



# Computer Perspectives: Computer Communications

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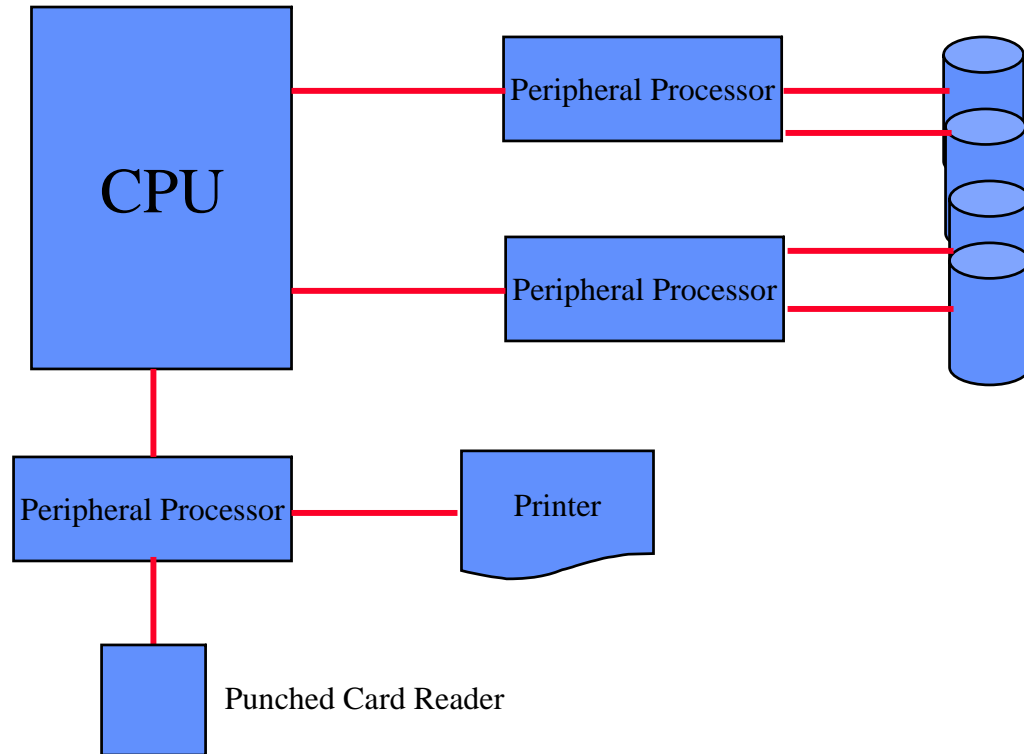
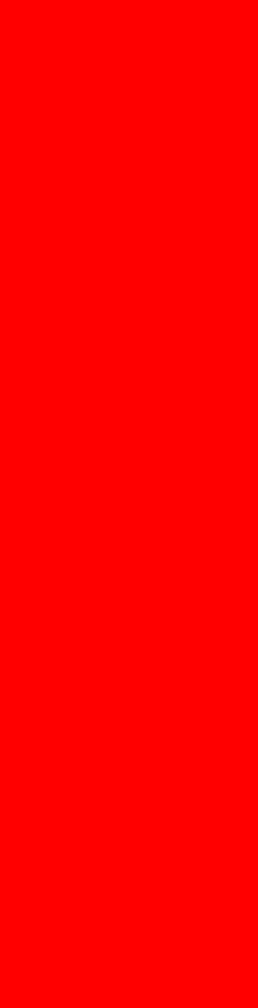
# The 1960's

- The age of the "mainframe", which carried on to the late 70's (and mainframes are still important)
- Big chunk of resource, shared by hundreds or thousands of users.
- "Batch" processing: specify
  - program(s) to run,
  - input dataset(s)
  - output dataset(s)
- ...and then scheduler releases "job"
- No interaction with user while running



# Mainframe Organisation

- A very important consideration in mainframe design is input/output (I/O) performance
- Mainframes were not single computers, although very often there was a single central processing unit (CPU)
- Peripheral processors handled various I/O tasks and arguably the development of "minicomputers" owes much to this approach.





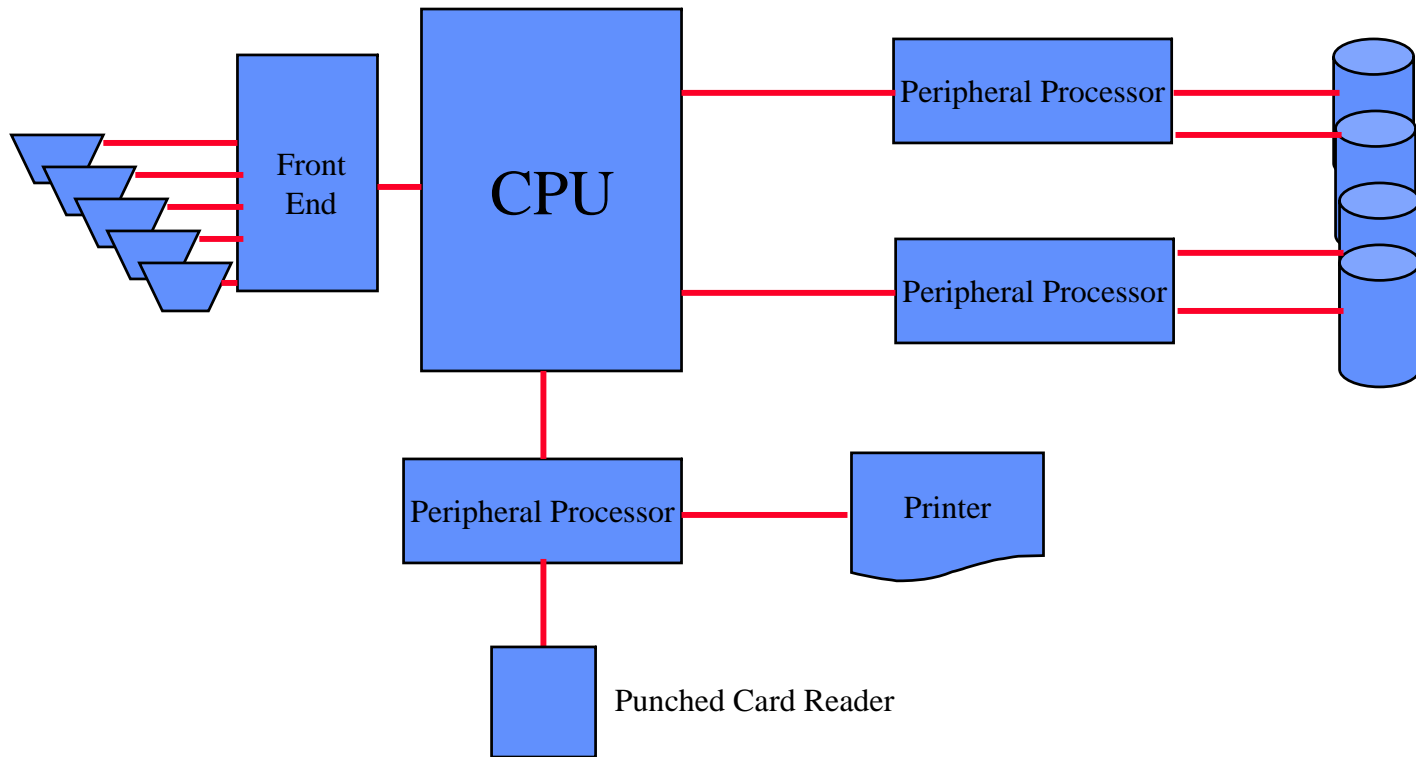
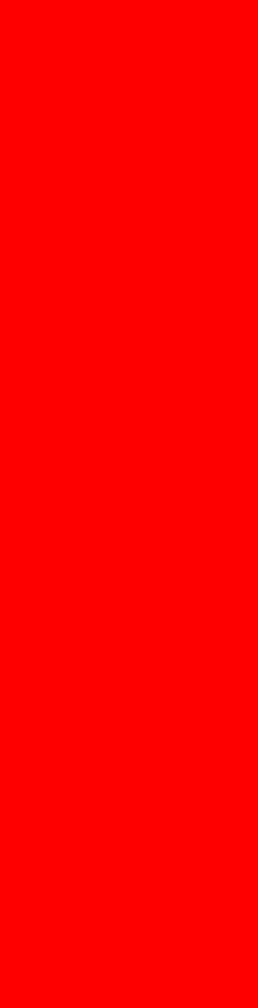
# Mainframe Org (cont'd)

- There is interprocessor communication over a specialised network.
- Proprietary, eg IBM defined its own interprocessor communication system
  - Peripherals were called "channels"
  - CPU would issue Execute Channel Program (EXCP) commands to channels
  - Companies other than IBM manufactured channels for IBM mainframes



# Time Sharing

- Interactive services ("time sharing") began to be developed in the 1960's (eg Cambridge 1961)
- Began appearing commercially in the late 60's including the truly dreadful TSO (time sharing option) from IBM.
- Peripheral processors which handled terminals were known as "front ends"





# Communication Evolution

• Two types of development:

- Improving the internal interconnect, and
- Extending the distance for the terminal link

Terminal links were also not universal standards (in particular IBM had high speed shared loops for connecting terminals to front ends) but standards for low speed terminals emerged (RS232) at 30, 120, 240 and 960 characters per second

These low speed terminals operated very simply, by sending and receiving single characters





# The first step?





# First Step Continued

- Probably first step in "convergence" between telecommunications and computing
- Note that nothing special is required from the telephone network, just ability to carry representations of acoustic signals
- The interface is not the socket on the wall, it's the telephone handset (acoustic, not electrical)!!!
- Well known in mid 60's; commonplace by the early 1970's



# Father of Packet Switching

- Donald Davies of UK National Physical Laboratory (NPL) "Proposal for the Development of a National Communication Service for On-Line Data Processing" (1964) and "Proposal for a Digital Communication Network" (1965)
- Concept of packet, envisaged links of 1.5 Mbps, switching 10,000 messages per second



# Arpanet

## 1967 Meeting of ARPA Principle Investigators

- (ARPA = Advanced Research Projects Agency of US Dept of Defense)
- Principle Investigators at universities in US
- To construct a network consisting of telephone circuits and switching nodes would facilitate resource sharing among computers on the network.
- Implement protocols and procedures within each connected computer in order to allow the use of the new network by the computers
- Switching node, the Interface Message Processor (IMP), was specified and ARPANET was approved in June 1968.
- Email, remote login (telnet), file transfer born



# An Observation at MIT

- Bob Metcalfe, building an IMP for MIT in 1970 discovers significant traffic entering the IMP from one MIT computer and going to another, i.e. not to the ARPANET: "Anomalous Traffic"
- "Sort of embarrassing", not using the ARPANET properly
- 1973 Bob invents the Ethernet at Xerox PARC
- 1982 Bob founds 3Com



# 1975-1985: The LAN

- Lots of different Local Area Networks:
  - Ethernet at Xerox PARC (Metcalfe, Boggs)
  - Token Ring at MIT (later at IBM) (Saltzer, Clark)
  - Slotted Ring at Cambridge (Hopper, Wilkes, Wheeler, Needham)
- Very simple systems, not terribly reliable
- But perhaps more importantly, distributed computing born: shared peripherals, shared file servers, and eventually the workstation: SUN MicroSystems, NFS, X-Windows,...



# Meanwhile, back in telco land...

- Digital telephony contemplated in 1960's
- In fact some pioneering work in the UK which got dropped (well postponed)
- Disgruntled engineers off to Canada, and Bell Northern Research launches first digital exchanges in mid 70's (Nortel breaks out of Canada)
- 1980 UK launches digital exchanges



# State in 1985

Almost three separate worlds:

- Internet (scaling up of Arpanet) dominated by academics. Email becoming only application.
- Local Area Networks dominated by computer manufacturers (and 3COM). Mainframe distributed.
- Traditional telecommunications dominated by traditional teleco operators and their suppliers

"Net heads and Bell heads"





# Convergence

● This is a relative term:

- Computers controlled exchanges long before digital telephony
- Internet has always run over links supplied by telecommunication operators
- LANs brought the ideas of computation and communication together, but industries remained separate. No one thought to buy Cisco until it was too late. (Although in late 90's, Alcatel bought Newbridge, Nortel bought Bay, Marconi bought FORE)

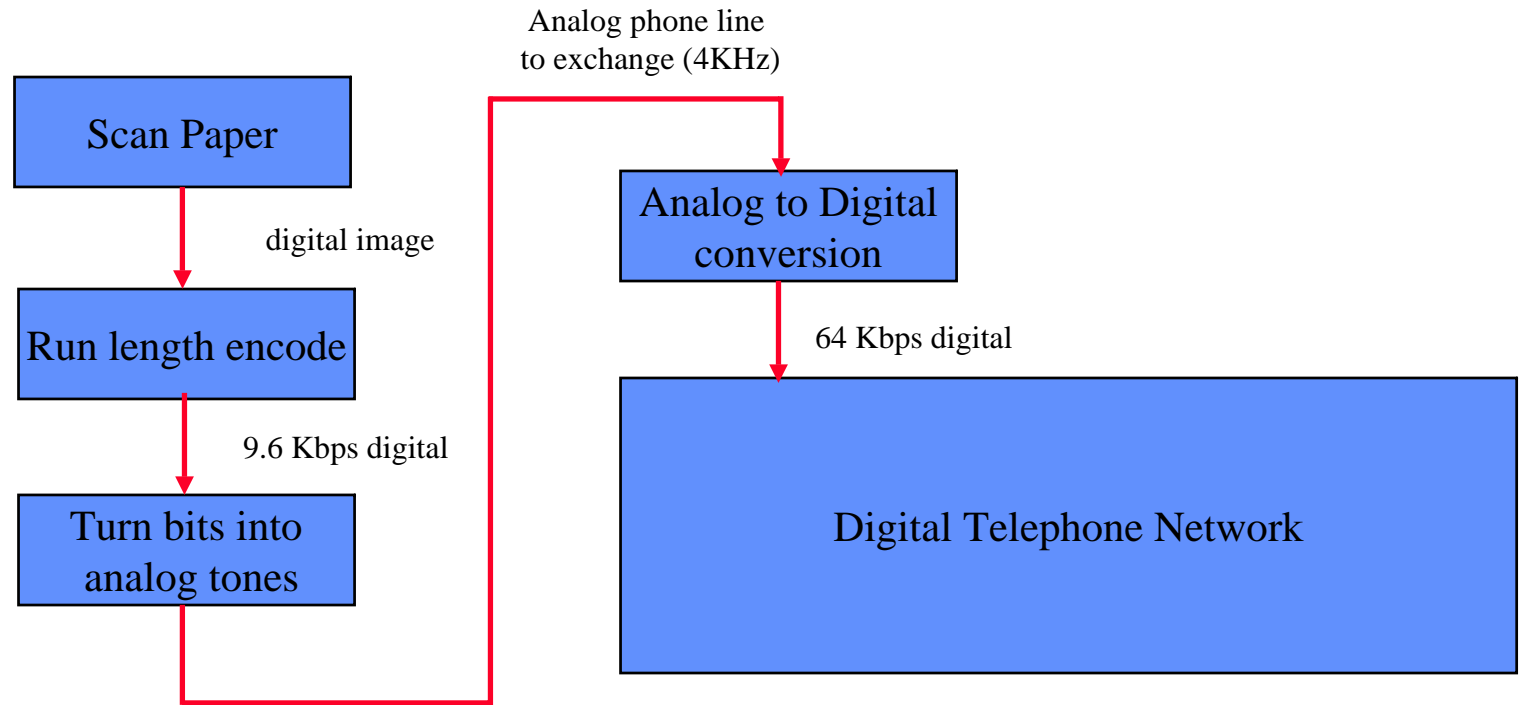


# Going Digital

- Worldwide changeover from analog to digital through the 1980's (BT turned off last analog exchange in 1995).
- Almost no change in service interface customer saw. All we've really done is move the interface to the wall socket, but its still analog in 95% (guess) cases.



# Eg fax: Is this sensible?





# LANs in the 90's

- Became "mission critical"; no longer toys
- Move away from "shared media" to switched for both performance and reliability, enabled by low cost integrated circuits



# Internet in the 1990's

- Always enjoyed exponential growth
- But there is a point where exponential growth becomes conspicuous: the Web
- This decade saw the convergence of local and long haul data communication.
- Decade belonged to Cisco which briefly became the largest company by value (\$500B)
- (Now only \$154,795,973,220 as I write.)



# Long haul capacity, 90's on

- Progress in optical transmission has been enormous.

- Telco operators seeing demand increasing so putting in more fibre
- Progress in getting more information down a wavelength of light
- Progress in getting multiple wavelengths of light down a fibre
- Costs of laser components falling rapidly

- Glut of transmission capacity



# Changing the interface

- Demands of end user traffic and ability to perform very clever (and adaptive) coding finally changed the interface to the telephone network in the late 1990's.
- Still not pervasive, but growing (DSL, wireless local loop)



# Have we converged?

- In an intellectual sense, yes.
- We rarely think about computers (including PDAs, mobile phones) in isolation.
- Television, Internet converging
- Voice network still works largely as a separate service from the Internet (although the underlying transmission systems are common)





# Has it all been done?

- Don't confuse malaise in an industry with lack of innovation
- We are seeing the effects of a successful development with "pioneers" reaping rewards but ending in commoditisation.
- But that means an inexpensive substrate on which to launch new innovation
- Lots of fun ahead