BUCKNELL UNIVERSITY
Computer Science

CSCI 315 Operating Systems Design

Computer Networks

The Purpose of Networking

- **Goal:** Allow computers to communicate (exchange data and/or commands).
- A few desirable properties:
  - Interoperability,
  - Flexibility,
  - Geographical range,
  - Scalability,
  - Privacy and security.

Matters of *Protocol*

Everything in networking happens through ***protocols***:

- A protocol determines how hosts share and access the medium,
- A protocol determines how hosts deal with the media bandwidth, errors, flow control, etc,
- A protocol determines how connections between hosts are established and maintained,
- A protocol determines how information is routed across short and long distances, etc, etc, etc…

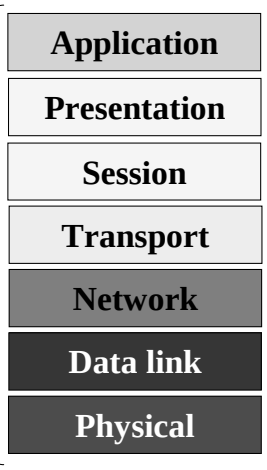
Question: Ok, but what is *protocol*?

The ISO/OSI Reference Model

Source: Computer Networks, Andrew Tanenbaum

ISO: International Standards Organization
OSI: Open Systems Interconnection

The protocol ***stack***



The idea behind the model: Break up the design to make implementation simpler. Each layer has well-defined functions. Layers pass to one another only the information that is relevant at each level. Communication happens only between **adjacent** layers.

The Layers in the ISO/OSI RF Model

Physical: Transmit raw bits over *the medium*.

Data Link: Implements the abstraction of an error free medium (handle losses, duplication, errors, flow control).

Network: Routing.

Transport: Break up data into chunks, send them down the protocol stack, receive chunks, put them in the right order, pass them up.

Session: Establish connections between different users and different hosts.

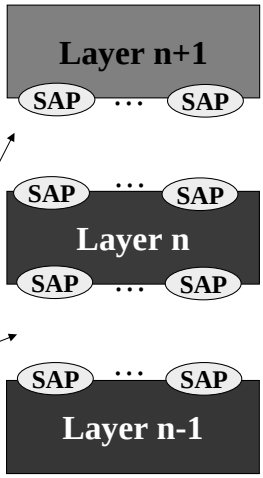
Presentation: Handle syntax and semantics of the info; examples: encoding, encrypting.

Application: Protocols commonly needed by applications (cddb, http, ftp, telnet, etc).

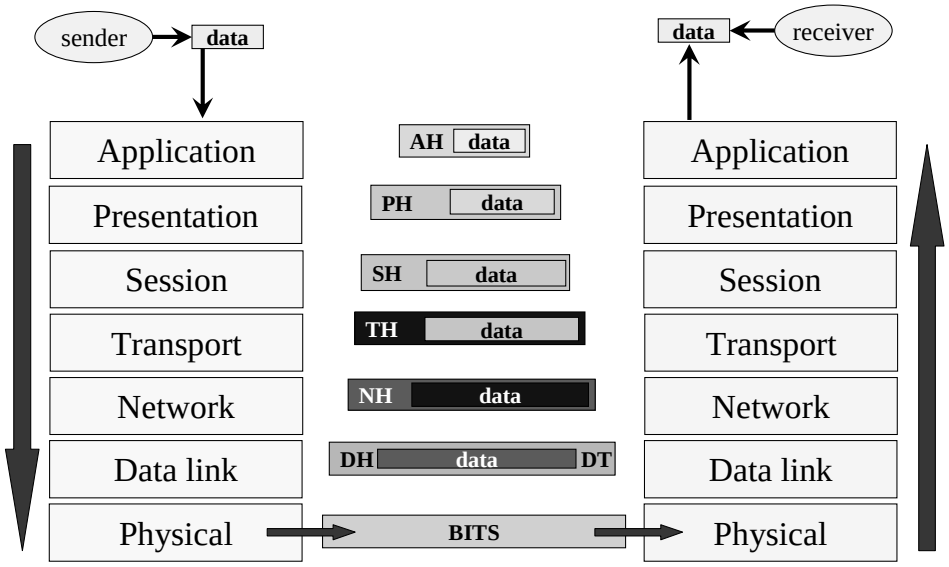
Communication Between Layers within a Host

It's important to specify the services offered to higher layers in the hierarchy. What they are and how to use them: *interface* (or perhaps API).

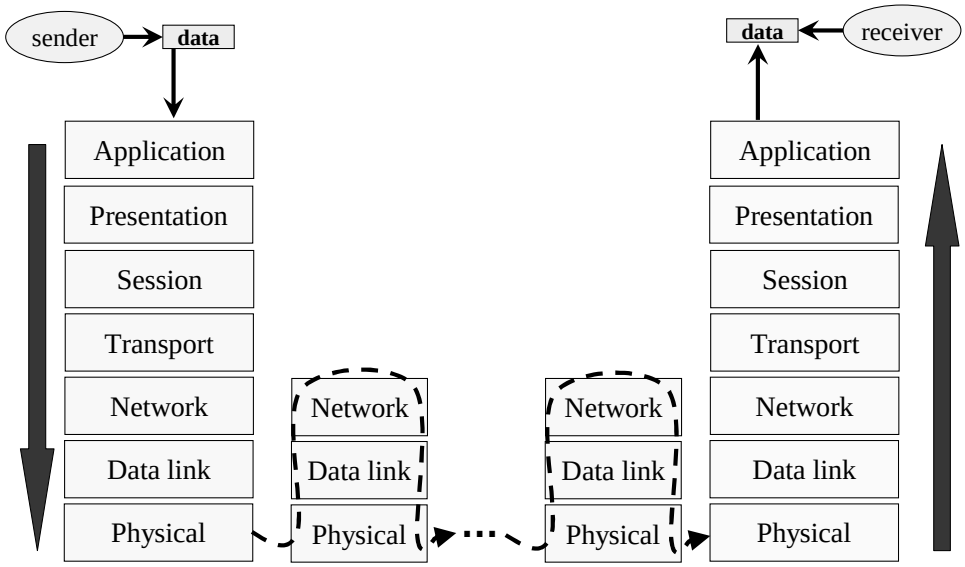
SAPs (service access points)
Note: This is ISO terminology.



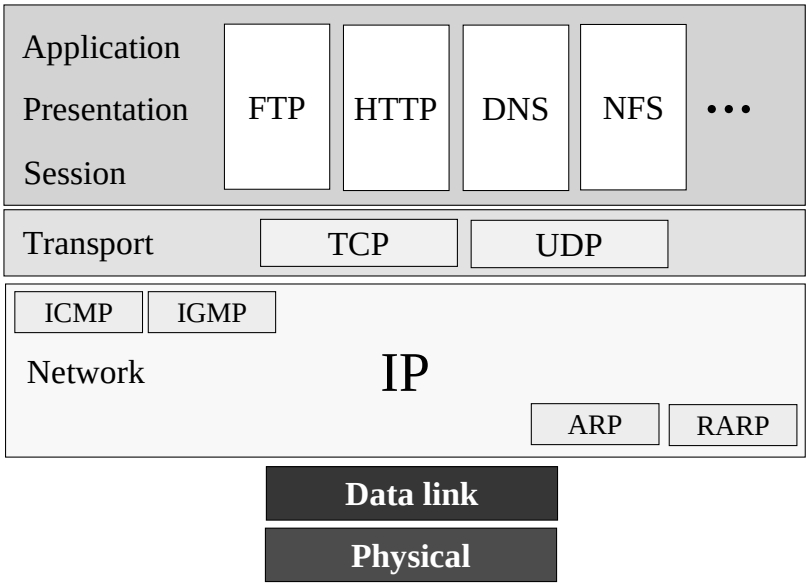
Communication Between Layers in Different Hosts



Communication across Many Hosts



The Layers in the TCP/IP Protocol Suite



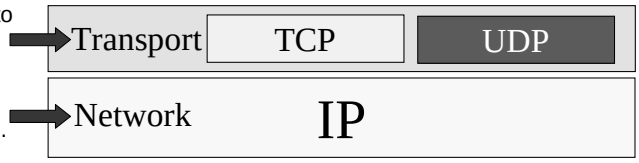
The TCP/IP Protocol Suite

TCP: connection-oriented; addressing involves host (IP address) and port number; packets are delivered in the order they were sent; no packets are lost.

UDP: best-effort datagrams; addressing involves host (IP address) and port number; packets are delivered in the order they were sent; no packets are lost.

Takes data and breaks into packets.

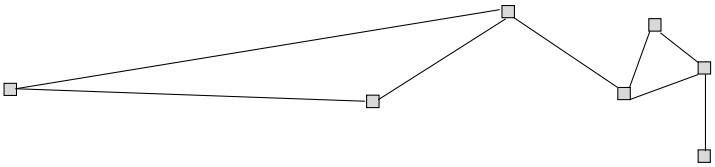
Pushes packets around from source to destination.



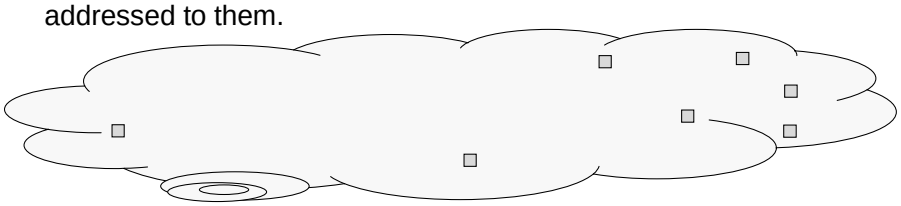
IP: defines addressing as in 127.0.0.1 (four bytes); data unit is the packet; packets are sent using the *datagram* paradigm.

Design Alternatives

Point-to-point channels: Physical links (as in wiring) connect every two communicating parties with a “private” channel.

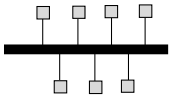


Broadcast channels: Communicating parties are connected by a shared medium; hosts can hear transmissions not necessarily addressed to them.

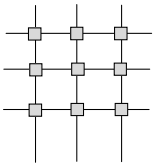


Network Topology

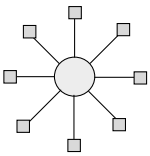
We can classify computer networks according to their topology:



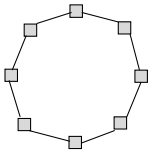
bus



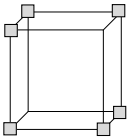
mesh



star



ring



hypercube

Range of Coverage

We can also classify computer networks according to their geographical coverage:

LAN: local area network

WLAN: wireless local area network

MAN: metropolitan area network

WAN: wide area network (long haul network)

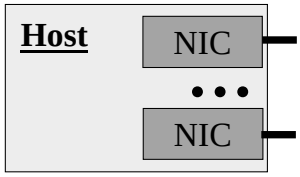
Most commonly, we're interested in the seamless integration of all these levels (as in the Internet).

Note: Different levels use very different technologies.

Technology

Network Interface Card (NIC): I/O device in the computer system that allows it to join a network.

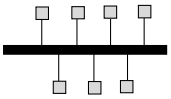
The NIC works with a specific medium (twisted-pair, coaxial cable, optic fiber, etc).



As long as its bus allows, a host can have multiple NICs.

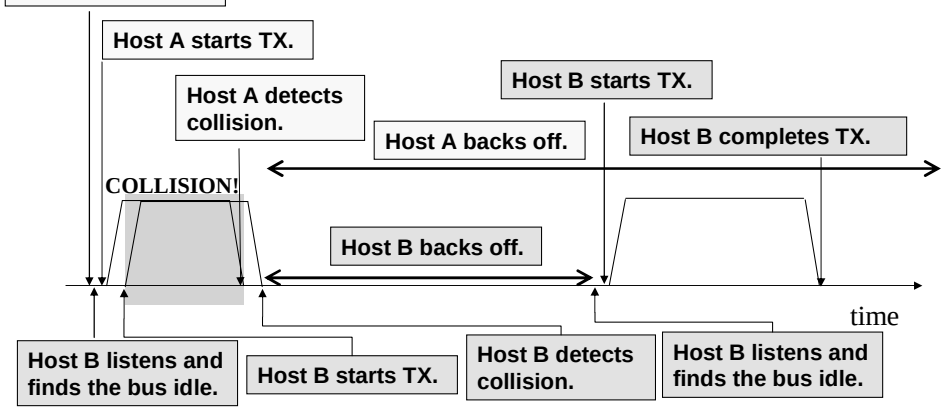
To the host, the NIC is just another I/O device, which has its own address (known as MAC address, set by the manufacturer). A *protocol* determines how the NIC accesses the medium.

Ethernet

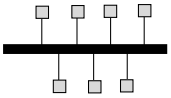


Ethernet has a bus topology.

Bus Arbitration by Collision Detection:
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

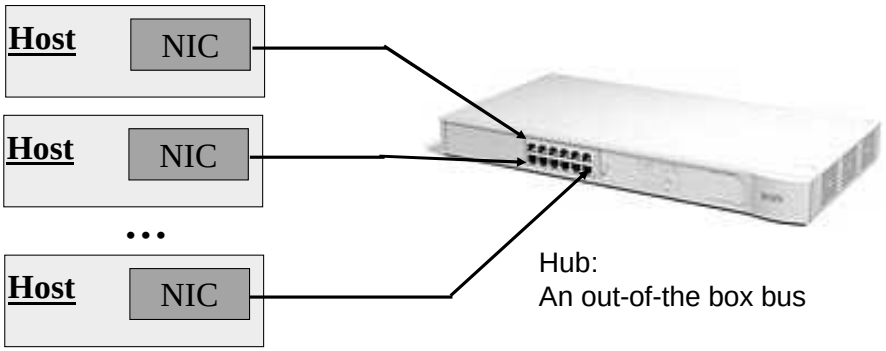


COTS Ethernet



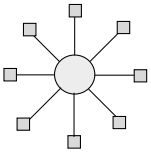
Ethernet has a bus topology

The medium could be anything that allows for a bus implementation.
(some options are easier to work with than others)

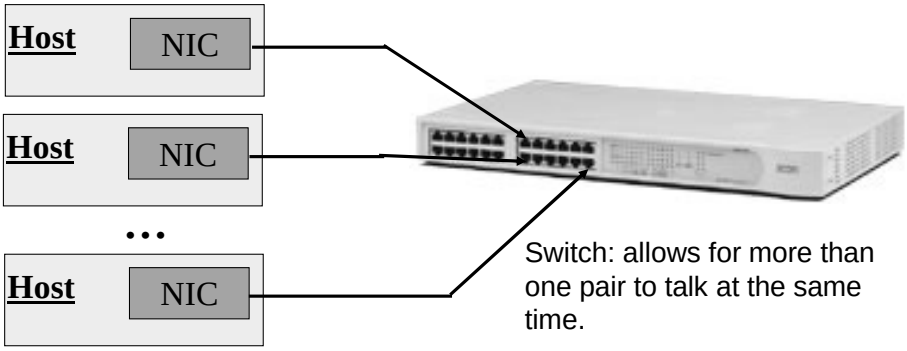


Hub:
An out-of-the box bus

Switched LANs

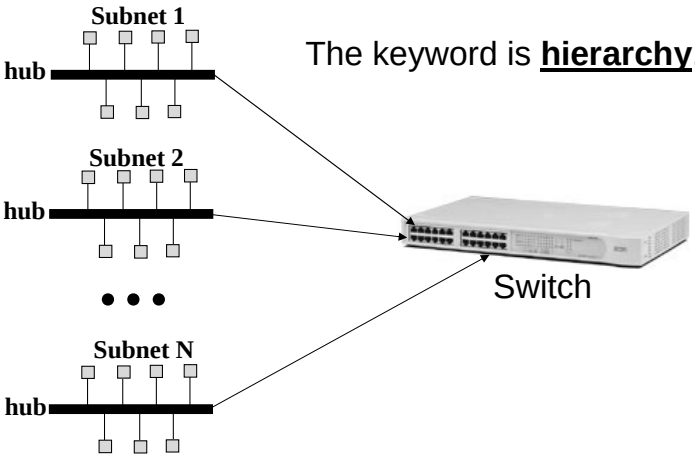


The bus bandwidth is limited: switches offer point-to-point connections.



Switch: allows for more than one pair to talk at the same time.

Network Architecture for Performance



The keyword is **hierarchy**.

Network Architecture for Performance and Coverage

Again, the keyword is **hierarchy**: