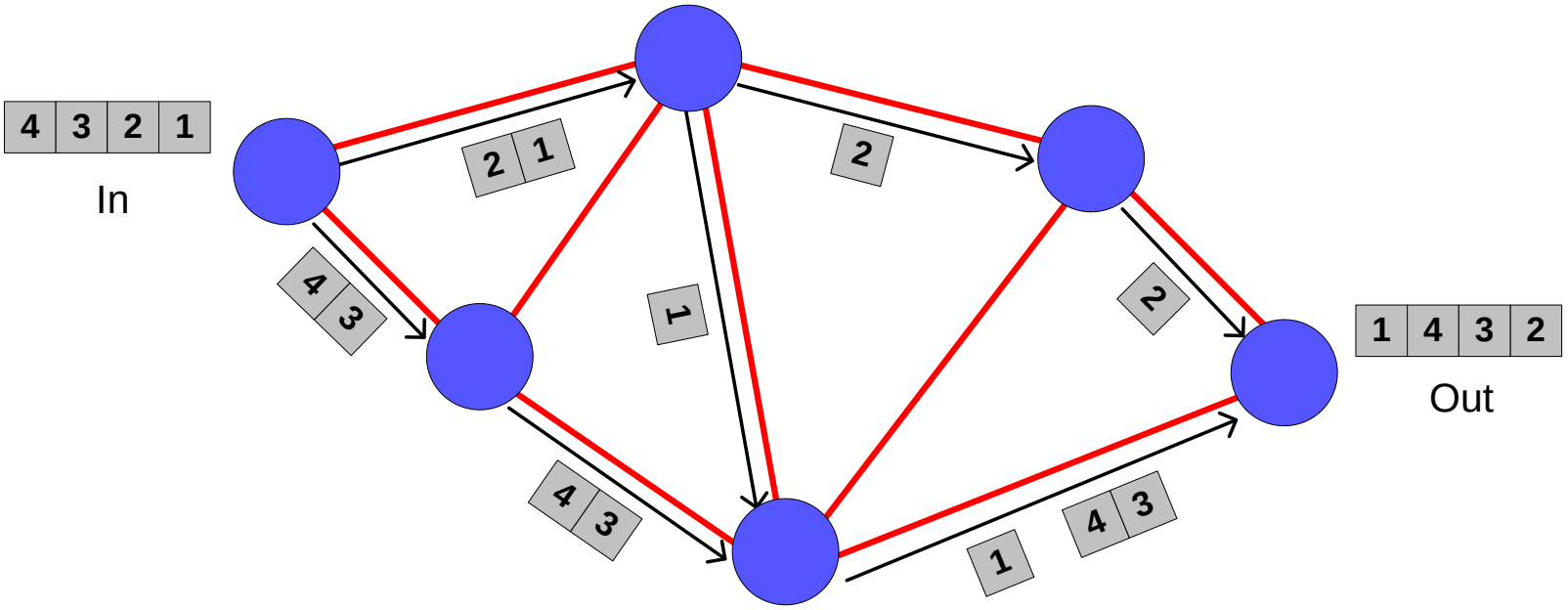
Data Communication Networks

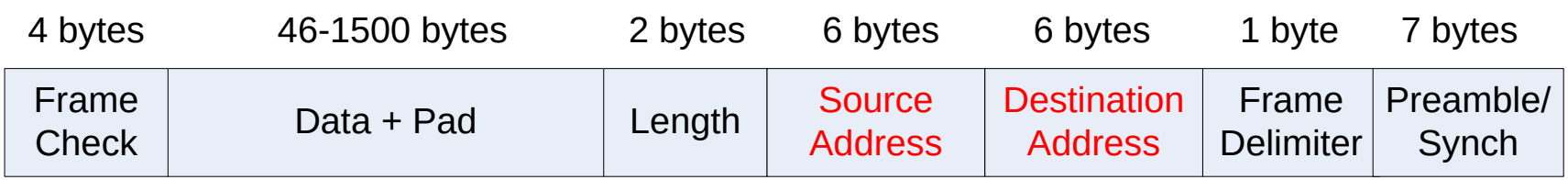
- Data communication networks typically do not send real time data
- As a result, packet switching is often used

Packet Switching



- When data is switched packet by packet, individual packets (or frames) can follow separate paths

Ethernet Packet Structure



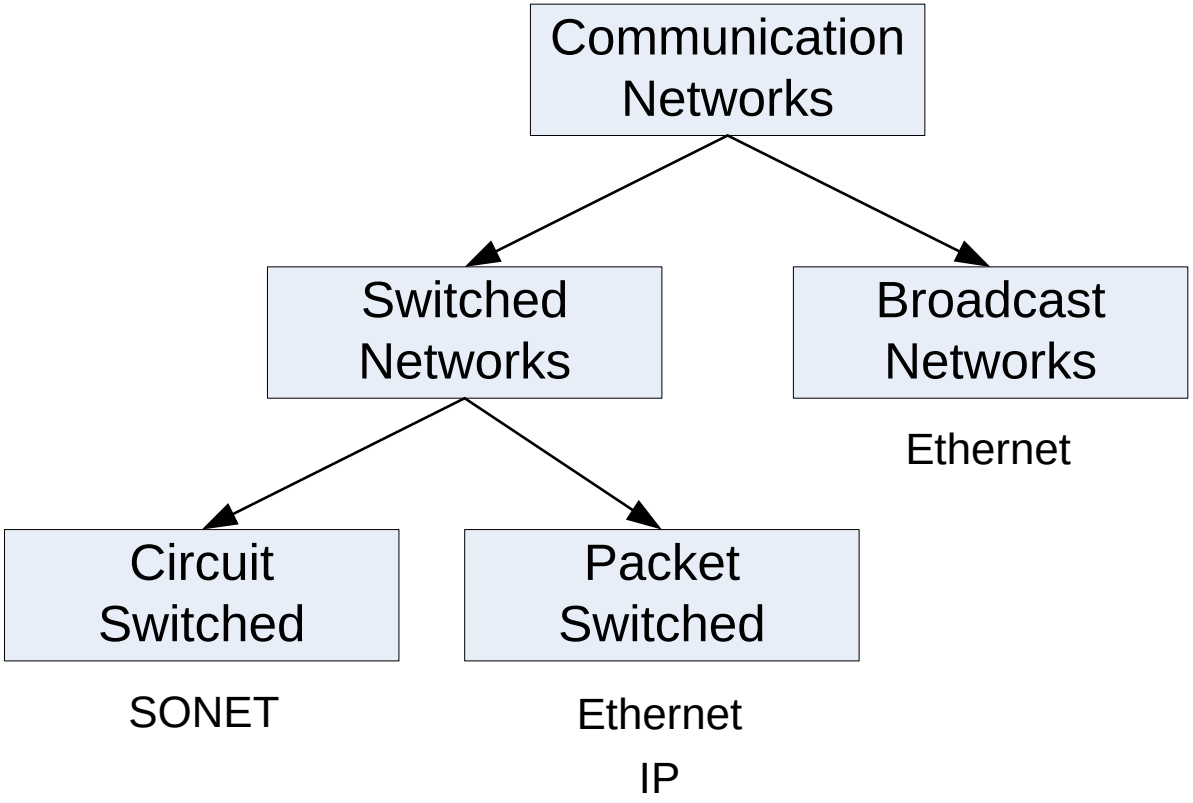
- Ethernet data packets contain address information that is used to direct the packets through a network

Internet Protocol (IP) Packet Structure

Source Address
(e.g. 172.16.2.32)
Destination Address
Sequence Number
Time to Live
Type of Service
Total Length
...

- IP packets contain address information that is used to direct the packets between hosts (e.g. computers) that may be in different networks

Network Classification by Switching Type



- There is no switching in broadcast networks
- Ethernet networks often contain broadcast regions connected by packet switches

Anatomy of a Data Communication Session (from *Network Routing Basics*, by James Macfarlane)

Sending Side

- Data from the user's application (on Computer A) must be passed to the network.
- The data may need to be converted (ASCI to EBCDIC for example).
- The data may need to be encrypted and/or compressed.
- If reliable communications are desired, a communication channel with the destination computer (computer B) must be established to track each packet. In that case, a mechanism is needed to tag each packet and follow up on the delivery attempt.

Anatomy of a Data Communication Session

Sending Side

- The data must be broken up into smaller chunks that can be handled by the network (you don't send a 10MB file in a single packet).
- The logical and physical addresses (IP address and MAC address respectively) must be determined for the destination computer.
- Error-detection information must be added to the packets.
- The best route to the destination host must be determined.

Anatomy of a Data Communication Session

Sending Side

- The packets then need to be formatted into the particular frame type unique to the network architecture of the of computer A (Ethernet, Token Ring, and so on).
- The packets must be converted into electrical or optical signals and placed on the cable or optical fiber.
- Access to the network cable or optical fiber must be managed.
- The packets may need to be repackaged along the way into a differing frame type if computer B resides on a network with a different LAN architecture.

Anatomy of a Data Communication Session

Receiving Side

- Computer B must have a way of knowing which packets are intended for it.
- Computer B must have a way of knowing which application should receive the packets
- Access to the network cable/fiber must be managed to retrieve the packets.
- The packets must be converted from electrical/optical signals to bits.
- The packets must be checked for corruption.

Anatomy of a Data Communication Session

Receiving Side

- The packets must be checked for correct order delivery and for missing packets. Packets received out of order must be reordered.
- If reliable delivery was utilized, an acknowledgement message must be sent for packets received intact. A retransmit message must be sent for missing packets.
- The packet data needs to be rearranged into a format the receiving application can understand.
- The data may need to be decrypted and/or decompressed.

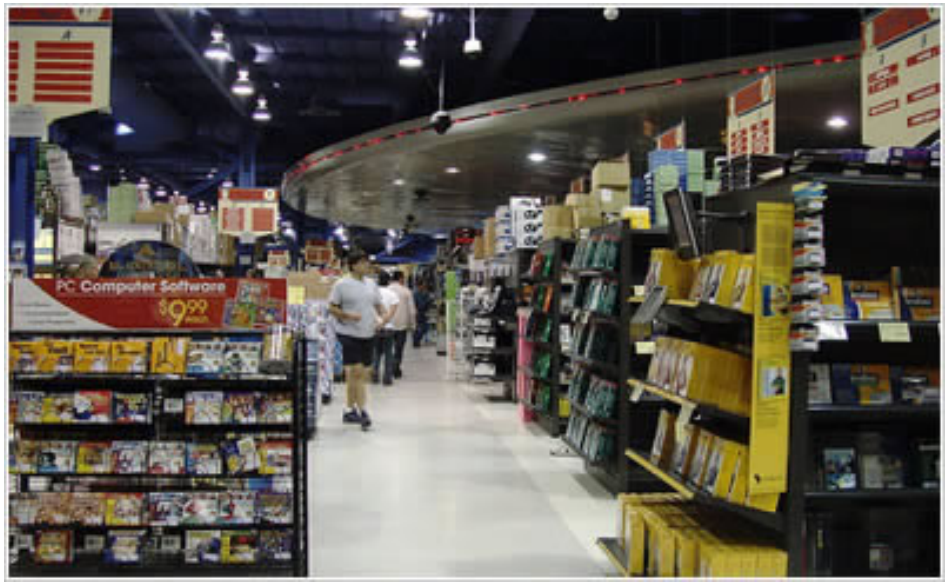
The Way Things Were in the Old Days

IBM 7904
"Mainframe"
- 1970's

- The manufacturer, e.g. IBM, handled all aspects of the computer to computer communication.

The Way Things are Now

- Multiple vendors handle various aspects of the communication.



Fry's Electronics
Palo Alto, CA, 2008
(photo by Klaus Nahr)

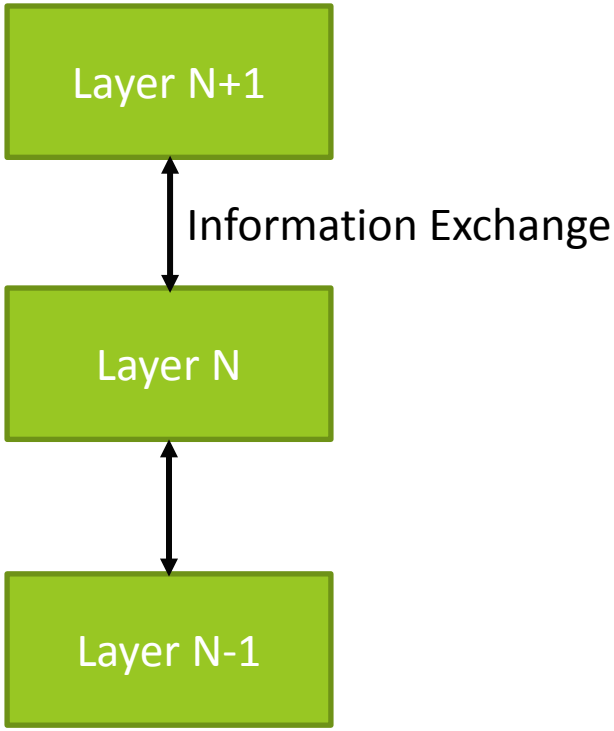
Problem → How do we ensure compatibility?
Answer → The OSI layered model (ISO, 1984).

The Open System Interconnection (OSI) Layered Network Model

	Layer Name	Function	Device
Host Layers	7 Application	Network entry point for data received from application	
	6 Presentation	Application based conversion, translation, encryption, and compression of data	
	5 Session	Establish a communication with another host	
	4 Transport	Breaks data into segments, flow control, ensure packet delivery	
Network Layers	3 Network	Address packets (logical address), route determination, determines physical addresses	IP Router
	2 Data Link	Frames packets (appends physical address and error detection bits), handles access to network media	Ethernet Switch
	1 Physical	Converts bits in frames to electrical/optical signals	Repeater

Based on *Network Routing Basics*, by James Macfarlane

Intra-Node Layer Communication



- In the OSI model, layers communicate only with other layers that are immediately above are below them.
- CIAN is investigating “cross-layer” communication between non-adjacent layers

Inter-Node (Peer-to-Peer) Communication

Presentation Layer ⟷ Logical Connection ⟷ Presentation Layer

Physical Layer ⟷ Physical Connection ⟷ Physical Layer

Optical Transceiver — Optical Fiber — Repeater (Optical Ampfier)

- For different network nodes, communication is only between the same layer