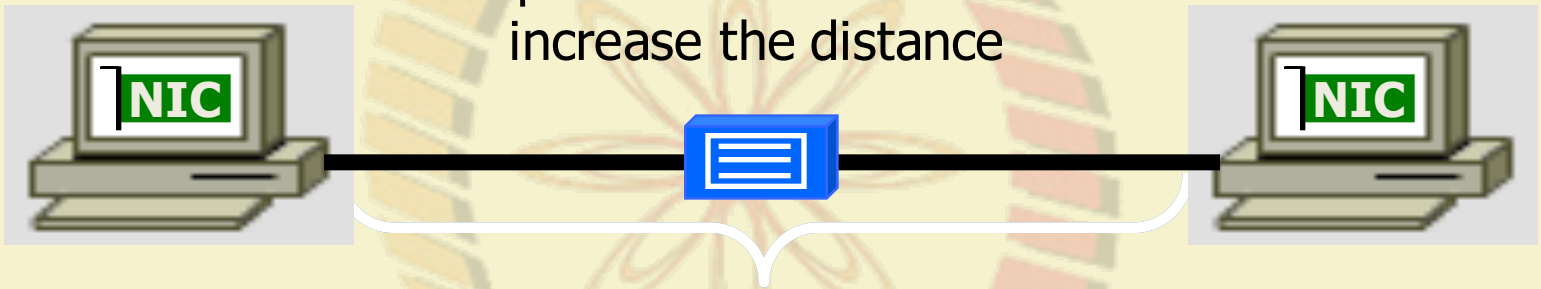
NICs, Repeaters, & Hubs

To connect two computers, you must...

- Install a NIC card in each.

Attach computers using a crossover cable

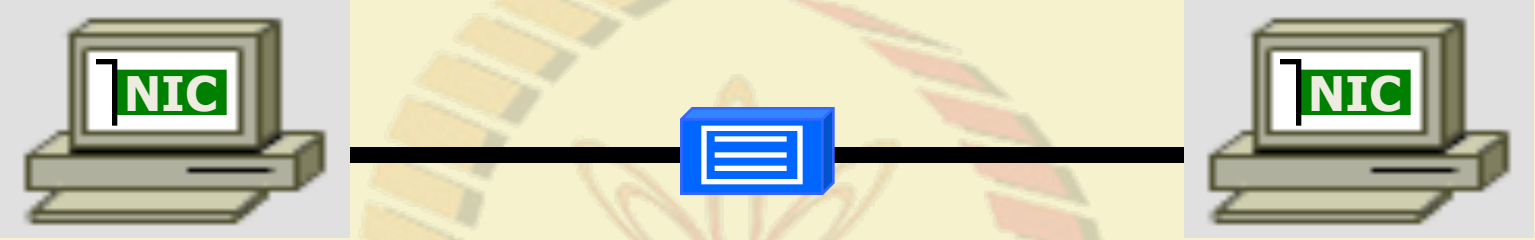
NICs, Repeaters, & Hubs



100 meters or approx. 300 feet

Repeaters amplify and retime signals

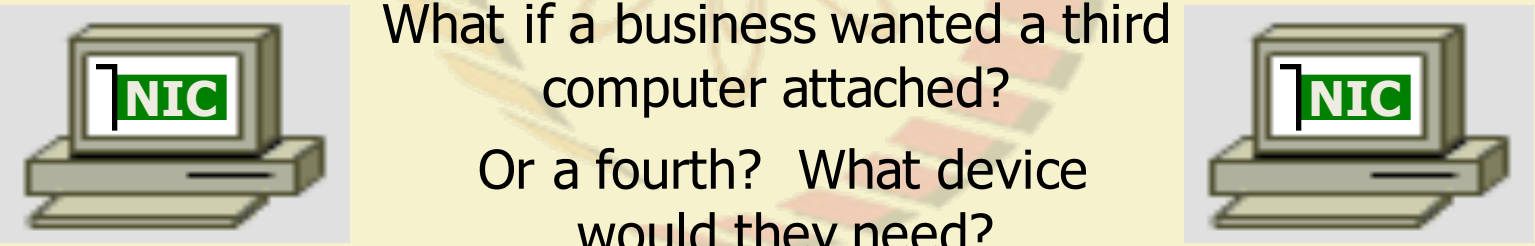
NICs, Repeaters, & Hubs



Using repeaters was fine as long as a business only needed two computers networked.

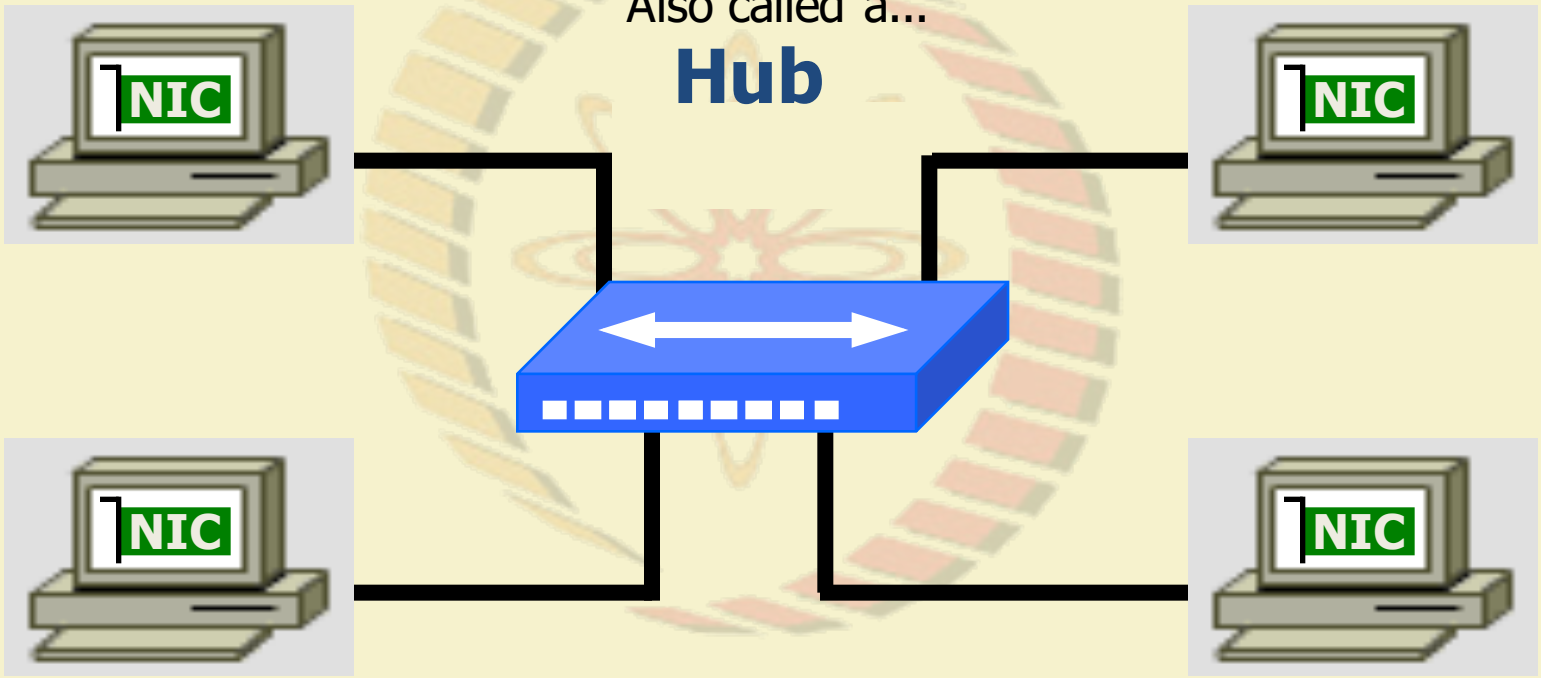
What if a business wanted a third computer attached?

Or a fourth? What device would they need?



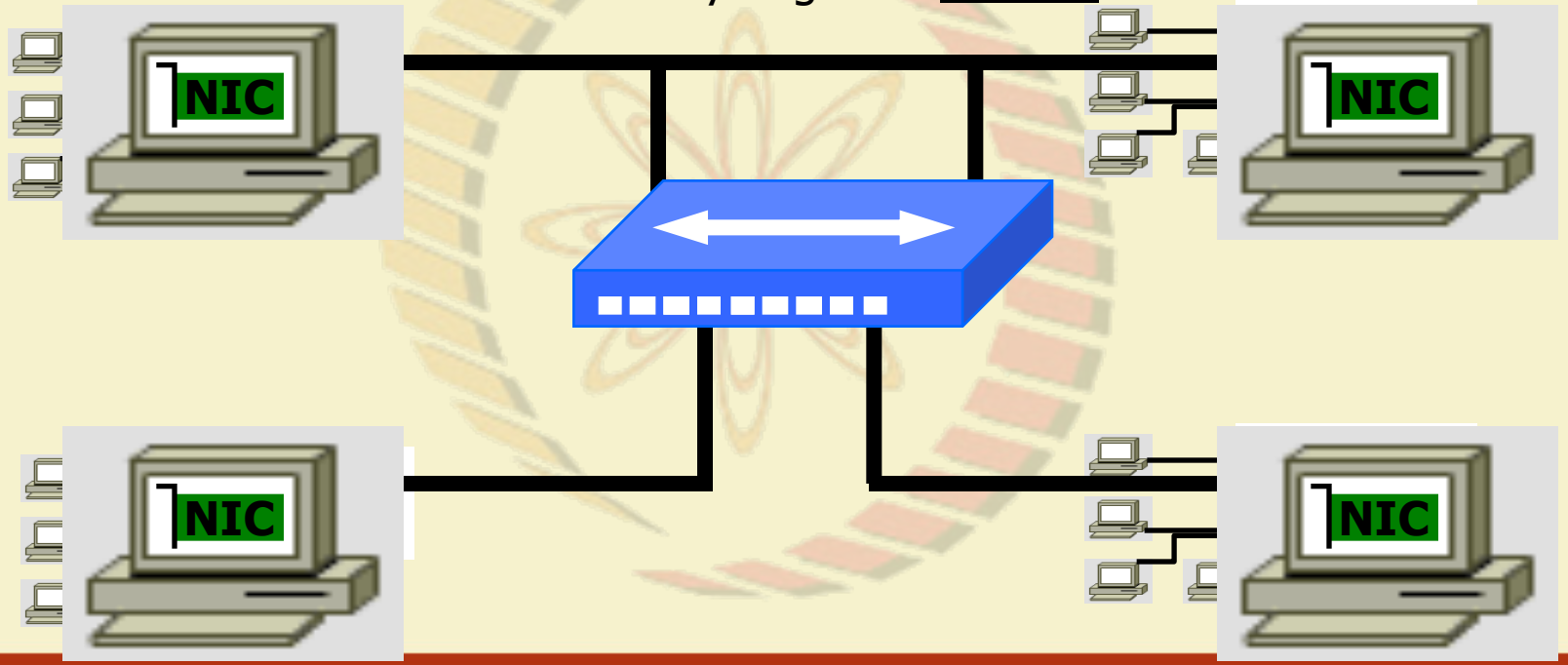
NICs, Repeaters, & Hubs

A multi-port repeater!
Also called a...
Hub



A Dilemma!

As businesses expanded their networks, they began to cascade hubs.



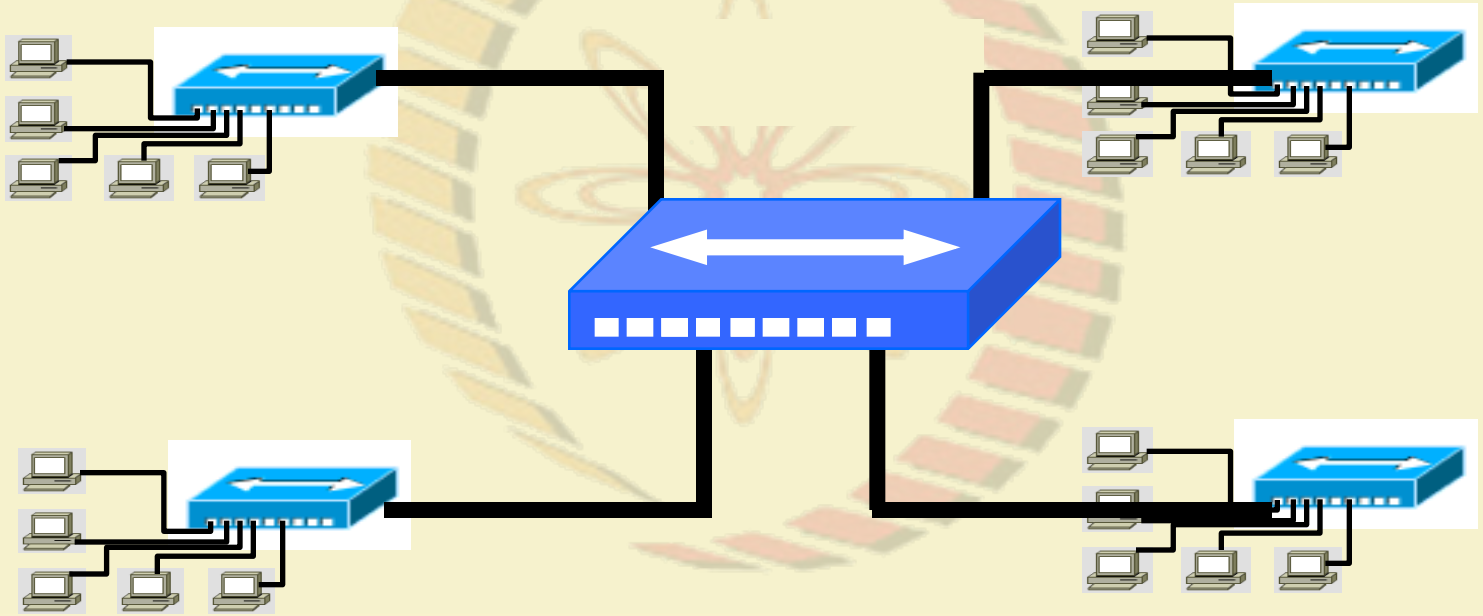
What's The Problem?

1) Hubs share bandwidth between all attached devices.
2) Hubs are stupid, Layer 1 devices. They cannot filter traffic.
3) Most LANs use a "broadcast topology," so every device sees every packet sent down the media.

Let's take a look at how broadcasting works

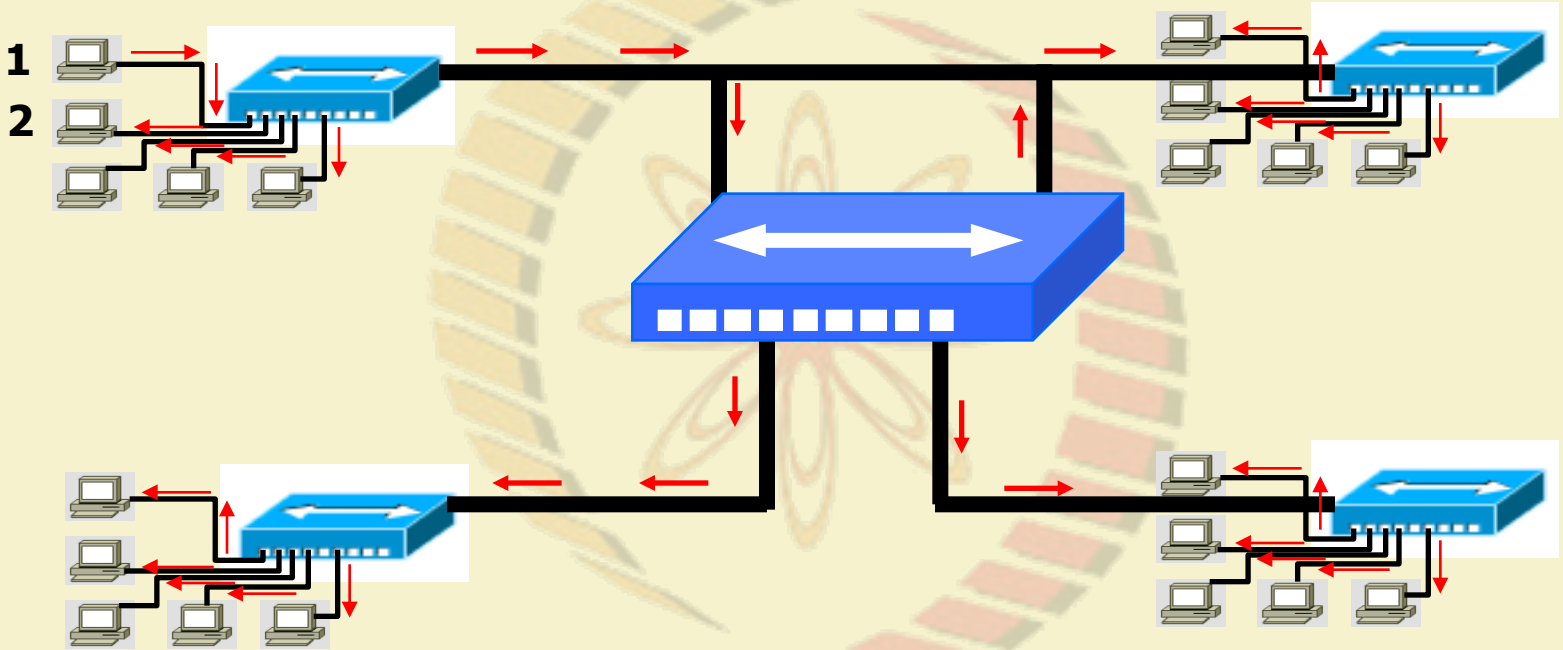
Broadcasts

In this picture, all hubs forward all traffic to all devices.



Broadcasts

So, if Host 1 wants ping Host 2, all hosts see the ping. This is what we mean by a broadcast topology



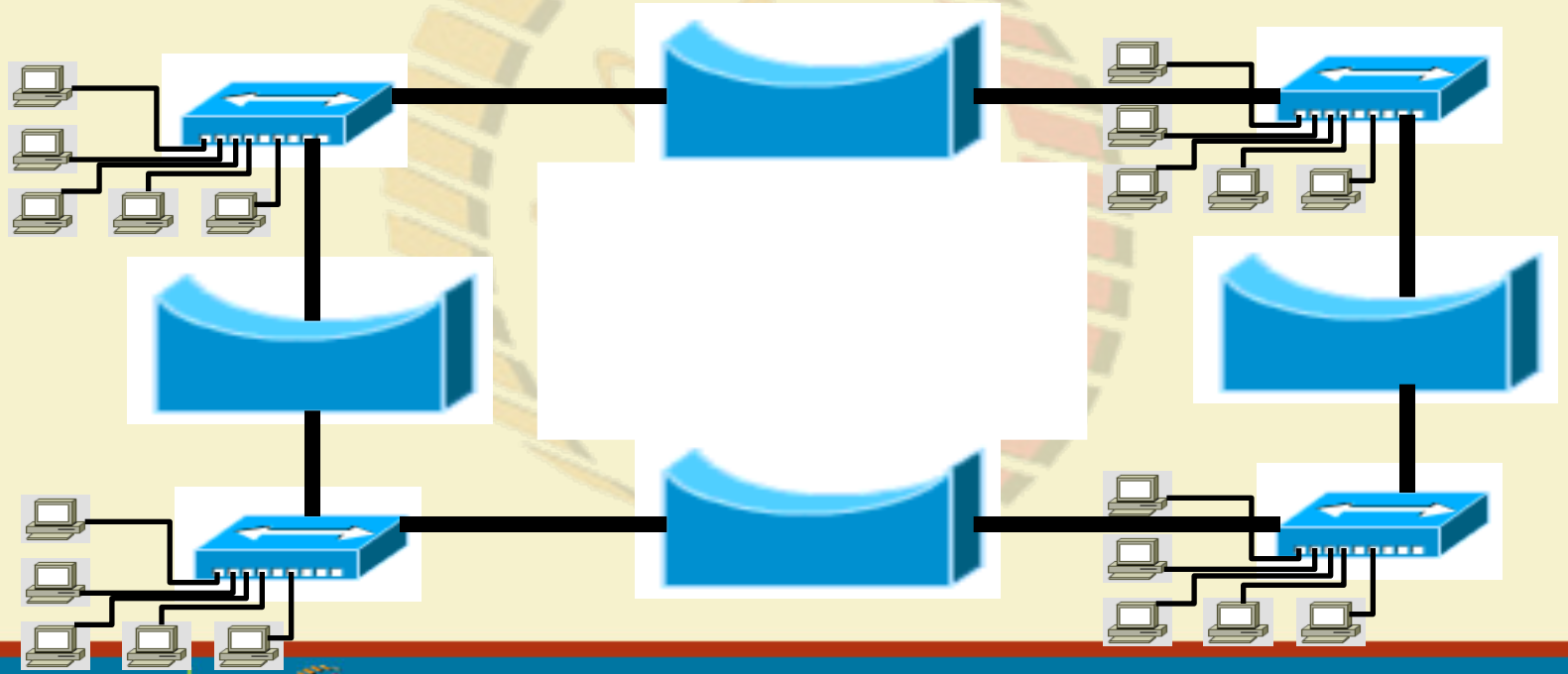
The red arrows show that all hosts receive the ping request. Only Host 2 will respond.

What's The Solution?

- We need a smarter hub!
- What's a "smarter hub" called?
- A Bridge!
- Bridges filter network traffic based on MAC addresses.
- Let's take a look at how this works.

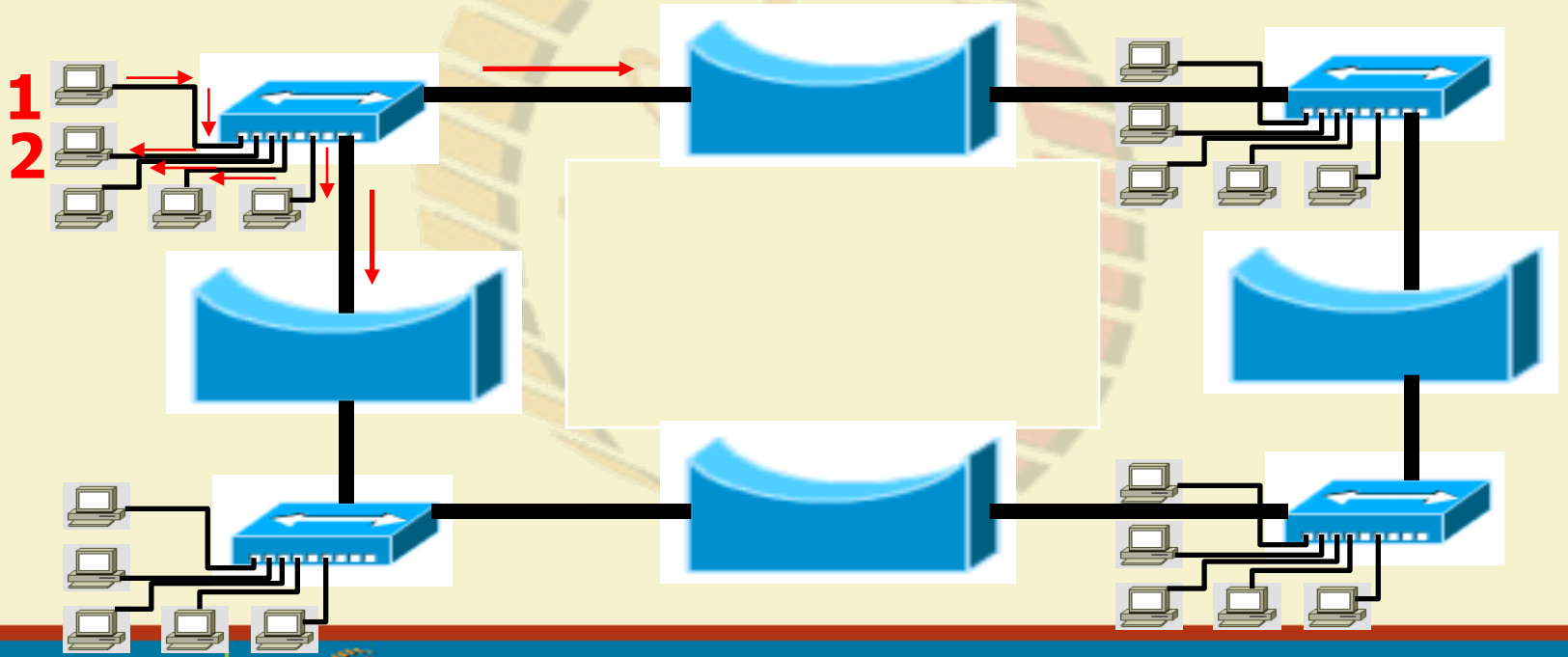
Bridge

To lessen the amount of LAN traffic, businesses began to uses bridges to filter frames based on MAC addresses.



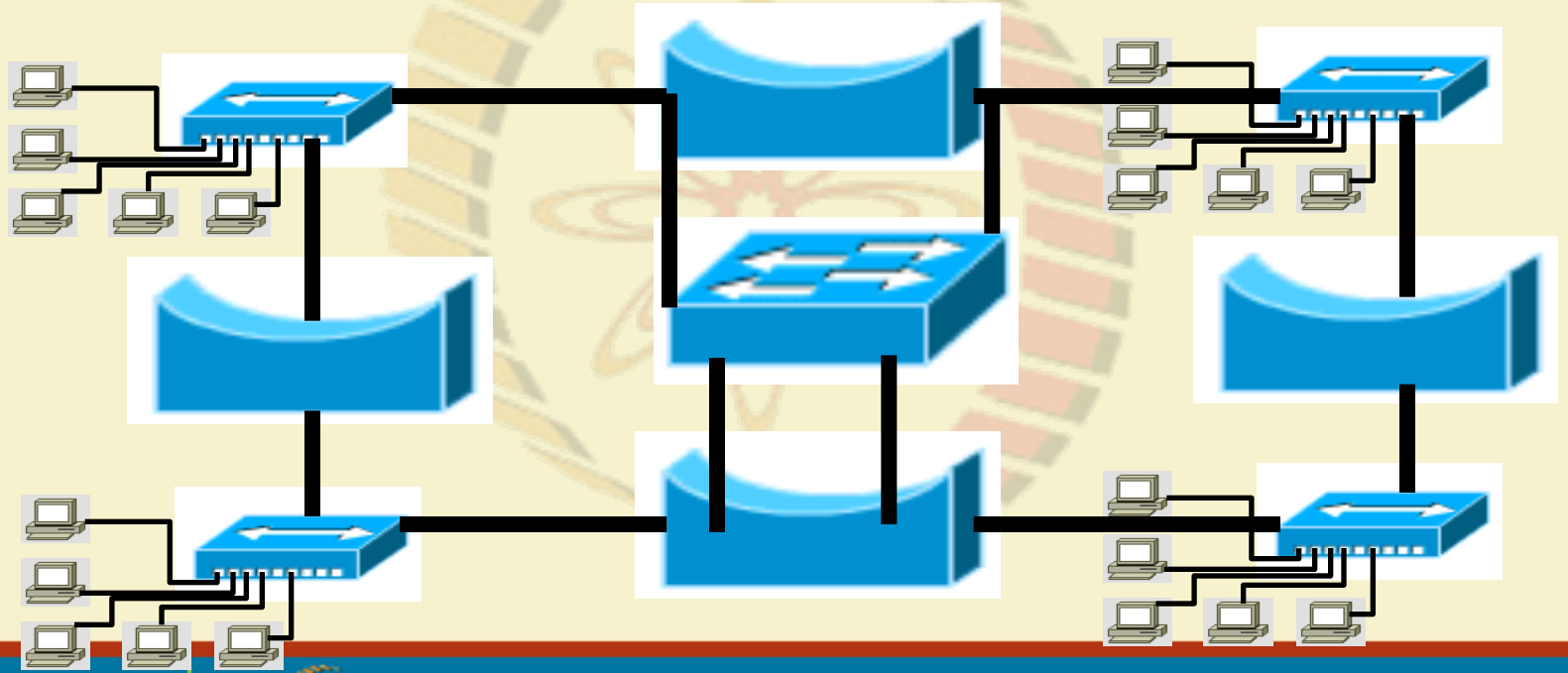
Bridge

Now, if Host 1 pings Host 2, only the hosts on that LAN segment see the ping. The bridges stop the ping.



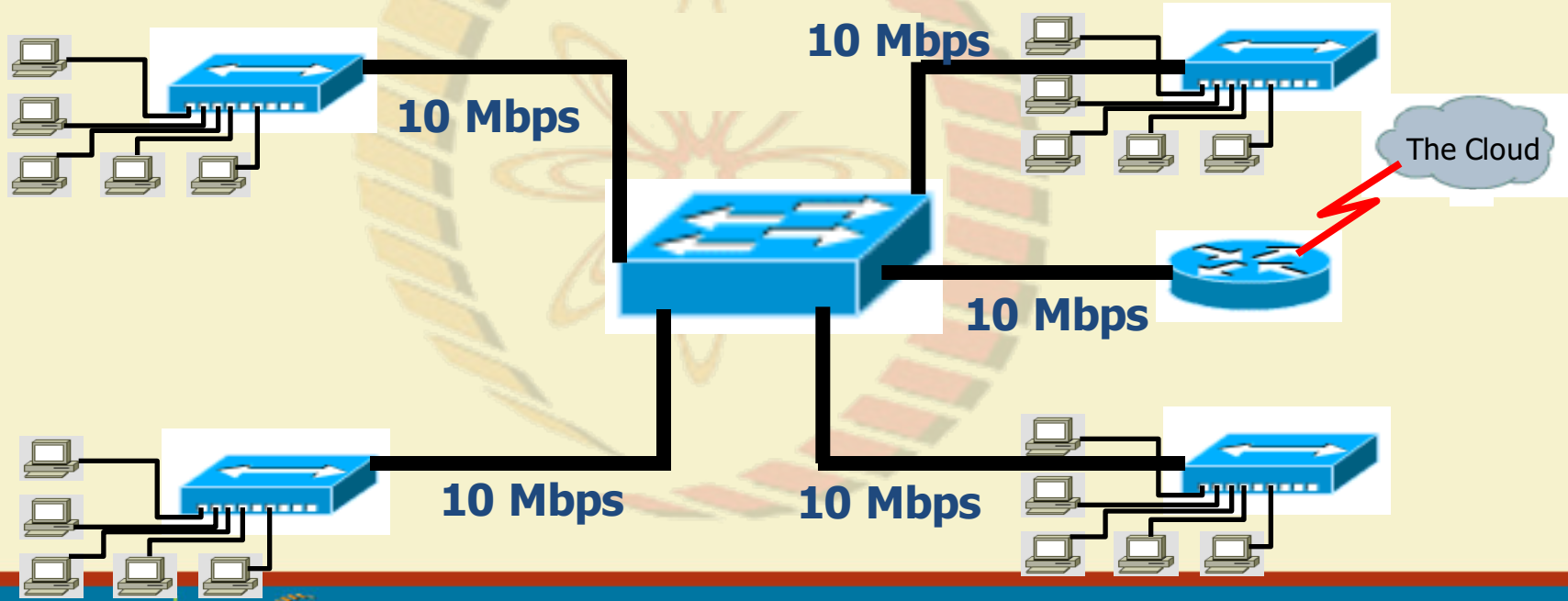
Switch

A switch (also know as a multi-port bridge), can effectively replace these four bridges.



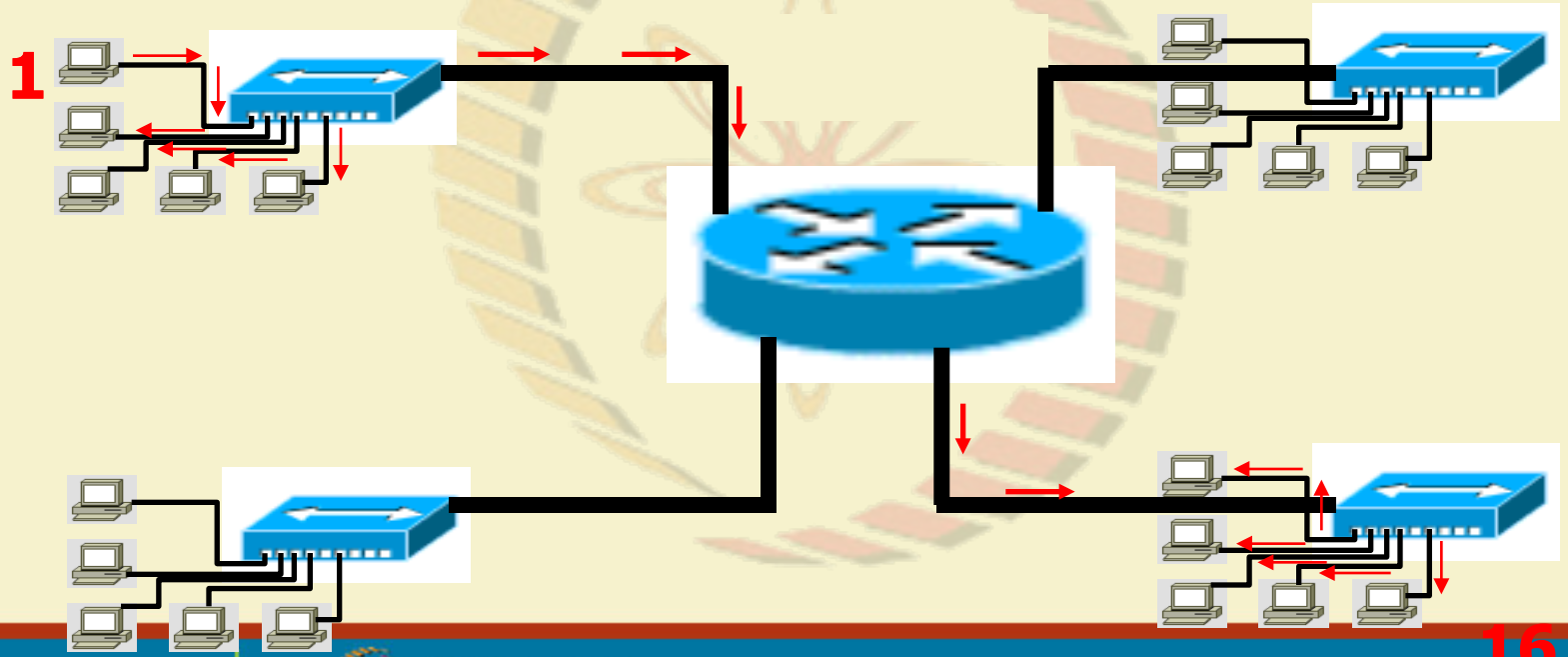
Switch

Another benefit of a switch is that each LAN segment gets dedicated bandwidth.

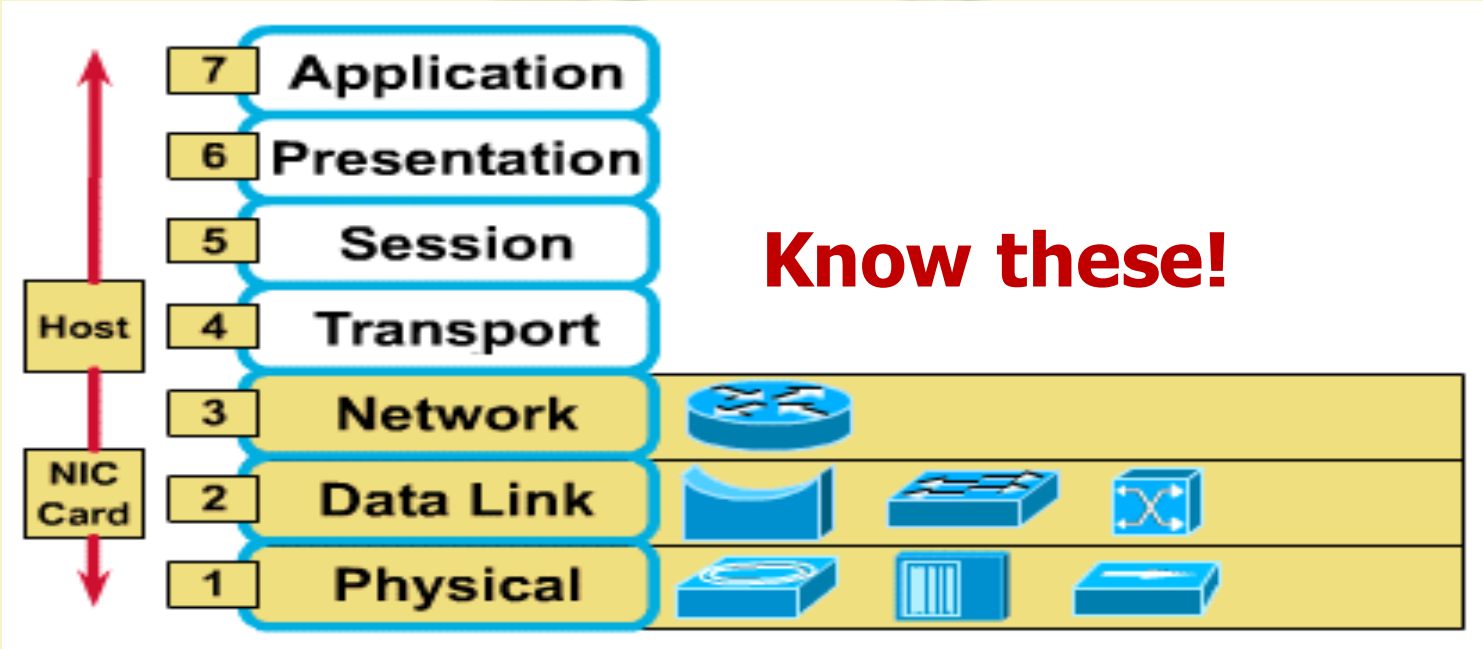


Router

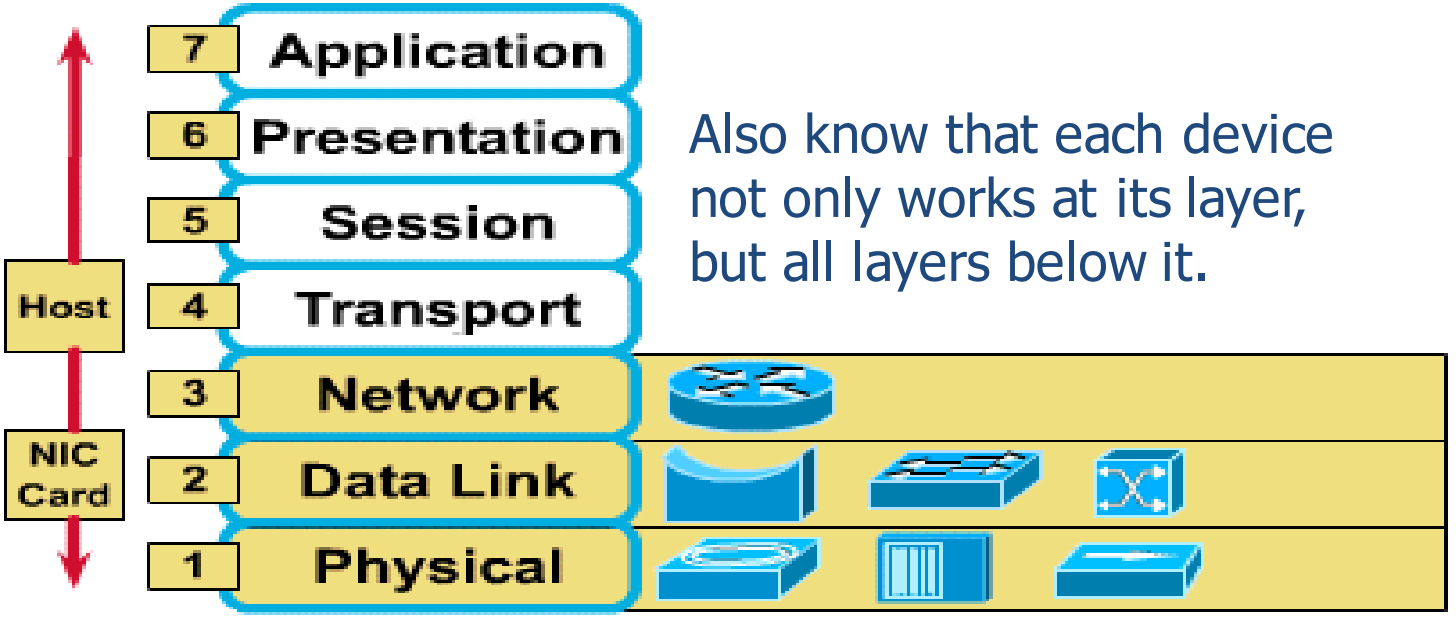
Routers filter traffic based on IP addresses. The IP address tells the router which LAN segment the ping belongs to.



Devices Function at Layers

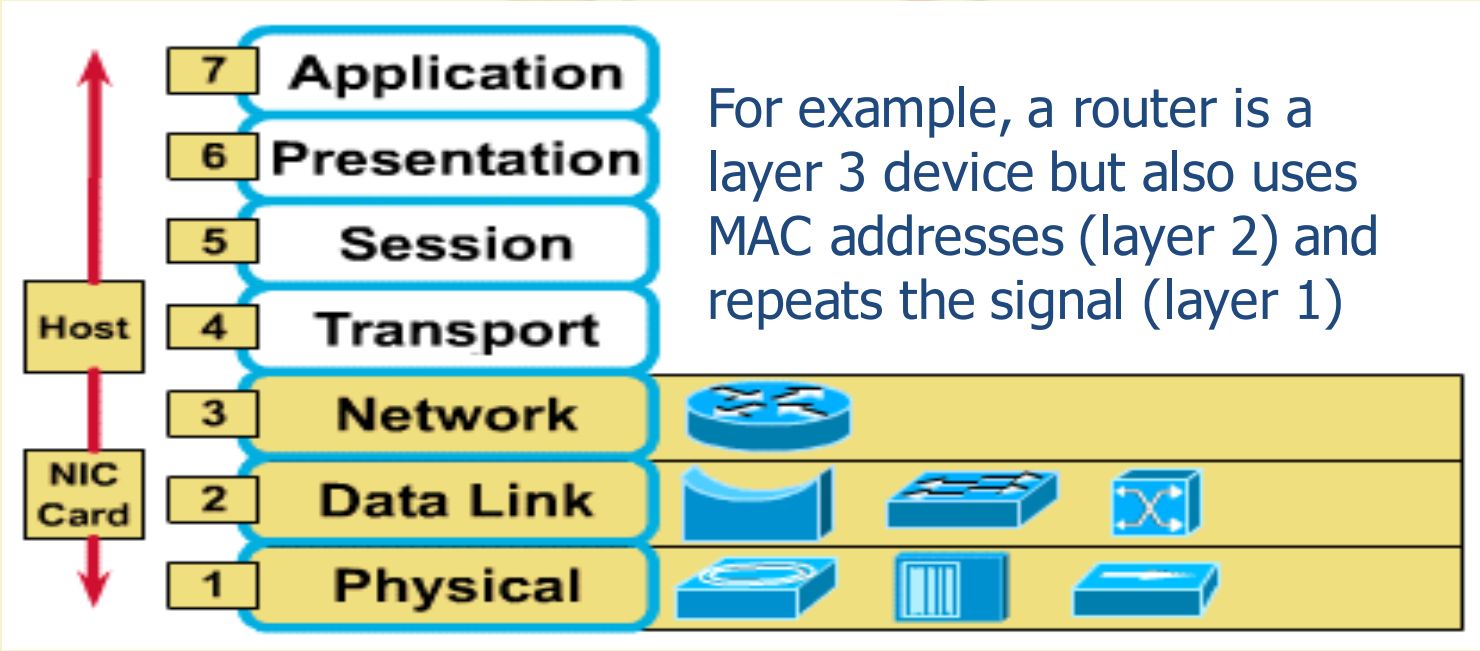


Devices Function at Layers



Also know that each device not only works at its layer, but all layers below it.

Devices Function at Layers



For example, a router is a layer 3 device but also uses MAC addresses (layer 2) and repeats the signal (layer 1)

Hierarchical Design Model

- A layered model for network design
- Consists of 3 tiers
- Access layer - for end user connectivity
- Distribution layer - for policy based routing and access control
- Core layer- for switching packets as fast as possible across the *internetwork*.

Few points to note ….

- Routers, by default, break up *broadcast domain*
- Broadcast domain – Set of all devices on a network segment that hear all the broadcasts sent on that segment
- Breaking-up of network broadcast is important – because when a host or server sends a network broadcast, every device on the network "must" read and process that broadcast.
- When a router's interface receives this broadcast – it discards the broadcast without forwarding it on to other network
- *Router also breaks up "collision domain" as well !*

Few points to note …. (contd)

- Switches aren't used to create internetworks, they're employed to add functionality to an internetwork LAN
- Switches only "switches" frames from one port to other within a "switched network"
- Switches break-up *collision domains*.
- Collision domain – Ethernet term ! – used to describe a network scenario in which one particular device sends a packet on a network segment, forcing other devices on the same segment to pay attention to it. At the same time, a different device tries to transmit, leading to collision, then both the devices must re-transmit – a situation found in a Hub
- Each and every port on a switch represent its own collision domain (*Hub represents only one collision domain and only one broadcast domain*)


thank you!