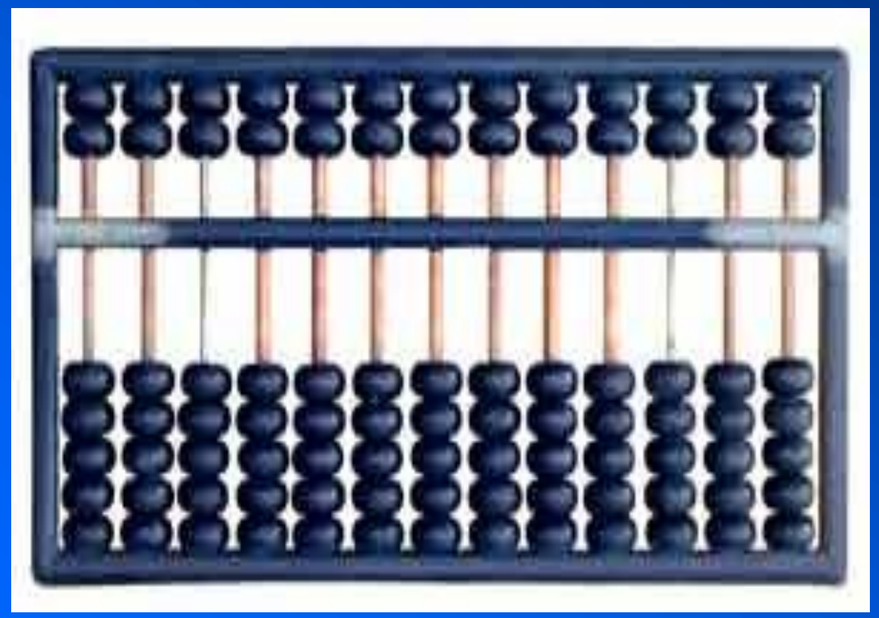
The computer: From abacus to Windows

- A brief history
- The guts of a computer
- Programming
- The Internet



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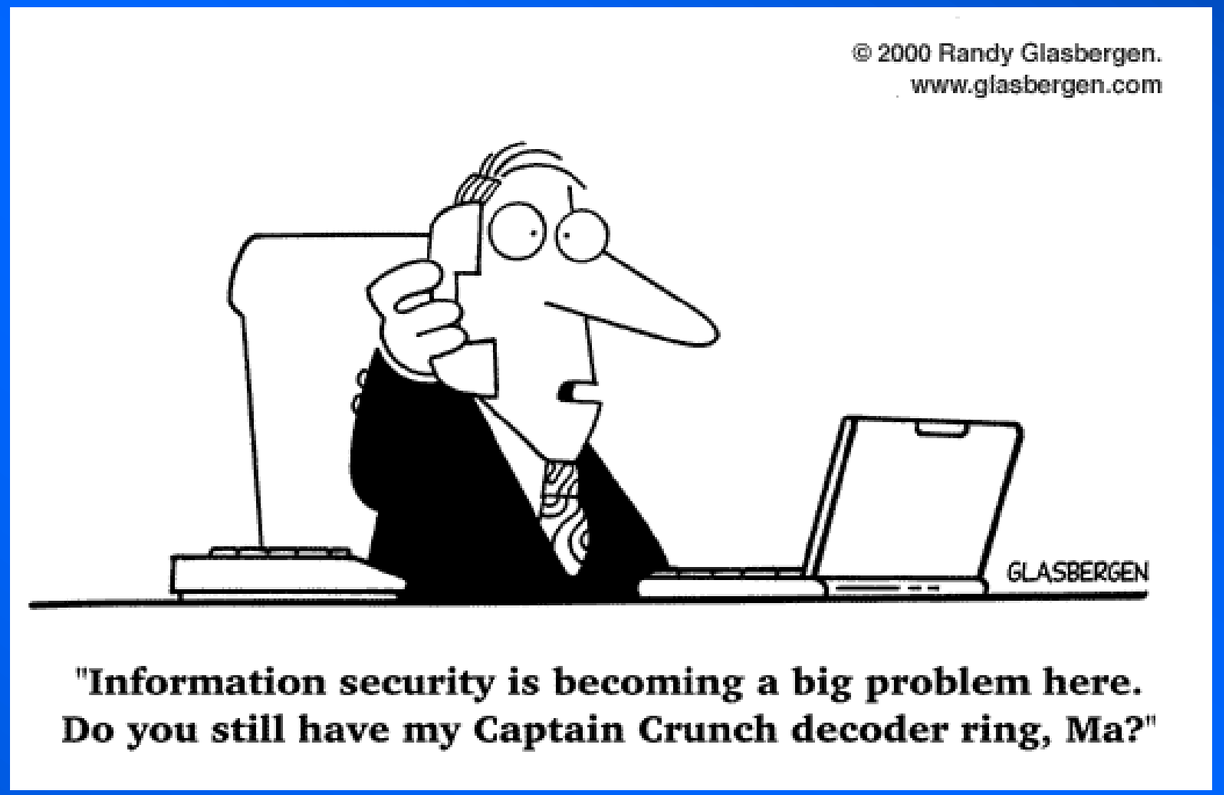
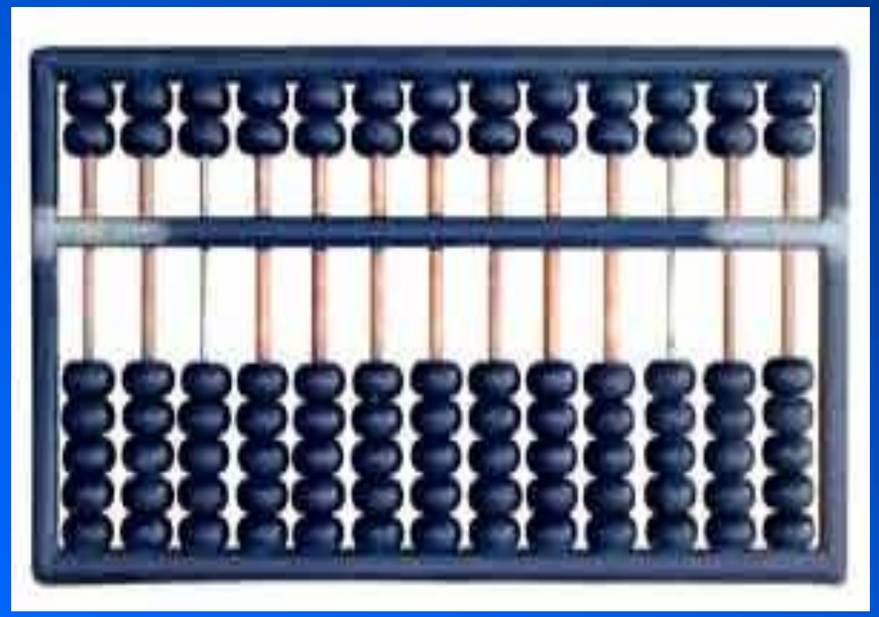
Computers An overview

- Abacus, Napier's bones, Jacquard loom, analytical engine, ENIAC
- Hardware, software, memory, I/O
- UNIX, DOS, Windows, NT
- Excel, Basic, Fortran, C, Matlab, Java, VB…



Along the way. More about …

- **Abacus and ENIAC**
- **Sputnik and PCs**
- **Fortran, C, VB**
- **Analogue and digital**



To err is human

To completely foul things up … takes a computer

A short history of computers before electronics

- 600 Chinese abacus analogue calculator

1617 John Napier: "Napier's bones" to calculate logarithms

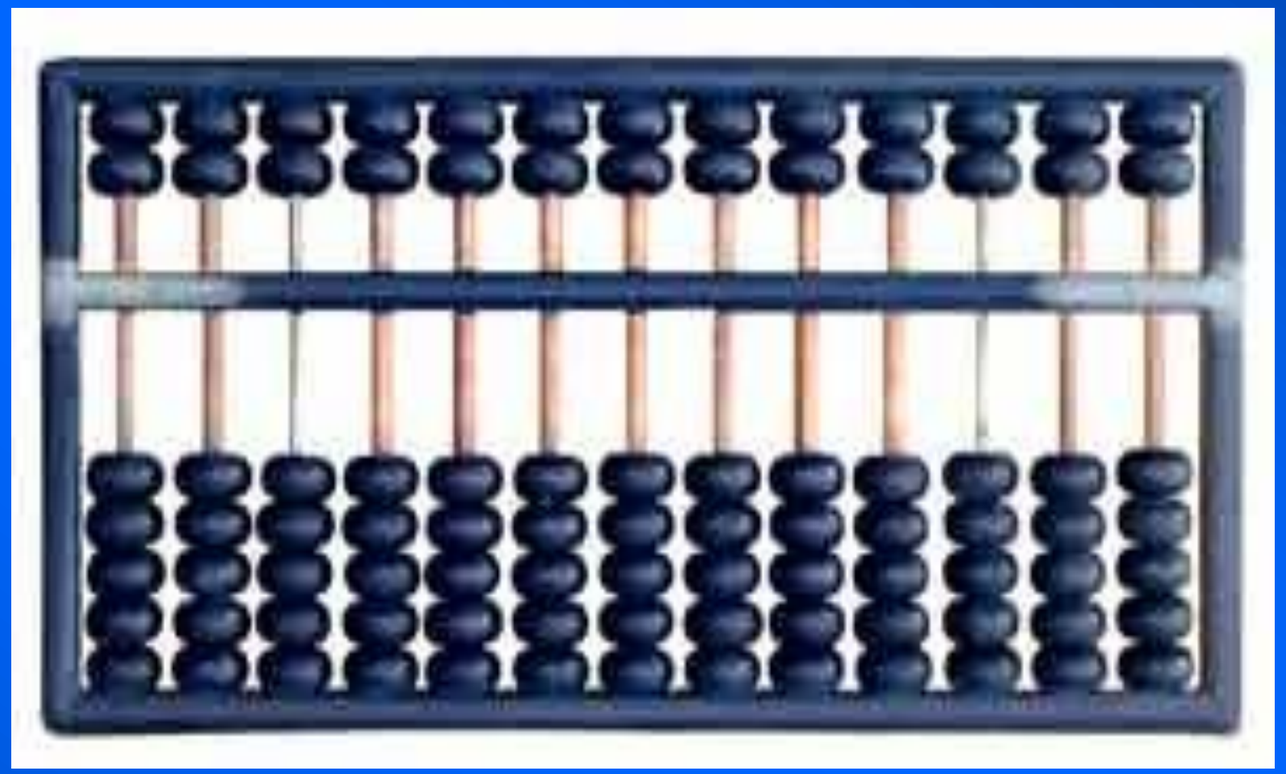
1642 Blaise Pascal: simple calculating machine (the *Pascaline*)

1801 Joseph-Marie Jacquard: Jacquard loom (punched cards for weaving)

1822 Charles Babbage: Difference Engine (tables of life expectancy)

1833 Charles Babbage: Analytical Engine (engineering beyond technology)

1854 George Boole: Boolean logic rules (true/false, on/off, 1/0, y/n)



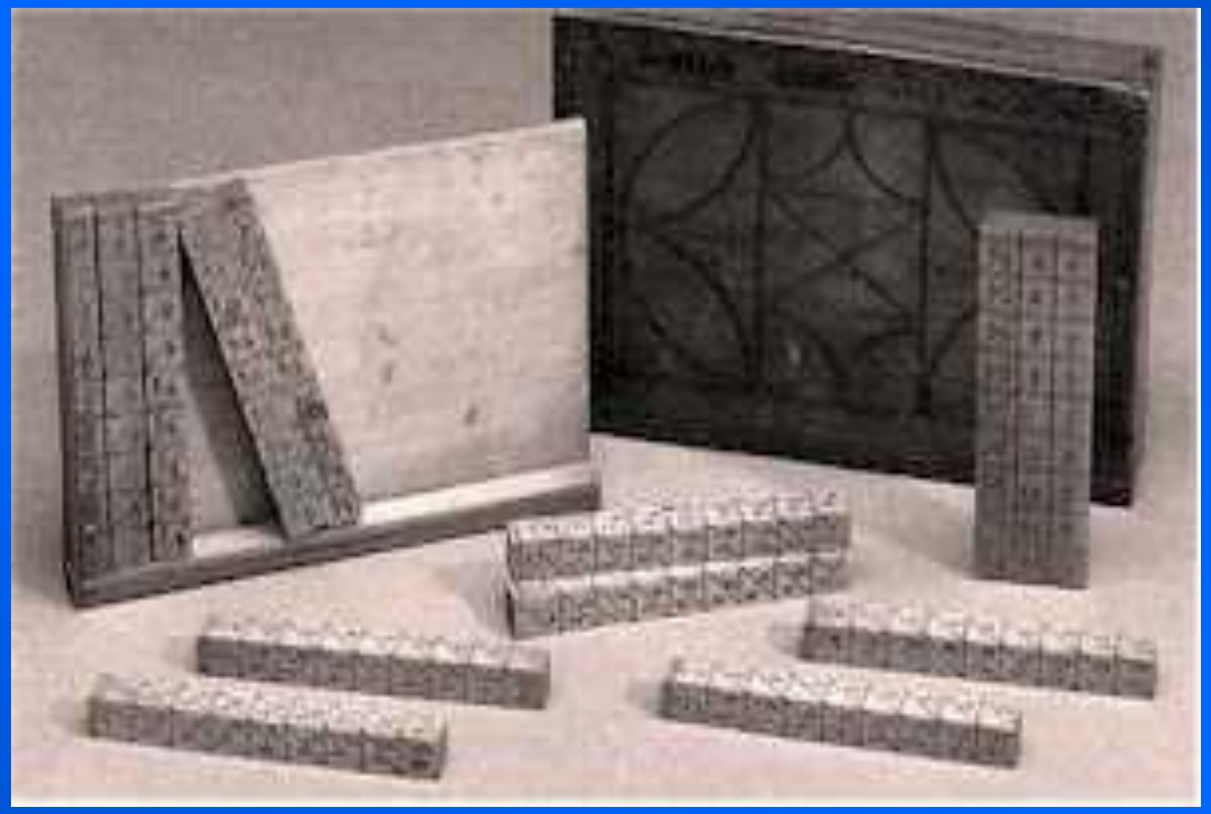
600 BC

Chinese abacus

- add, subtract, multiply, divide, take the square root
- from the Greek *abax* for “calculating board”
- *suan pan* in Mandarin, meaning "calculating plate"
- first record is a sketch in a book from Yuan Dynasty (14th century)
- called the **first computer**

1617

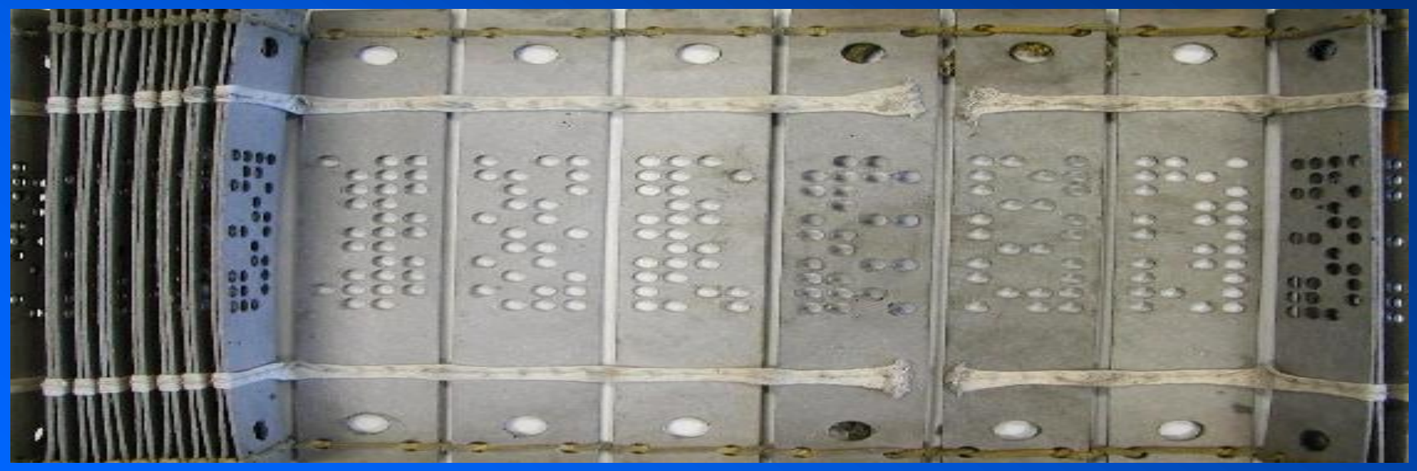
Napier’s bones



- a set of rods marked at the top with a counting number
- multiply by adding diagonally from right to left along a row
- a form of **logarithm** (exponents add when multiplied)
- aided astronomical calculations of Brahe and Kepler
- precursor to the modern **slide rule**

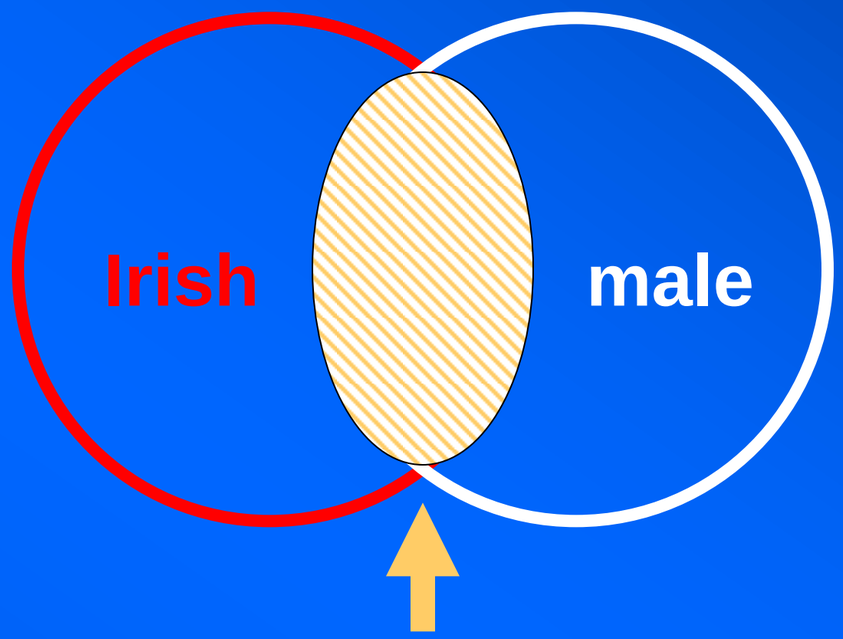
1801

Jacquard loom



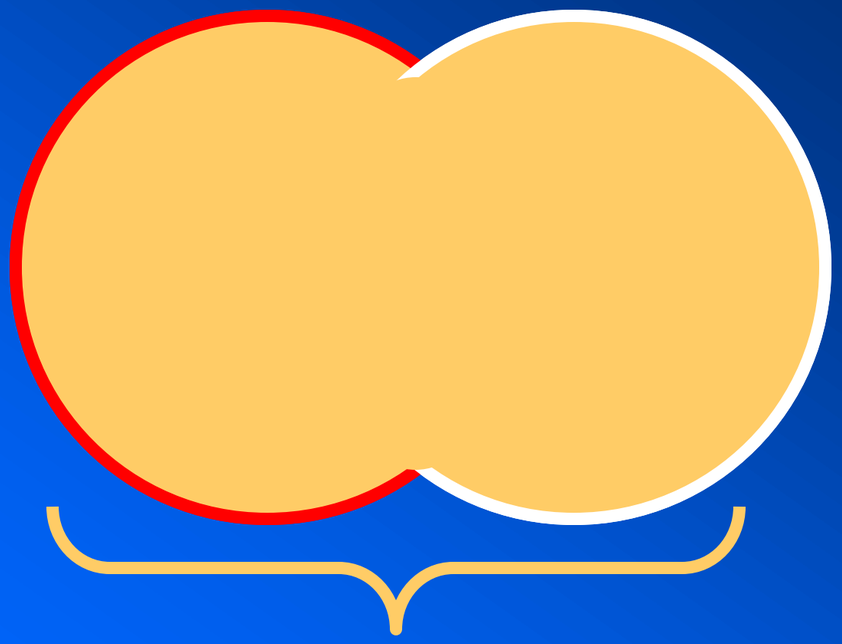
- **The Jacquard loom controlled the weaving with pattern-encoded, punched cards. A hole determined the loom action.**
- **Only very simple patterns were woven with the mass-production fabric-making machines of the Industrial Revolution.**
- **Up to 10,000 cards made up a "program."**

1854 George Boole (Boolean logic)



Irish and male

A AND B



Irish or male

A OR B

- reduced logic to simple algebra: AND and OR (and NAND, NOR)
- A AND B is the intersection (# of Irish males) (restricts)
- A OR B is the union (# of Irish or male) (expands)
- truth tables, binary logic, search parameters

A short history of computers after electronics

1890 Herman Hollerith: **punch card** (1890 U.S. census; 1911 British census)

1912 Lee de Forest: triode **vacuum tube** (cathode, anode, grid)

1943 British Colossus: 2,500 valves (code breaking)

1946 American ENIAC: Electronic Numeric Integrator And Calculator

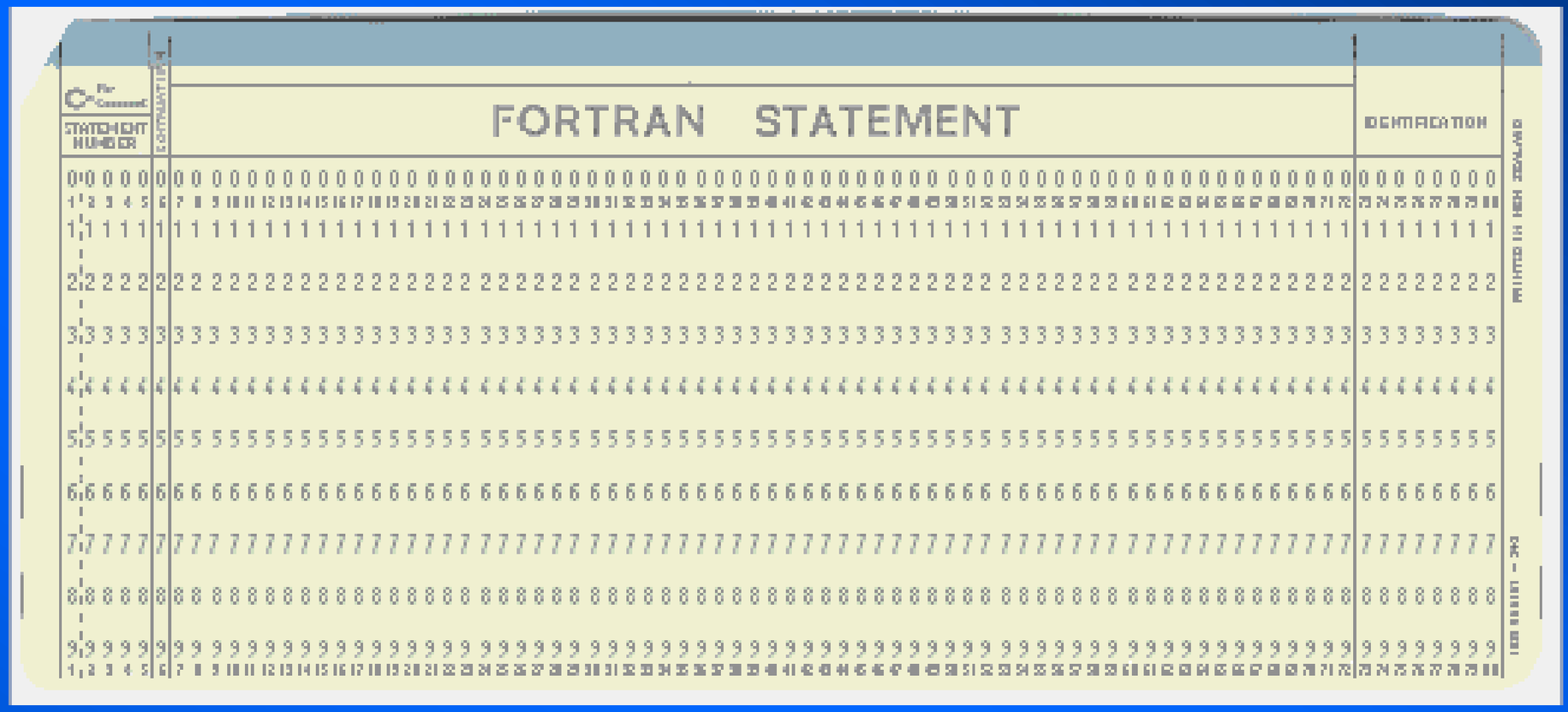
1947 Point contact **transistor**: Bell Labs (junction transistor in 1948)

1957 Soviet man-made satellite (***sputnik***) launched

1958 Integrated circuit (IC): Jack Kilby (TI) and Bob Noyce (Intel)

1971 First microprocessor: Intel 4004 (2,250 components/300 mm^2)

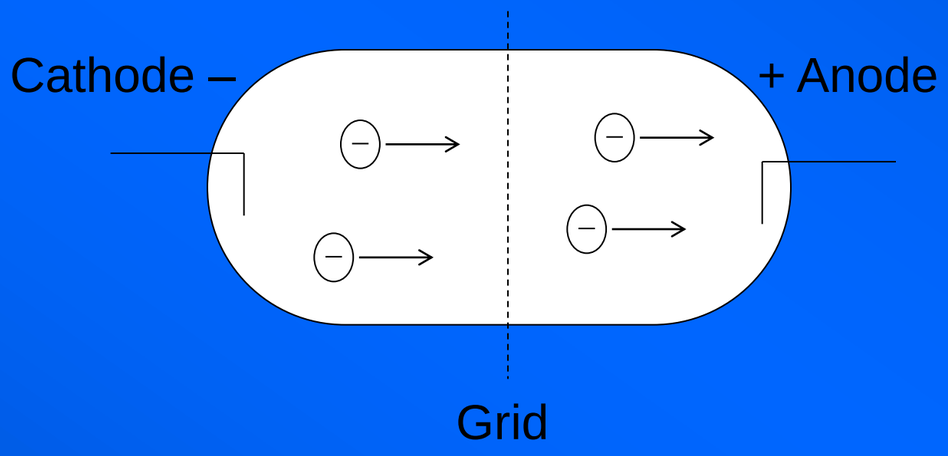
1890 Hollerith punch card

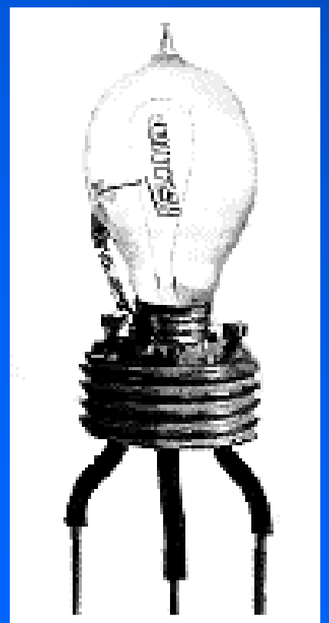


- Paper medium for inputting data
- The punched card was first used by the New York City Board of Health and several states for vital statistics tabulation.
- Punched cards were then used in the 1890 U.S. census by the **Tabulating Machine Corporation** (later called IBM).

1912

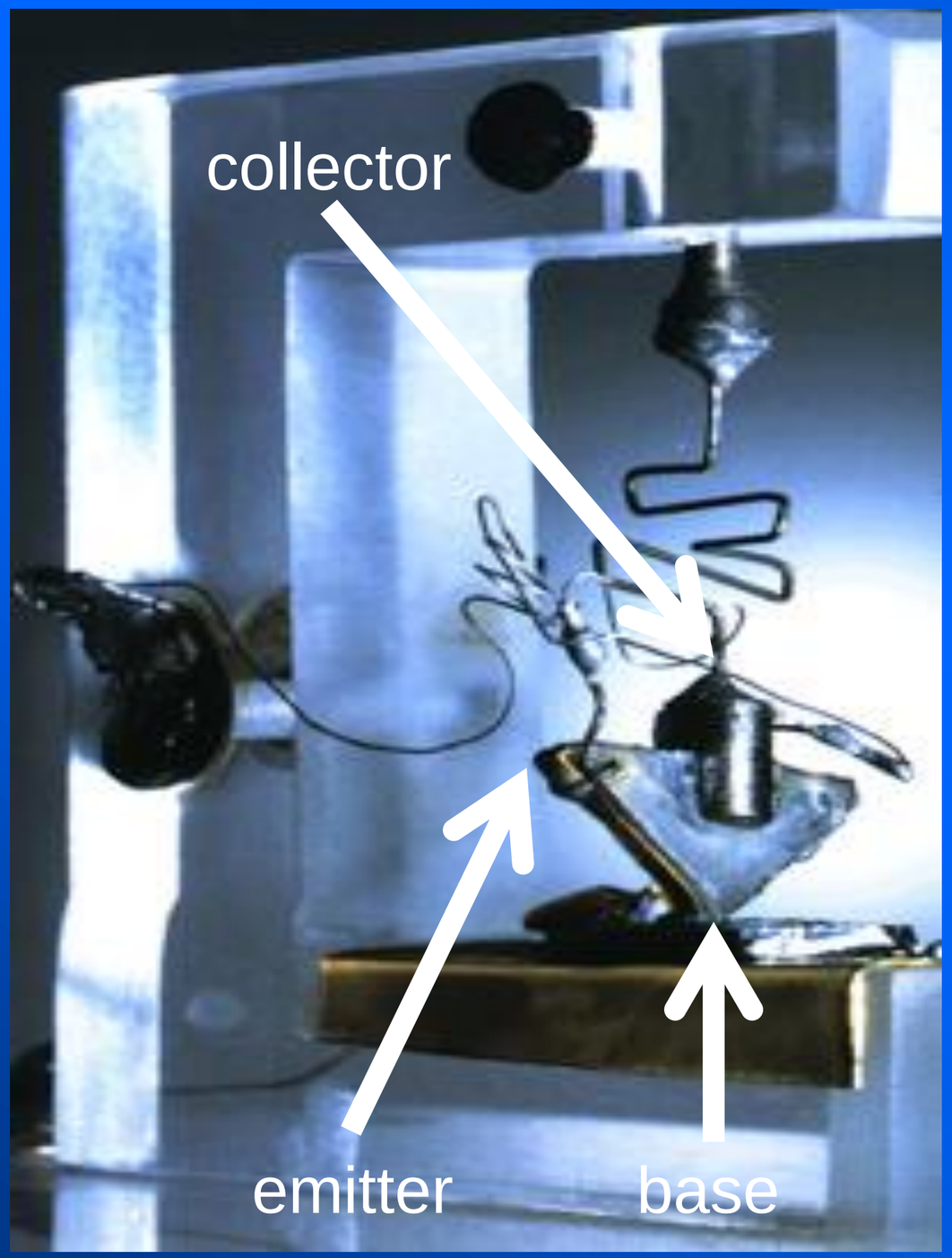
Triode vacuum tube





vacuum tube from the early 1900's

- **Lee De Forest added a third electrode (or grid consisting of small wires surrounding the cathode) to the vacuum tube.**
- **The grid's negative potential controlled the flow of electrons from the cathode to the anode.**
- **The lower the potential, the more electrons could flow, thus producing an amplified current.**



1947

Point contact transistor

The point contact transistor (transfer resistor) was invented at Bell Labs by Shockley, Bardeen, and Brattain. ("This thing must have gain.")

Base so-called because the germanium semiconductor rested on the “base.” (Collector and emitter are vacuum tube terms.)

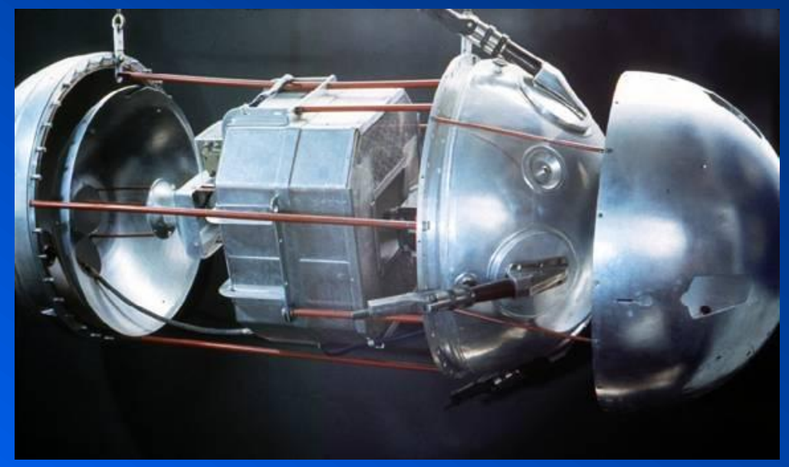
Amplified a current as in a vacuum tube (but not prone to breakdowns).

The junction transistor was invented a year later. (Silicon eventually replaced germanium.)

1958 Integrated circuit

- Cutting individual transistors, attaching electrodes, and reconnecting them was a difficult process.
- Jack Kilby (Texas Instruments) and Bob Noyce (Intel) both had the idea of "wiring" a circuit on one piece of semiconductor.
- The first integrated circuit (IC) consisted of one transistor, one resistor, and one capacitor on germanium. Silicon was used soon after.

1957-1969-1971 Sputnik-Apollo-Intel

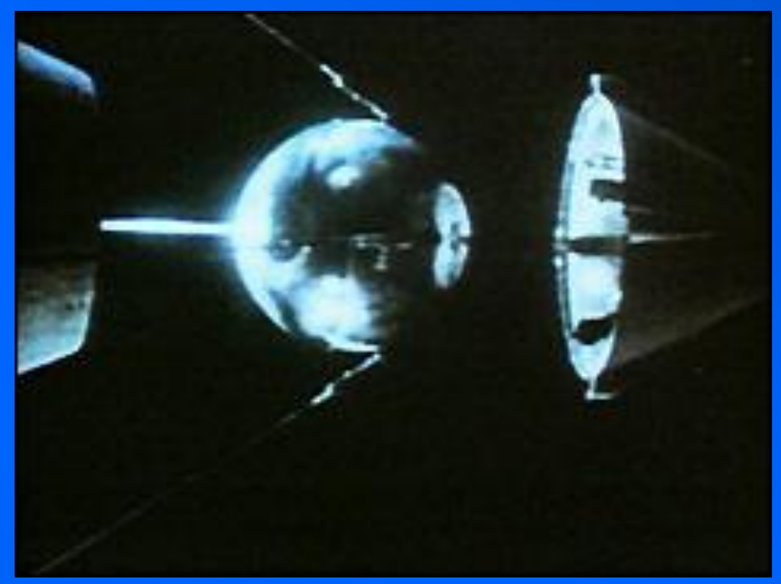


- **The USSR launched Sputnik (meaning satellite) … and the space race had begun.**

- **Our first artificial satellite was the size of a basketball, weighed 183 pounds, and took 98 minutes to orbit the earth. After 57 days in orbit, it was destroyed re-entering the atmosphere.**

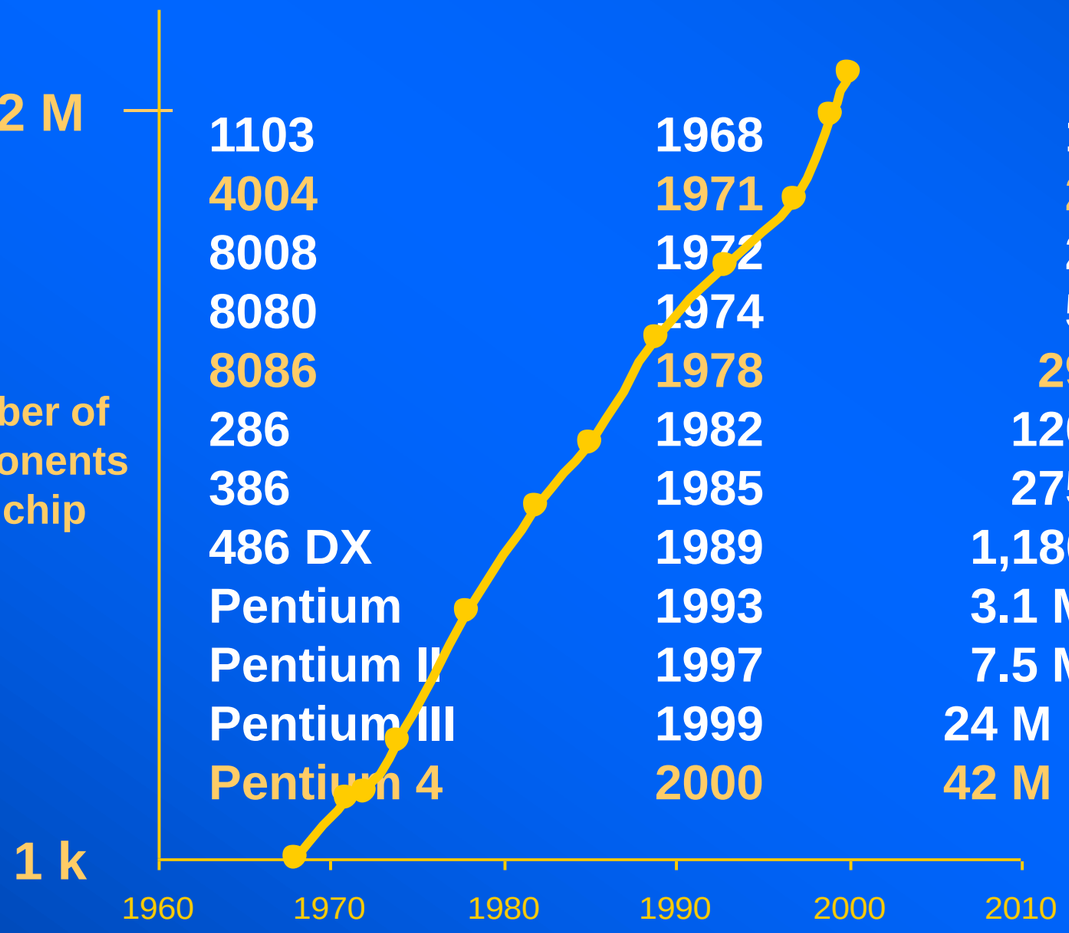
www.hq.nasa.gov/office/pao/History/sputnik/

- **“*Never before had so small and so harmless an object created such consternation.*” Daniel J. Boorstin, *The Americans: The Democratic Experience***

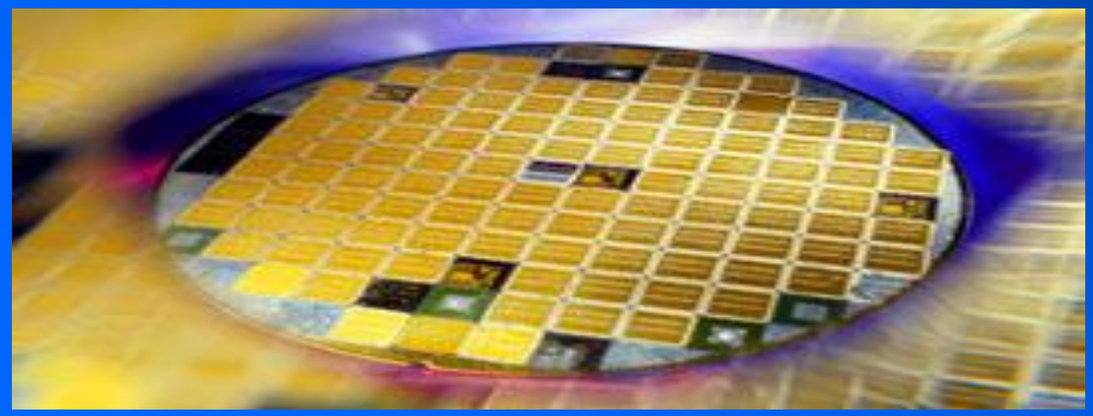


- **Sputnik and the following Russian and American space programs (with help from Intel) lead to miniturised and cheaper computer components.**

Moore's Law (1964)

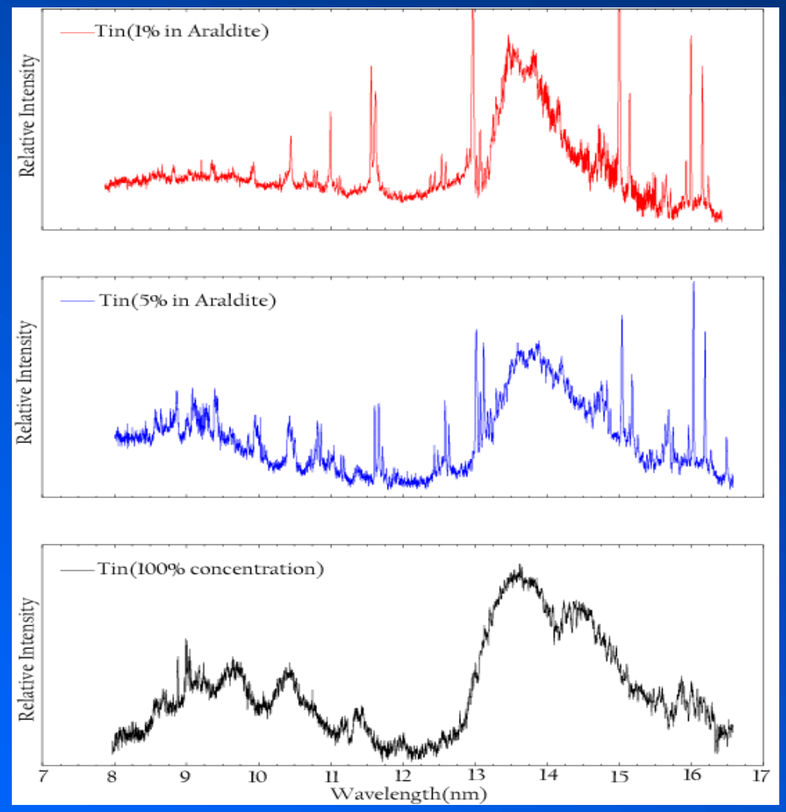


1103	1968	1,000
4004	1971	2,250
8008	1972	2,500
8080	1974	5,000
8086	1978	29,000
286	1982	120,000
386	1985	275,000
486 DX	1989	1,180,000
Pentium	1993	3.1 M
Pentium II	1997	7.5 M
Pentium III	1999	24 M
Pentium 4	2000	42 M

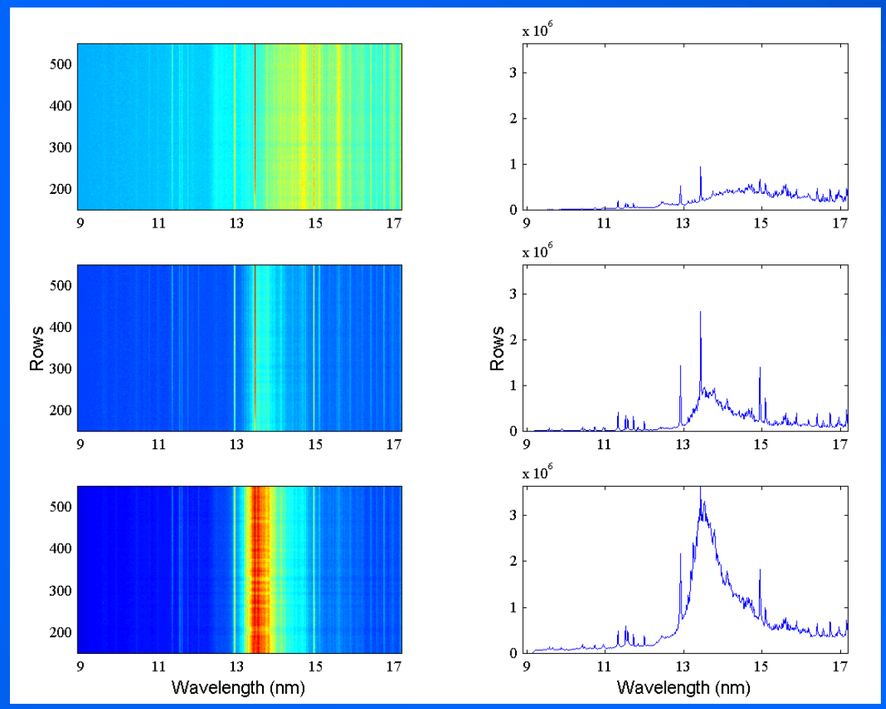


- "The number of components per chip will double every 18 months"
  -- Gordon Moore, Intel
- 42 million (26th square of a chess board: 2^{26} = 67 million)

Next generation lithography (2007?)



- Current lithography uses 193-nm ArF laser
- Next generation lithography (NGL): 13.5-nm atomic transition from tin ions
- 1.5 billion transistors on one chip



Onward

Abacus, ENIAC and beyond

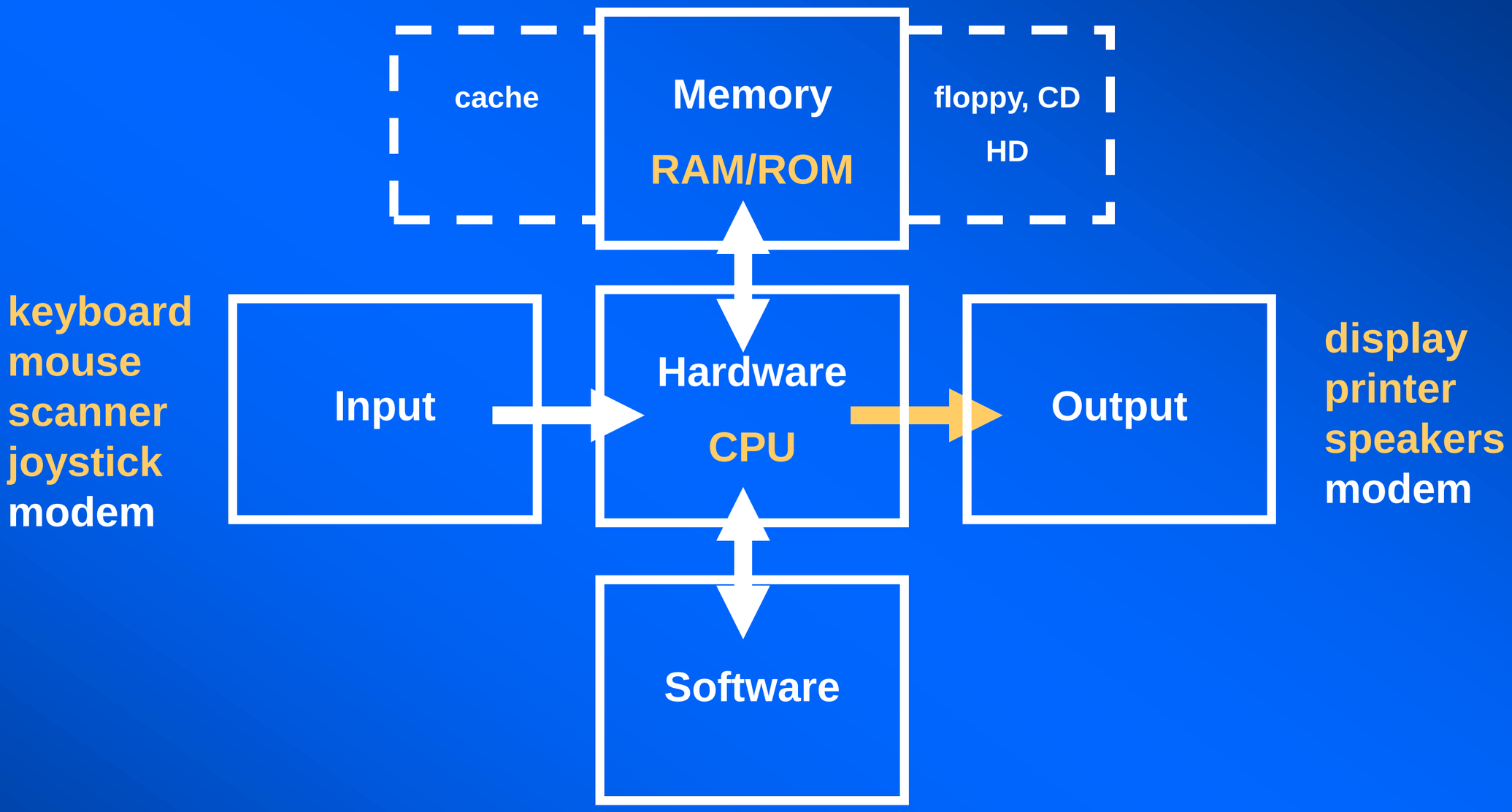
600 BC
add
subtract
multiply
divide
square root

2000
Pentium III
42 million transistors

1946 **ENIAC: University of Pennsylvania (ballistic trajectories; 18,000 tubes: each valve - 4 months: 1 every 10 minutes) 100 x 10 x 3 feet, 3 tons, 100,000 components.**

1968 **Apollo 8: First trip to the moon. 3000 times smaller than ENIAC.**

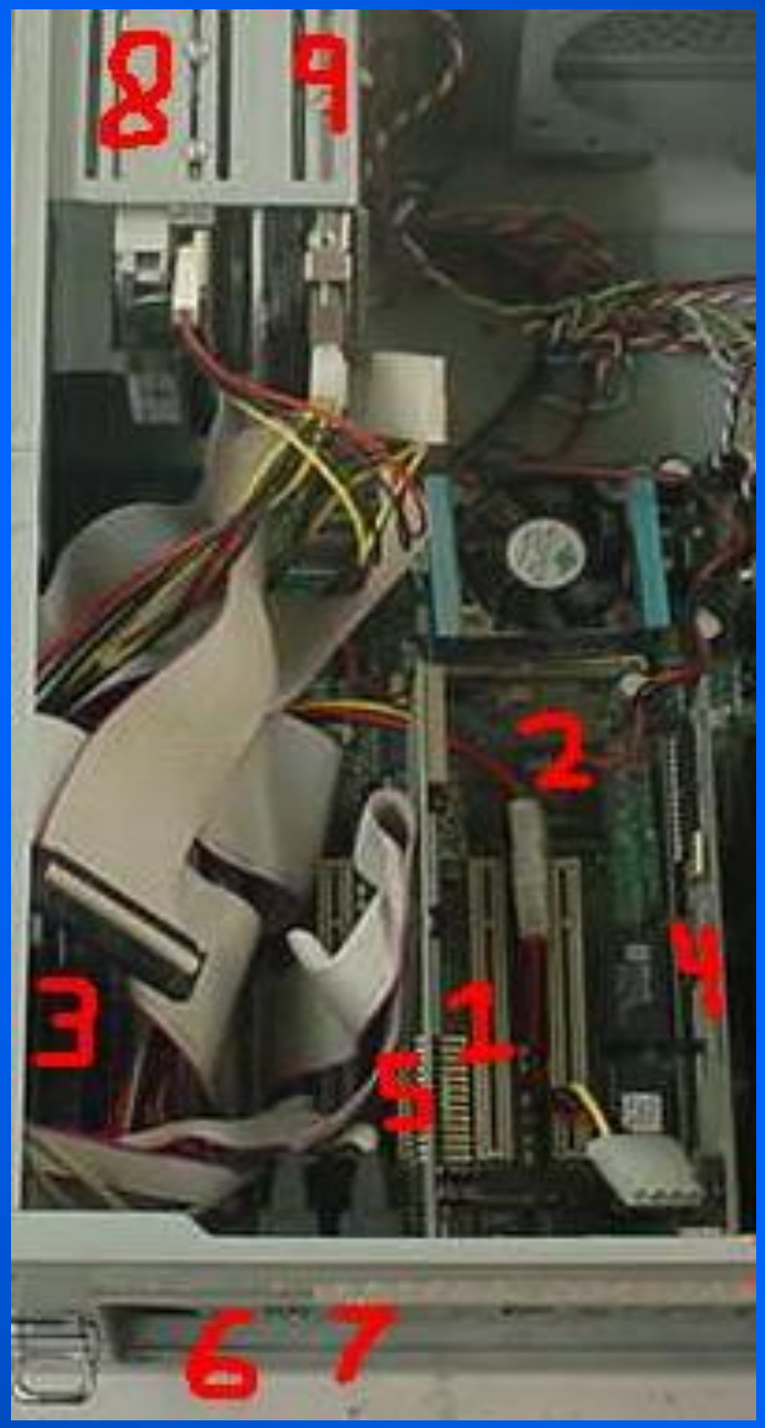
A computer The basics (in-->operate-->out)



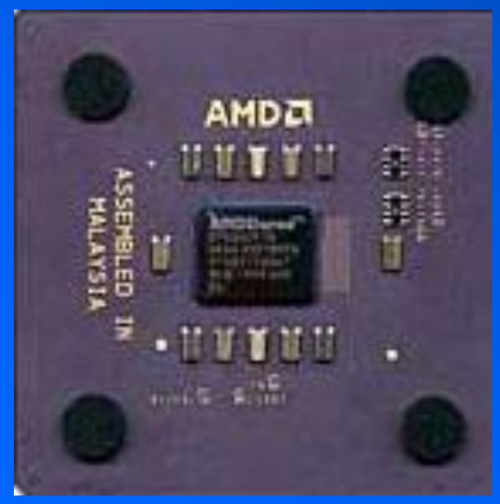
- memory/input/output connected by data buses 8-bit/16-bit/32-bit
- stand-alone or networked (LAN/WAN)

Hardware The guts of a computer

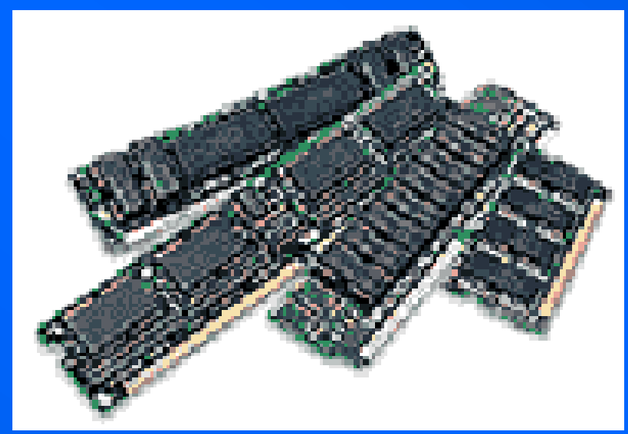
1. Motherboard
2. CPU
3. RAM
4. NIC
5. Video card
6. Com ports
7. Parallel line port
8. Floppy disk drive
9. Hard disk drive



1



2

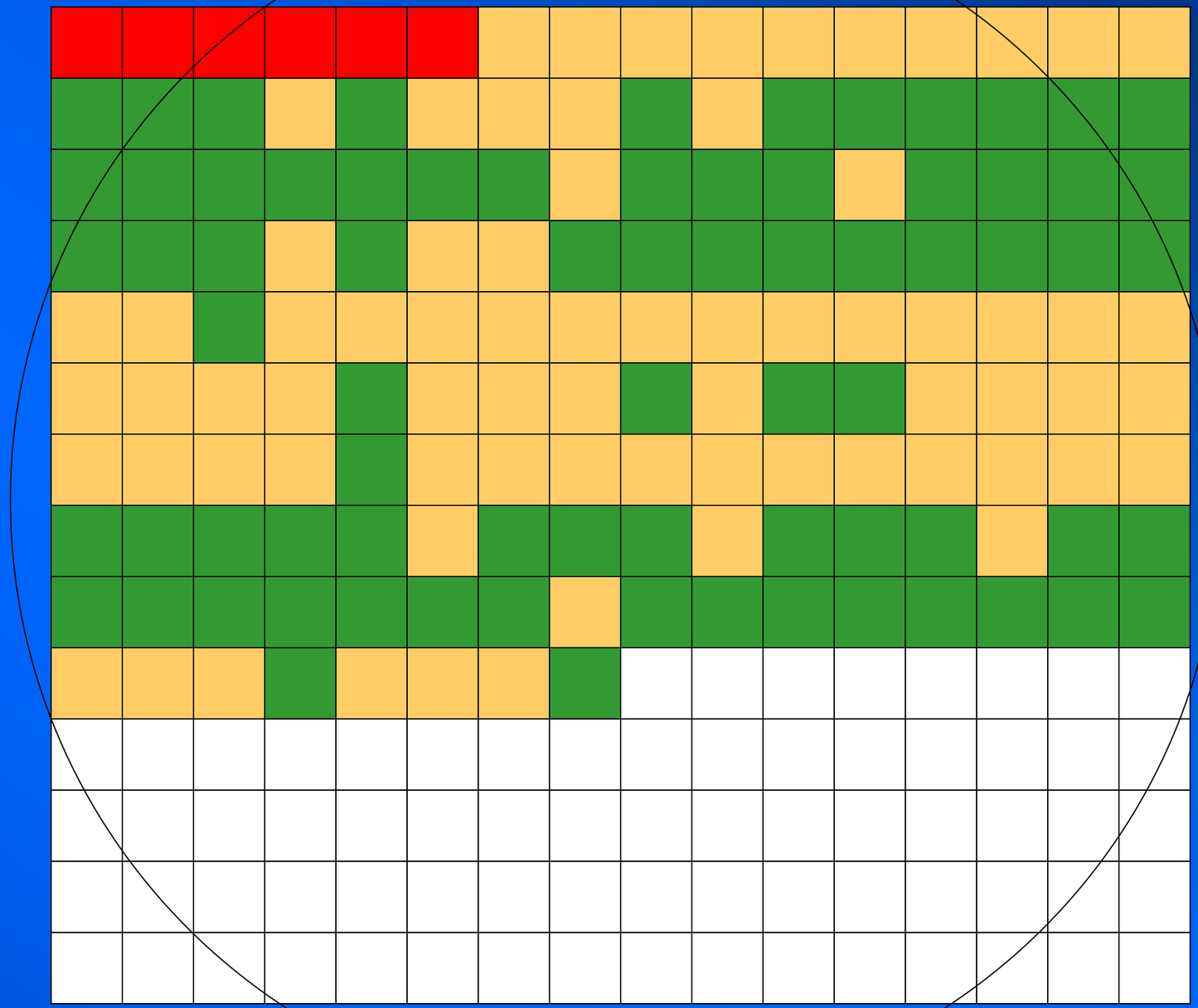


3

Hardware is hard -- can crush your fingers

Hard drive All points addressable in memory

system files
contiguous files
fragmented files
free space



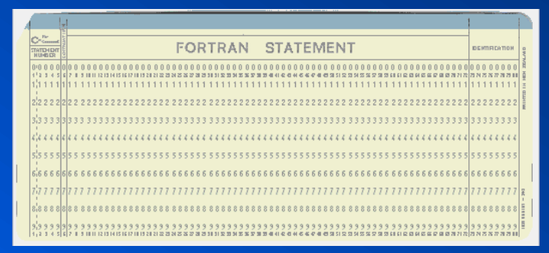
Hitachi 90 GB hard drive
FAT, cylinder, sector

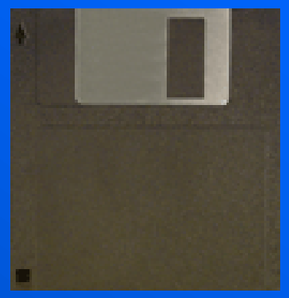
Good to defrag a hard drive now and again

Memory Computer storage (ROM)

1801 Jaquard loom uses pattern-encoded, punched cards

1890 IBM uses paper punched cards





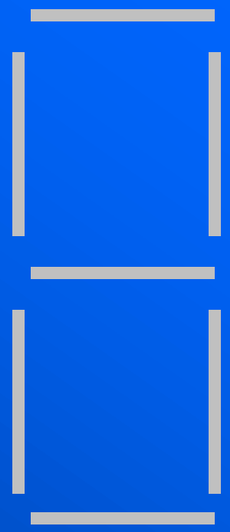
1971 IBM introduces the first memory disk 5 1/4" floppy disk (1.2 MB) and then in 1984 the standard 3 1/2" (1.44 MB)

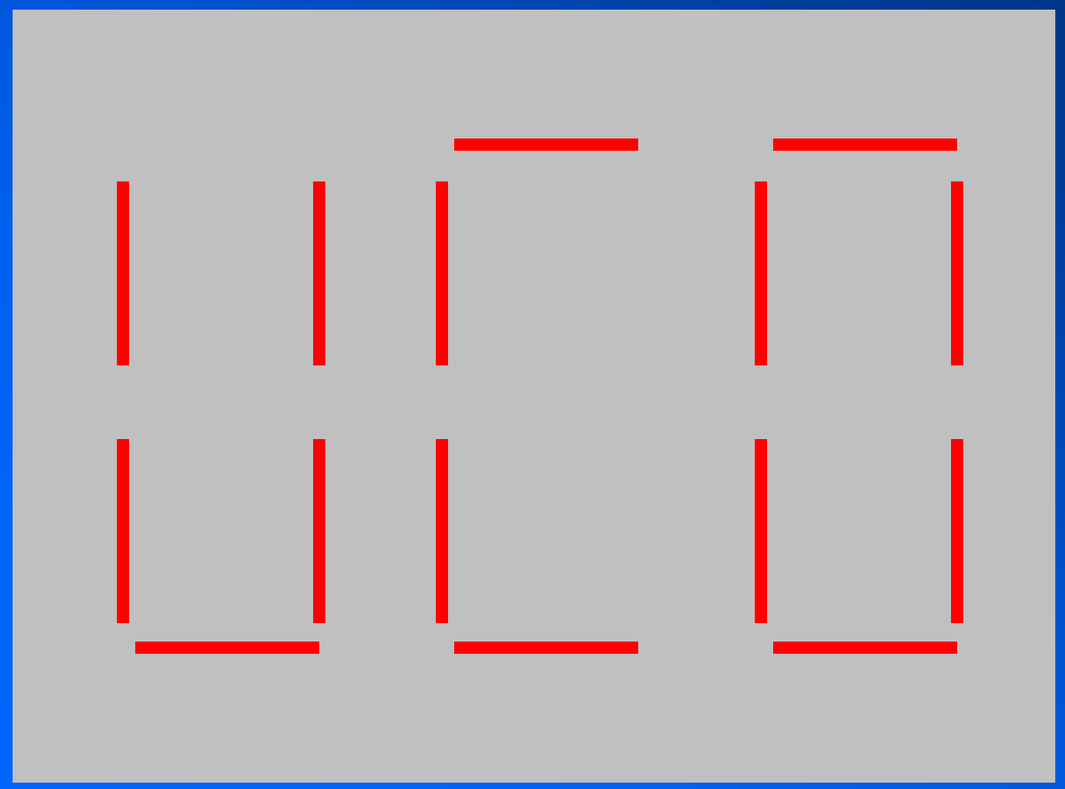
1982 Sony & Philips introduce CD (compact disc) 680 MB

1995 DVD technology introduced. Sony and nine other companies create a single DVD standard, which held 4.7 GB (7x CD).

1999 Unlike magnetic memory in hard and floppy disks, flash memory is electronically rewritable using transistor logic gates

Output Display (LED/LCD)





- Light emitting diode (LED) invented by Monsanto in the mid 1960s
- Liquid crystal displays (LCD) more liquid than crystal (very sensitive to temperature)
- Familiar seven-segment display to display numbers and letters (encoding)

Output Display (CRT/TFT/LCD)

Yesterday's television

Today's computer

1855 The **cathode ray tube** was invented in Germany and modified by William Crookes in 1878, who first confirmed the existence of cathode rays. **Resolution is measured in pixels** (picture element); ***e.g.*****, 1024 x 768.**

1984 First major **thin film transistor** product: a 1-inch pocket TV from Seiko-Epson. TFTs can be fabricated on large transparent substrates.

LCD is now the dominant technology.

Can't fit a CRT in your pocket

Binary and decimal The basics

1 k	10^3	1 “kay”	1,000*
1 M	10^6	1 “Meg”	1,000,000
1 G	10^9	1 “Gig”	1,000,000,000
1 T	10^{12}	1 “Tera”	1,000,000,000,000

compare a “googleplex”, the so-called largest number

google = 10^{100} = 1 followed by 101 zeros

googleplex = $10^{\text{googleth}} \approx \infty$

* computers speak in “binary” – on/off, 0/1, T/F, Y/N – 2 states

- $2^{10} = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 1{,}024 \approx 1{,}000 = 1$ k
- $2^{20} = 2^{10} \times 2^{10} = 1{,}024 \times 1{,}024 = 1{,}048{,}576 \approx 1{,}000{,}000 = 1$ M
- …

Bits and bytes Data representation (or encoding)

What is a bit (binary digit)?

- the smallest amount of data
- has two states: binary (0 or 1)
- perfect for binary arithmetic (base 2)
- powers of 2: $2^8 = 256$
- 8 bits = 1 byte

binary numbers (1-8)

0001 = 1
0010 = 2
0011 = 3
0100 = 4
0101 = 5
0110 = 6
0111 = 7
1000 = 8

1000 $= 1x2^3 + 0x2^2 + 0x2^1 + 0x2^0$
$= 1x8 + 0x4 + 0x2 + 0x1$
$= 8$

0111 $= 0x2^3 + 1x2^2 + 0x2^1 + 1x2^0$
$= 0x8 + 1x4 + 1x2 + 1x1$
$= 7$

1 0 0 0 0 1 1 1 serial 87 ("W")

1
0
0
0
0
1
1
1

parallel 87 ("W")

More bits and bytes 256 characters: 2^8 (1 byte)

ASCII: American Standard Code for Information Interchange
128 standard characters, 256 extended characters
Stored as octal numbers (3-binary)
plain text : no formatting

065 A	080 P	095 _	110 n	125 }	140 î	155 ¢	170 ¬
066 B	081 Q	096 `	111 o	126 ~	141 ì	156 £	171 ½
067 C	082 R	097 a	112 p	127 □	142 Ä	157 ¥	172 ¼
068 D	083 S	098 b	113 q	128 Ç	143 Å	158 P	173 ¡
069 E	084 T	099 c	114 r	129 ü	144 É	159 ƒ	174 «
070 F	085 U	100 d	115 s	130 é	145 æ	160 á	175 »
071 G	086 V	101 e	116 t	131 â	146 Æ	161 í	176 _
072 H	**087 W**	102 f	117 u	132 ä	147 ô	162 ó	177 _
073 I	088 X	103 g	118 v	133 à	148 ö	163 ú	178 _
074 J	089 Y	104 h	119 w	134 å	149 ò	164 ñ	179 ¦
075 K	090 Z	105 i	120 x	135 ç	150 û	165 Ñ	180 ¦
076 L	091 [	106 j	121 y	136 ê	151 ù	166 ª	181 ¦
077 M	092 \	107 k	122 z	137 ë	152 ÿ	167 º	182 ¦
078 N	093]	108 l	123 {	138 è	153 Ö	168 ¿	183 +
079 O	094 ^	109 m	124 |	139 ï	154 Ü	169 _	184 +
080 P	095 _	110 n	125 >	140 î	155 ¢	170 ¬	185 ╣

Information storage File types

- Text files (.txt)
- Data files (.dat or proprietary)
- Proprietry software files:
  Word, Excel, Access, *etc*. (.doc, .xls, .db1)
- Sound files
- Picture files
- Movie files

All "digital" information is stored in files as bits: 0s or 1s.
1 byte encodes 256 states (2^8 bits)

"Watson" in octal

087097116115111110

W a t s o n

"Watson" in binary

W a
000010000111000010010001
t s
000100010110000100010101
o n
000100010001000100010000

72 bits to store "Watson"
i.e.,
"Watson" = 9 bytes

Sound data files No more records, tapes, or CDs

Marvin the martian -- . wav (49 kB)

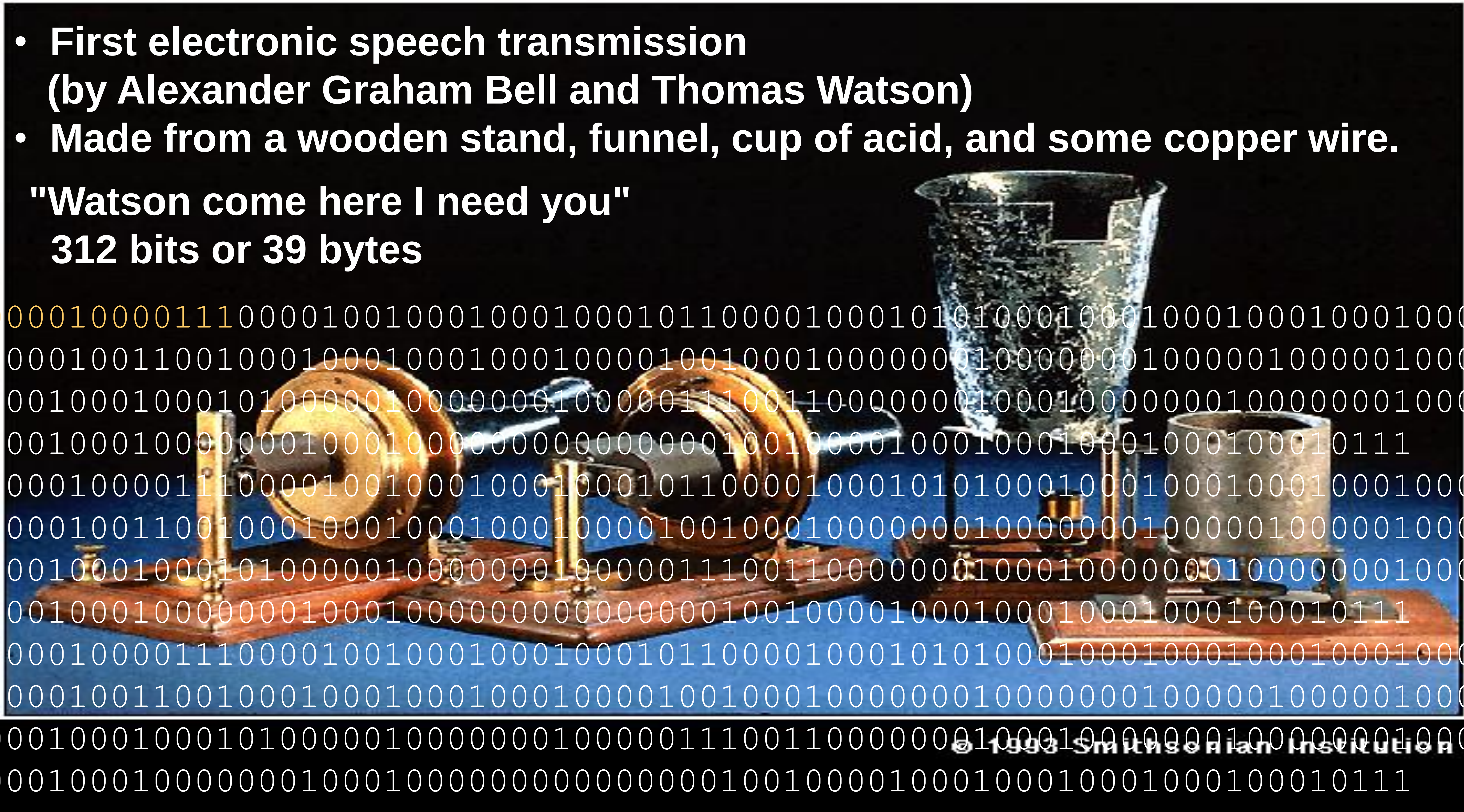
Oh drat …

WAV file	**(top-quality stereo, uncompressed) about 10 MB**
MP2	**reasonable-quality stereo) about 1 MB**
MP3	**(acceptable-quality stereo) as low as 200 kB / minute**
RealAudio	**(acceptable mono) about 100 kB / minute**
WMA	**Windows Media (Microsoft) smaller than MP3**
AAC	**Advanced Audio Coding (Apple i-Pod)**

MP3 (formally MPEG Layer III) compresses digital audio

A binary file 0s and 1s

10 March 1876



- **First electronic speech transmission (by Alexander Graham Bell and Thomas Watson)**
- **Made from a wooden stand, funnel, cup of acid, and some copper wire.**

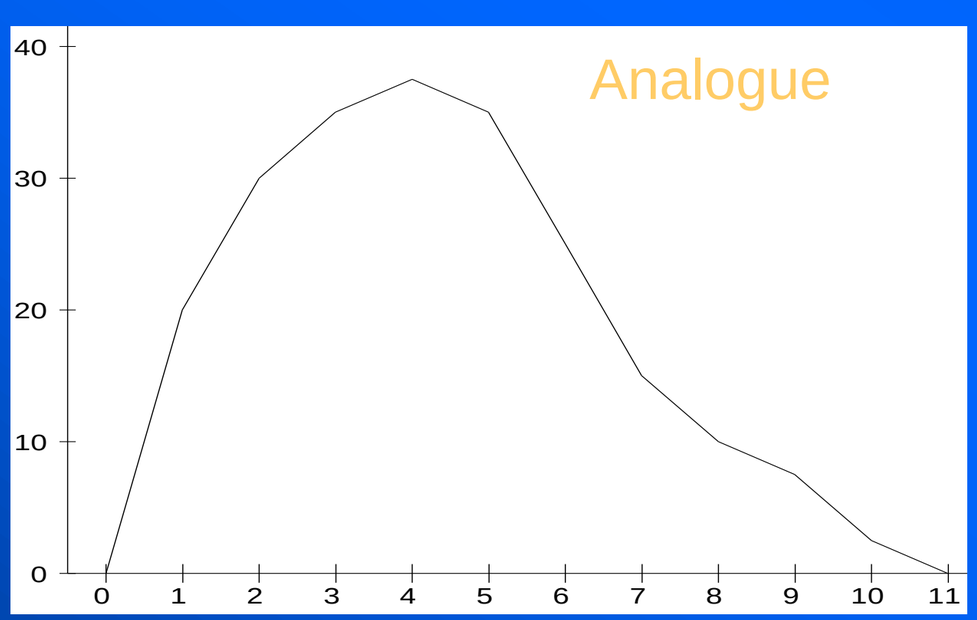
"Watson come here I need you"
312 bits or 39 bytes

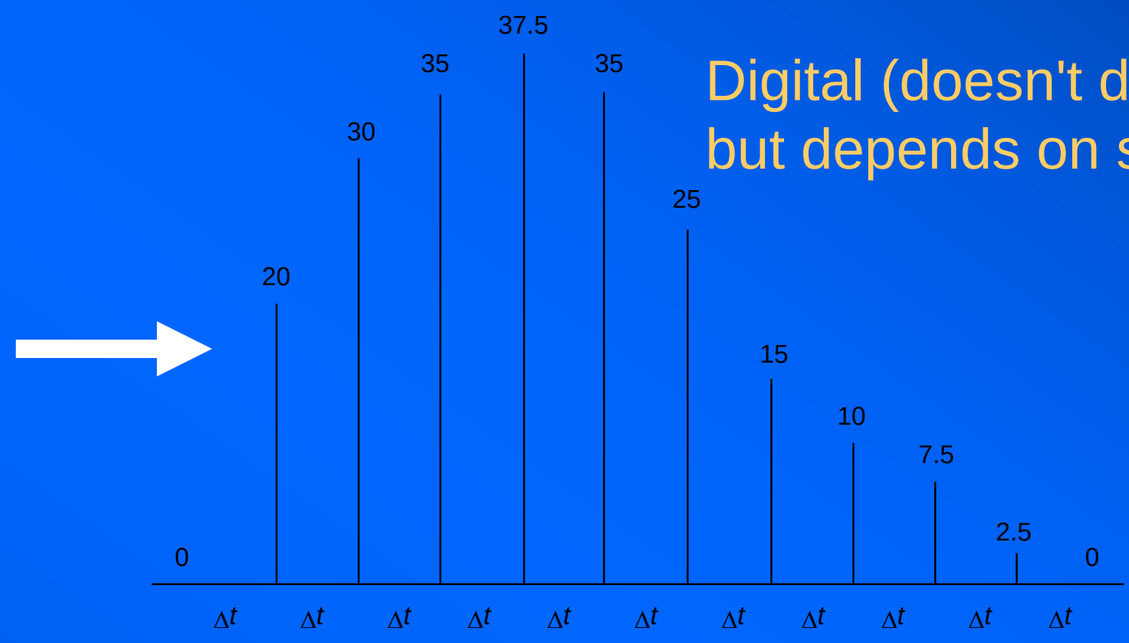
000010000111000010010001000100010110000100010101000100010001000100010000
000010011001000100010001000100001001000100000001000000010000010000010000
000100010001010000010000000100000111001100000001000100000001000000010000
00010001000000010001000000000000000100100001000100010001000100010111
000010000111000010010001000100010110000100010101000100010001000100010000
000010011001000100010001000100001001000100000001000000010000010000010000
000100010001010000010000000100000111001100000001000100000001000000010000
00010001000000010001000000000000000100100001000100010001000100010111
000010000111000010010001000100010110000100010101000100010001000100010000
000010011001000100010001000100001001000100000001000000010000010000010000
000100010001010000010000000100000111001100000001000100000001000000010000
00010001000000010001000000000000000100100001000100010001000100010111

33 million bits to print a single A4 page

Analogue/digital Physical measurement as a number

- any physical measurement is an analogue (time, temperature)
- measurements are converted from analogue to digital
- the amount of "sampling" or number of points = resolution





The number of samples × the sample time equals the total sample time.
Sample frequency determines resolution/size.
The greater the frequency, the better reproduction, the bigger the file.

gbobledigook rlues ok

why typos won't matter in tmoorrow's wrold

orus is the age of sbusttiutes: intsaed of lagnuage, we have jragon intsaed of pirncpiles, solgans and, intsaed of gneuine iedas, Birght Idaes.

Eric Bnetley mdae a btiter obsrevation alnog thsee lnies in the *Nwe Rpeublic* bcak in 1952. Eevn he mghit have ben apaplled to dicsover that, just hlaf a cnetury laetr, our brians would hvae leraned to do whtiout acucrate spleling too.

Yet that appaers to be the csae. Resaerch by a Cmabrigde lnagugae and raeding epxert, Dr Rsoaleen McCrathy, sugegsts taht we can udnrestnad any wirtten text, howveer mnagled, as long as the frist and lsat lteters of ecah wrod are in the rghit palce. Taht ptus piad to the shcool of thuoght that we raed lteter by letetr. It sgugests insetad taht our barins pratcise a mroe sohpisticiated from of ptatern recogintion with wrods, making it poitnless to work too hrad at odrering eevry letetr crroectly.

Are messages half redundant?

Information II Compression

- **Morse code is a non-uniform code (not equal space to each letter)**
- **English text compression (u always follows q; j never follows x; …), so not all combinations possible**
- **lossy (data not encoded in one-to-one correspondence) so can not be uniquely decoded**

Compare encryption/decryption

Boltzmann entropy: $2^x = 26$
i.e., x = log(26)/log(2) = 4.7
4.7 bits required to encode a 26-letter alphabet

A	.-
B	-...
C	-.-.
D	-..
E	.
F	..-.
G	--.
H	....
I	..
J	.---
K	-.-
L	.-..
M	--
N	-.
O	---
P	.--.
Q	--.-
R	.-.
S	...
T	-
U	..-
V	...-
W	.--
X	-..-
Y	-.--
Z	--..

SOS : "... --- ... "

Information III Coding and encoding, compression

1508-1512

Detail from Michelangelo's Sistine Chapel

1866

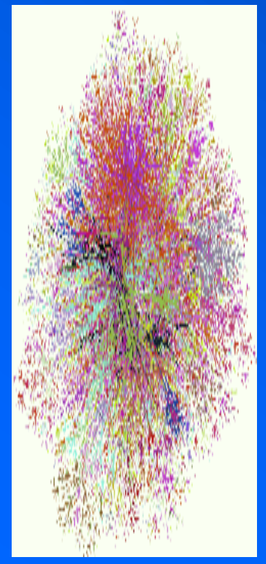
Valencia, Kerry to Heart's Content, Newfoundland (1,300 mile of cable)

1876

Alexander Graham Bell to Thomas Watson (next room)

1969

ARPANET Los Angeles to San Francisco



1989

World wide web

Information IV Secret decoder ring

- messages encoded, sent, and decoded
- Colossus used at Bletchley Park to decode German Enigma messages

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

- Ronald Wilson Reagan
- 666?

Unpacking the jargon

speed, size, memory, bandwidth (10 years ago)

- Intel Pentium III
- 650 MHz
- 128 MB
- Windows 2000
- 10 GB
- 8 MB
- 3.5 floppy drive
- CD-ROM or CDRW
- 100 Base-T (10 MB/s)
- V.90 or 56Kflex
- 2 USB
- 15" TFT
- keyboard, mouse

- Processor
- Processor speed
- RAM (processor)
- Operating system
- ROM (hard drive)
- Video memory
- Data (small storage)
- Data (large storage)
- Network card (LAN)
- Modem
- I/O Ports
- Monitor
- Standard peripherals

Unpacking the jargon

speed, size, memory, bandwidth (today)

- Intel core i7
- 2 GHz
- 8 GB
- Windows 7
- 256 GB
- 2 GB
- USB
- CD-ROM or CDRW
- 100 Base-T (100 MB/s)
- Optical fiber/WiFi
- 3 USB + HDMI
- 15.6" LCD
- keyboard, mouse

- Processor
- Processor speed
- RAM (processor)
- Operating system
- ROM (hard drive)
- Video memory
- Data (large storage)
- Data (large storage)
- Network card (LAN)
- Router
- I/O Ports
- Monitor
- Standard peripherals

System basics

speed, size, memory, bandwidth

System	Style	CPU Clock / RAM	HD ROM	Modem	Monitor	Cost
Dell 3600	laptop	650 MHz/128 MB	10 GB	56 k	15" TFT	1,200
Acer	laptop	2 GHz / 8 GB	256 GB	fiber	15” LCD	1,200

CPU	central processing unit
RAM	random access memory
ROM	read only memory
LCD	liquid crystal display

RAM	fast/volatile
ROM	slower/non-volatile

MHz	megahertz (s^{-1})
MB	megabyte
GB	gigabyte
k	1000 bps (bits per second)

M	**1 million** (1,048,576)
G	**1 billion** (1,073,741,824)

Sizing up a system (in Windows)

speed, size, memory, bandwidth

`My Computer | right-click | Properties`

CPU 2.536 GHz
1,047,544 kB RAM (1 GB)

`LOCAL DISK (C:) | right-click | Properties`

Used space: 23.1 GB
Free space: 51.2 GB

Capacity: 74.4 GB

`Start | Settings | Control Panel`

Network and Dial-up Connections
Phone and Modem Options

Operating systems I From UNIX to Windows

DOS

UNIX

Windows

The operating systems handshakes the parts: processor, software, memory, disk, I/O, communication ports.

In the beginning (1969)

was UNIX, a mainframe OS.
Then came DOS and MS-DOS for the IBM PC (1981).

} text-based

And then came a really bright idea--an OS for the people

Xerox
Apple/Macintosh (Mac)
Windows (Microsoft)
Solaris (Sun Microsystems)
Linux (Linus Torvalds)

} GUI "gooey"

Linux was created when UNIX became a commercial product

Open source versus proprietary

EXCEL Plot the trajectory of a rocket or projectile in

Excel

Microsoft Excel

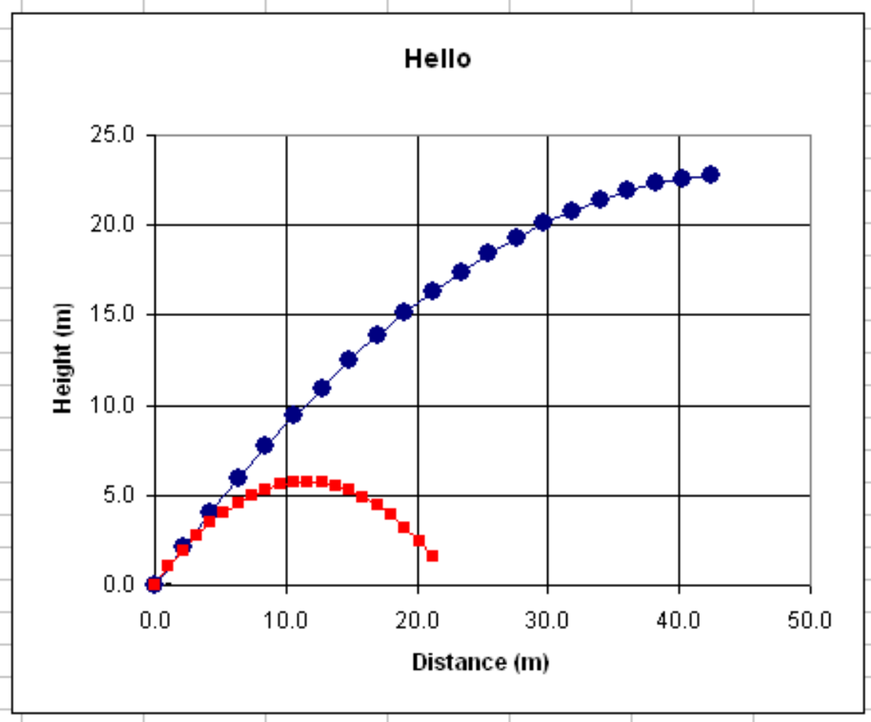
File Edit View Insert Format Tools Data Window Help

A1 =

TYPE.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1										maximum	22.8	meters					
2		v0	30	m/s		15	m/s			height							
3		theta	45	degrees		45	degrees										
4		a	-9.8	m/s2		-9.8	m/s2			time at	2.2	seconds					
5										maximum height							
6		Time	Distance	Height		Distance	Height										
7		t	x	y		x	y			furthest	91.8	meters					
8		(sec)	(m)	(m)		(m)	(m)			distance							
9																	
10		0.00	0.00	0.00		0.00	0.00										
11		0.10	2.12	2.07		1.06	1.01										
12		0.20	4.24	4.05		2.12	1.93										
13		0.30	6.36	5.92		3.18	2.74										
14		0.40	8.49	7.70		4.24	3.46										
15		0.50	10.61	9.38		5.30	4.08										
16		0.60	12.73	10.96		6.36	4.60										
17		0.70	14.85	12.45		7.42	5.02										
18		0.80	16.97	13.83		8.49	5.35										
19		0.90	19.09	15.12		9.55	5.58										
20		1.00	21.21	16.31		10.61	5.71										
21		1.10	23.33	17.41		11.67	5.74										
22		1.20	25.46	18.40		12.73	5.67										
23		1.30	27.58	19.30		13.79	5.51										
24		1.40	29.70	20.09		14.85	5.25										
25		1.50	31.82	20.79		15.91	4.88										
26		1.60	33.94	21.40		16.97	4.43										
27		1.70	36.06	21.90		18.03	3.87										
28		1.80	38.18	22.31		19.09	3.22										
29		1.90	40.31	22.62		20.15	2.46										
30		2.00	42.43	22.83		21.21	1.61										
31																	
32																	
33																	

Sheet1 Sheet2 Sheet3



Cells = data e.g., C2 = 30

Change input to get new output

Software I The language of a computer

Word processor
Spreadsheet
Database
Presentation
Internet browser
E-mail
Operating system

February 3, 1976

To me, the most critical thing […] is the lack of good software …. Without good software […], a hobby computer is wasted. Will quality software be written […]?
Almost a year ago, [we] developed Altair BASIC. Though the initial work took only two months, [we] have spent most of the last year documenting, improving and adding features to BASIC. Now we have 4K, 8K, EXTENDED, ROM and DISK BASIC. The value of the computer time we have used exceeds $40,000.
… I would appreciate letters from any one who wants to pay up, or has a suggestion or comment.

William H Gates III

BASIC I Math equation = computer statement

EQUATE

The basic principle of every program

input x = 3

↓

operate x^2

↓

output y = ?

```
10 X = 3
20 Y = X^2
30 PRINT Y

9
```

Any mathematic equation can be “coded”

BASIC II A simple program with a loop

y = f(x)

input

↓

operate

↓

output

***e.g.*, square, cube, general polynomial, any equation**

```
10 FOR X = 1 TO 10
20     Y1 = X^2
30     Y2 = X^3
40     Y3 = 2*X^2 + 3*X + 6
50     PRINT Y1, Y2, Y3
60 NEXT X
```

1	1	11
4	8	20
9	27	33
16	64	50
25	125	71
36	216	96
49	343	125
64	512	158
81	729	195
100	1000	236

BASIC III A little more complicated

The average of 10 numbers

input

↓

operate

↓

output

The **input** is 10 numbers (*e.g.*, marks on ten tests). *What goes in*.
The **operation** is the guts of the program. *What to do with* the input.
The **output** is the result of the operation on the input. *What goes out*.

```
N = 10
DATA 66,68,72,67,70,66,73,72,70,68
FOR I = 1 to N
   READ NUMBERS(I)
NEXT I
SUM = 0: SSQ = 0: AVERAGE = 0: SD = 0
FOR I = 1 to N
   SUM = SUM + NUMBERS(I)
NEXT I
FOR I = 1 to N
   SSQ = SSQ + (NUMBERS(I) - SUM/N)^2
NEXT I
AVERAGE = SUM/N
SD = SQR(SSQ/(N-1))
PRINT "Ave. = " AVERAGE, "Stn. dev. = " SD
```

```
Ave. = 69.2     Stn. dev. = 2.573368
Ok
```

Fortran I FORmula TRANslation

-created at IBM (first compiler: IBM 704 in 1957)
-most popular language for numerical applications
-ANSI standard, Fortran77, ISO and ANSI standard, Fortran90
-Fortran 77 and Fortran 90 use different I/O libraries

Loose Error checking example

NASA planetary probe failure: control software statement:

```
DO 15 I = 1.100   (wrong)
DO 15 I = 1,100   (right)
```

Fortran ignores spaces and the line was compiled as

```
DO15I = 1.100
```

This statement assigned 1.100 to a variable named DO15I

Fortran II A little more complicated

Formula translation

input

↓

operate

↓

output

The **input** is 2 numbers: *What goes in*.
The **operation** is a formula. *What to do with* the input.
The **output** is the result of the operation. *What goes out*.

```
C ***** EQUATE.F
C ***** This PROGRAM evaluates a simple
C ***** equation: input, operate, output.
      Program test
      open (5,FILE="input.txt")
      open (6,FILE="output.txt")
      Read(5,100) x,y
      z = x * y
      Write(6,200) x,y,z
100   Format(F4.1,2x,F3.1)
200   Format(F4.1,2x,F3.1,2x,F6.2)
      end
C *************************************
```

HTML The simplest non WYSIWYG

APL
BASIC
C
C++
COBOL
FORTRAN
HTML
Java
JavaScript
Visual Basic
Visual C
...

A simple HTML program first.html

```
<HTML>
<head>
<title>My first web page </title>
</head>
<body>
<h1>Hello world</h1>
</body>
</HTML>
```

HTML revisited Hypertext Markup Language

second.html

```
<HTML>
<head>
<title>My second web page </title>
</head>
<body bgcolor="00FFFF">
<h1>Heading 1</h1>
<h2>Heading 2</h2>
<h3>Heading 3</h3>
Text<br>
More text<p>
<b>bold</b> text in <i>italics</i>
<li> list 1 </li>
<li> list 2 </li>
<li> list 3 </li>
<hr>
<a href = "link.html">go to link</a><br>
<img src = "image.jpg" alt = "sample text“
align=top width=150 height=150 border=0></a>
<img src = "image.bmp" alt = "sample text“
align=top width=150 height=150 border=0></a>
<img src = "image.gif" alt = "sample text“
align=top width=150 height=150 border=0></a>
</body>
</HTML>
```

- **Visual browser (Netscape, Explorer)**
- **non-linear Hypertext**
- **What you see is not what you get (*cf*. WYSIWYG)**
- **markup tags: `<tag>`**
- **`View Source` (downloadable)**
- **Cut and paste to save text, right-click to save images**

Scientific computing A little more complicated

A day in the life of a computational physicist

Clarity and transparency of physical ideas

Extreme portability
codes must compile on different platforms

Extreme modularity
code fragments are reused in multiple projects

Separate out the physics (from the graphing, visual, logic)

Maintain performance

Excel

BASIC

Fortran

C, C++

Matlab

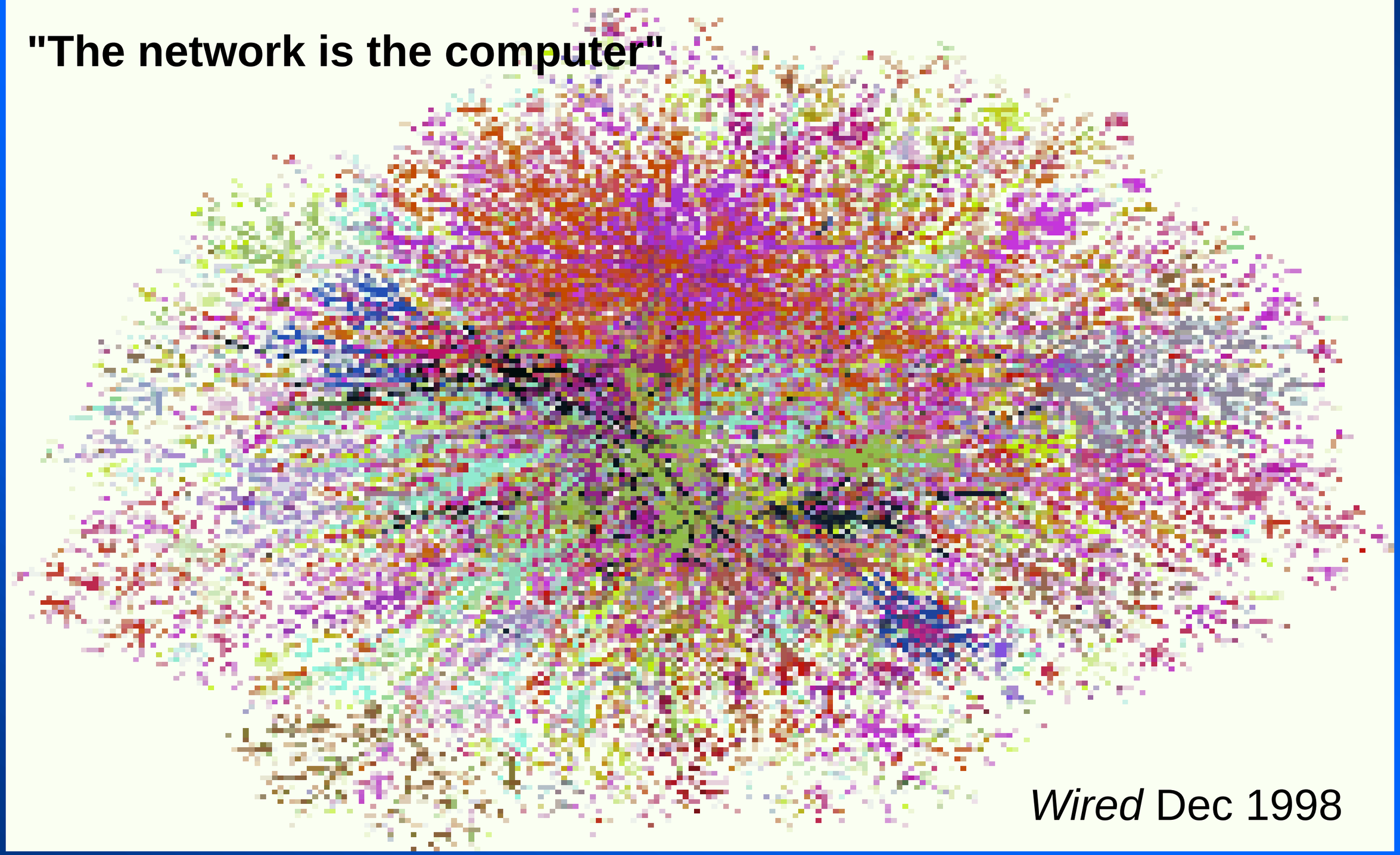
Java

VB

Interfacing

Wired to the net The "global village"

"The network is the computer"



Wired Dec 1998

The beginning From ARPANET to ETHERNET to the world wide web

1969 The U.S. Department of Defense Advanced Research Projects Agency Network (**ARPANET**)

progenitor of the internet

20 years as a military/academic tool

1973 **ETHERNET** created by Xerox PARC

1 second to display a page, 2 seconds to print a page, 15 minutes to transfer the data.

1989 Tim Berners-Lee (CERN) created the world wide web (**WWW**), an "network of networks" with appropriate HTTP protocol.

web browser displays web pages (Mosaic, Netscape, Explorer)

2^{32} world wide web addresses (IPs), 4 bytes (4 3-digit numbers in DDN)

4 billion web addresses (*cf*. 6 billion people)

a web address: www.ucd.ie --> 193.1.172.140

ARPANET The beginning

ARPA (Advanced Research Projects Agency) to ARPANET

1958 ARPA set up by Eisenhower in response to *sputnik* and the Soviet-American space race.

1966 Bob Taylor thought up the first network to get different machines (also from different companies) to "talk" to each other without having to physically relocate and to share limited resources.

NOT as some say to communicate in the event of a nuclear strike.

ARPANET: initial "net" of 10 "nodes" or "hosts"

University of California at Los Angeles (UCLA), Stanford Research Institute (SRI), University of California at Berkeley, and University of Utah. System Development Corporation (SDC) at Santa Monica, University of Michigan, and University of Illinois. Project Mac at MIT, Harvard, and Carnegie-Mellon University in Pittsburgh.

ARPANET The first network message: "login"

September 1, 1969 UCLA

October 1, 1969 SRI

October 1, 1969 Charley Kline typed "login" at UCLA and it appeared at SRI near San Francisco

Thereafter, 1 node a month

1971 15 nodes

1972 37 nodes

...

E-mail was a surprising afterthought (and FTP) spawning the net (until www).

"Don't tell anyone! This isn't what we're supposed to be working on."

ARPANET The first network message: "login"

First computer to computer message

As soon as SRI attached to its IMP, under my directions, one of my programmers, Charley Kline, arranged to send the first computer-to-computer message. The setup was simple: he and a programmer at SRI were connected via an ordinary telephone line and they both wore headsets so they could talk to each other as they observed what the network was doing. Charley then proceeded to 'login' to the remote SRI host from our UCLA HOST. To do so, he had to literally type in the word 'logon'; in fact, the HOSTS were smart enough to know that once he had typed in 'log', then the HOST would 'expand' out the rest of the word and add the letters 'in' to it. So Charley began. He typed an 'l' and over the headset told the SRI programmer he had typed it (Charley actually got an 'echo' of the letter 'l' from the other end and the programmer said 'I got the l'.) Then Charley continued with the 'o', got the echo and a verbal acknowledgement from the programmer that it had been received. Then Charley typed in the 'g' and told him he had now typed the 'g'. At this point the SRI machine crashed!! Some beginning.

-- Leonard Kleinrock to John Seabrook in the *New Yorker*.

Why a network? The empire and the rebel

- shared resources (plotter, printer, CPU, …)
- computer-to-computer 'talk': protocol (Do they speak the same language?), general communication
- there must be a relay (switching):

  circuit switching (one long continuous copper wire)

  message switching (store and forward -- c.f. broken telephone)

  packet switching (1,024)

- BUT communications are bursty (c.f. pauses in phone calls at ends of sentences and between words). Computer communications more bursty ("sending" computer messages all at once).
- Recall analogue/digital (degeneracy)
- AT & T was a vast, physical, analogue circuit switching network

ETHERNET Trains and automobiles

Xerox: 1second to display, 2 seconds to print,
15 minutes to send along a network

train 1

n cars

train 2 has
to wait

1. circuit switching
2. packet switching

2. more smaller packets

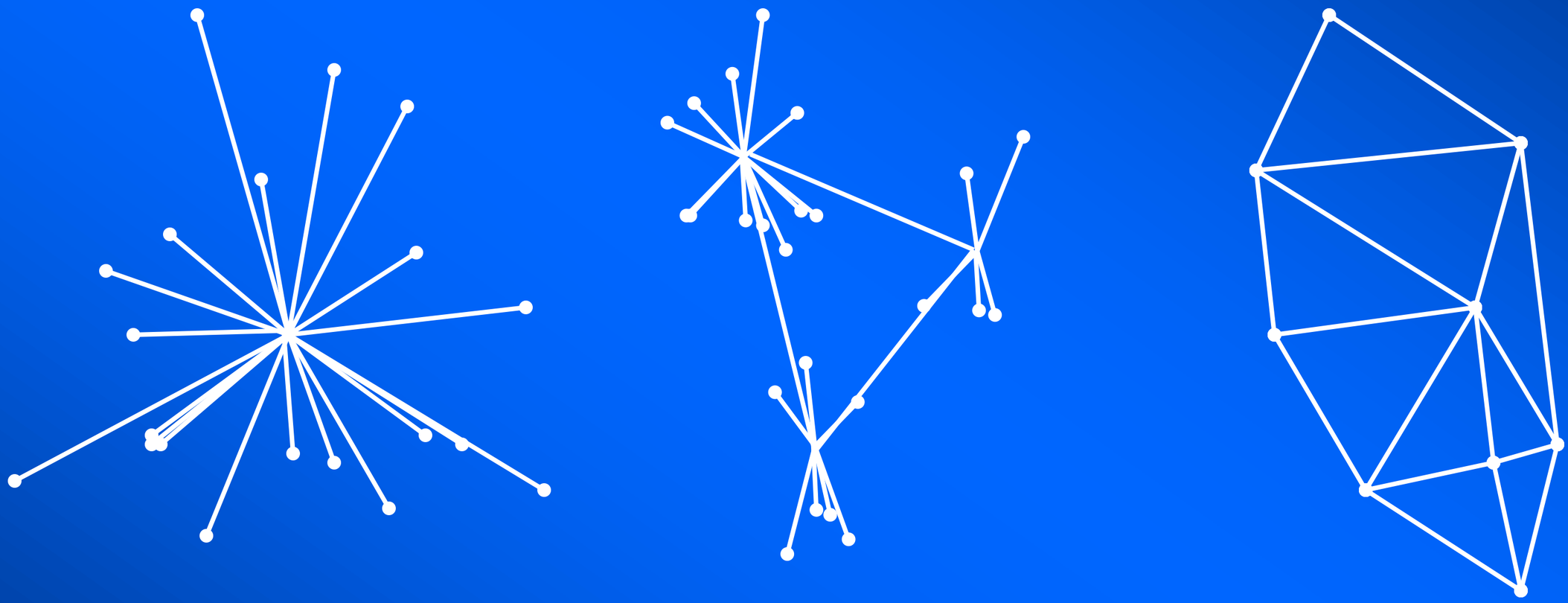
get through along any route

cf. moving house

n cars

Distributed network No central host

Information is sent in packets of 1,024 bits (data, header, check bit, sequence) along a network of nodes.



centralised

one central node

decentralised

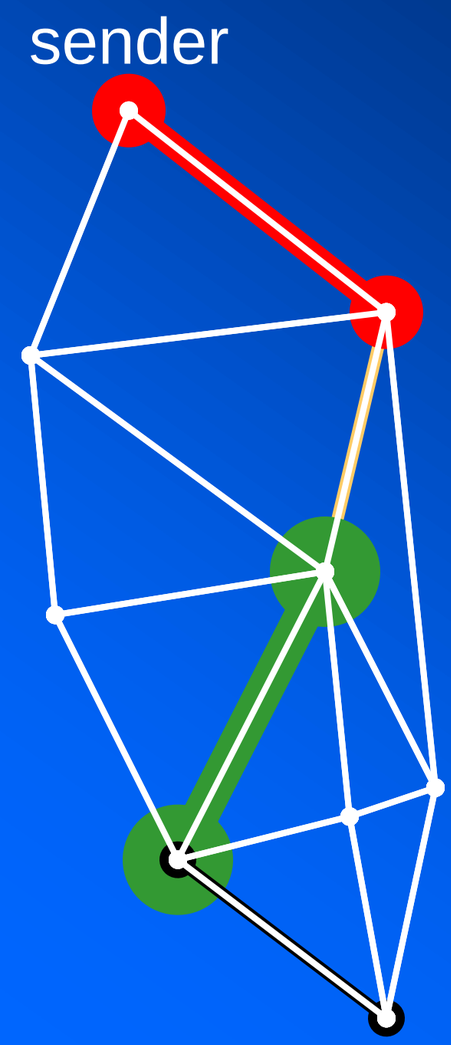
distributed

distributed, redundant, multiple paths

Packet-switching Small chunks of data

message sent ("Watson come here I need you").

- information sent in packets (data, header, check bit, sequence)
- de-assemble message into 1,024-byte packets
- header has IP address (*e.g.*, 193.1.172.140 or www.ucd.ie)
- different packets can go along any route and at any rate
- re-assemble packets into text message (sequence)
- sender/receiver machines have an agreed upon protocol
- protocol is NP (ARPANET), TCP/IP (internet)
- TCP/IP (transmission control protocol/internet protocol)



message received ("Watson come here I need you").

Bandwidth I Or how fast is the web?

message sent ("Watson come here I need you").

193.1.172.140

1087097116115111110 (Watson)

2099111109101 104101114101 (come here)

3073 110101101100 121111117 (I need you)

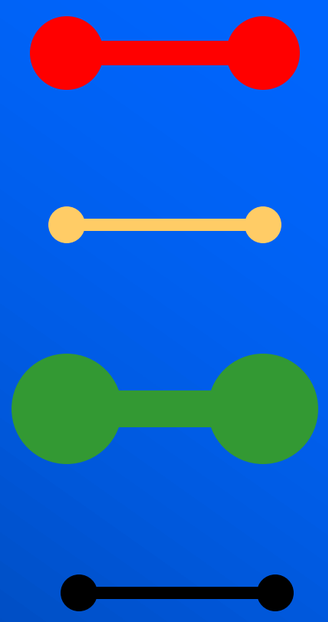
4314 (check bit)

message received ("Watson come here I need you").

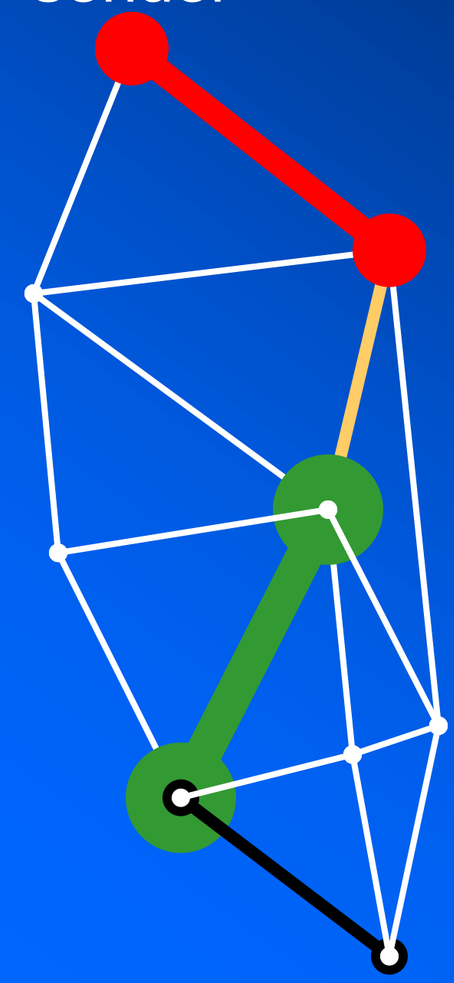
a message can be reassembled in any order: 4 3 1 2
(recall pictures appearing in parts)

Bandwidth II Or how fast is the web?

message sent ("Watson come here I need you").



Broadband (ISDN)



message received ("Watson come here I need you").

ultimate speed (complete reassembly of message) or bandwidth depends on the slowest link

different parts of the message can travel different routes

Bandwidth III Or how fast is the web?

- Bandwidth is the amount of data transmitted in a fixed time.
- A modem that works at 57,600 bps has twice the bandwidth of a modem that works at 28,800 bps (twice as much information per second).
- For digital devices, bandwidth is expressed in bits per second (bps) or the baud rate. For analogue devices, bandwidth is expressed in cycles per second, or Hertz (Hz).
- Internet communication paths follow a succession of links, each with its own bandwidth. If one link is much slower, there is a bandwidth bottleneck.
- high bandwidth = broadband

Birth of the internet TCP/IP

In 1833, Charles Babbage devised the first "computer." The analytical engine had all the ingredients of a modern computer (CPU, storage, stored program, I/O) but was never built (engineering constraints, finances).

In 1962, Paul Baran devised the first network at the nuclear think tank RAND. The goal was a survivable network, but was never built (service in-fighting). It had all the ingredients of the modern internet:

1. Distributed net of message-switching digital computers (nodes) (3 or 4 neighbour nodes necessary redundancy).
2. Small packets (message-blocks) (*cf*. moving house).
3. Hot-potato routing.
4. 1,024 switching nodes with microwave transmitters 20 miles apart.

When did ARPANET become the internet?

Network Protocol (NP) of ARPANET not sufficient for myriad different computers

January 1, 1983 NP --> TCP/IP

TCP

- packets
- de-assembly/reassembly
- envelopes
- reorder
- errors
- retransmit if lost packets

IP

- naming
- addressing
- routing

Networks linked by routers

TCP/IP built into UNIX

Spam A plague on all your houses

- SPAM is a registered trademark of the Hormel Foods Corp. for luncheon meat. SPAMARAMA™ is a trademark of the Hormel Foods Corp. for an annual festival in Austin, TX.
  Saturday, April 3rd, 2004 Noon to 6
  $5 at the gate

- AOL receives 2 billion e-mail messages/day. Filters block out half as SPAM. (March, 2003)

- US legislation bans spammers from deceptive practices to send junk mail.

Recommended Reading References

- **John Naughton**, "***A Brief History of the Future -- The Origins of the Internet***," **Weidenfeld and Nicolson, London, 1999.**

- **Brian Kernighan**, "***Assembly for the Class of 2007: D is for Digital and Why It Matters***," **Brian Kernighan, Professor of Computer Science - September 7, 2003, Princeton.**

- **John K. White**, **"*Do The Math!" Sage, Los Angeles, 2013.***