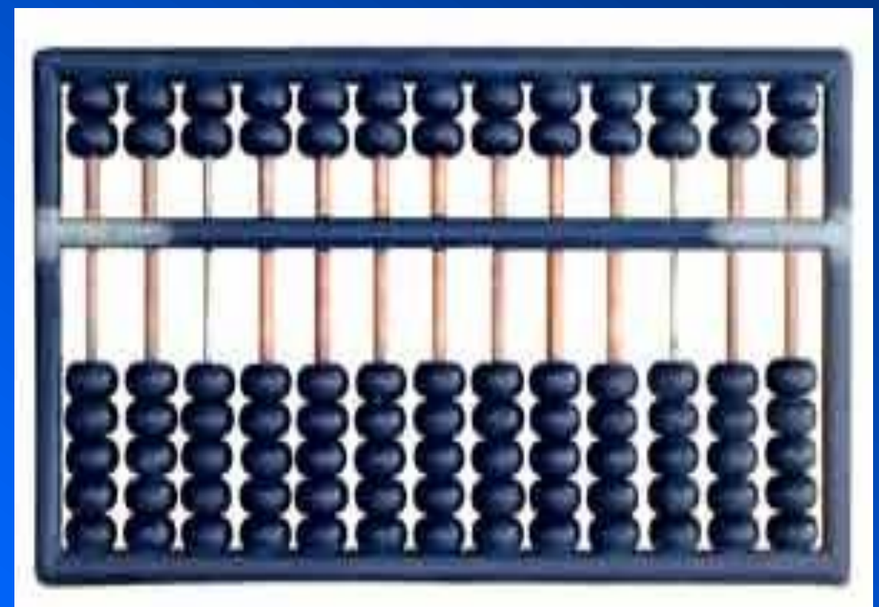
The computer: from abacus to Windows

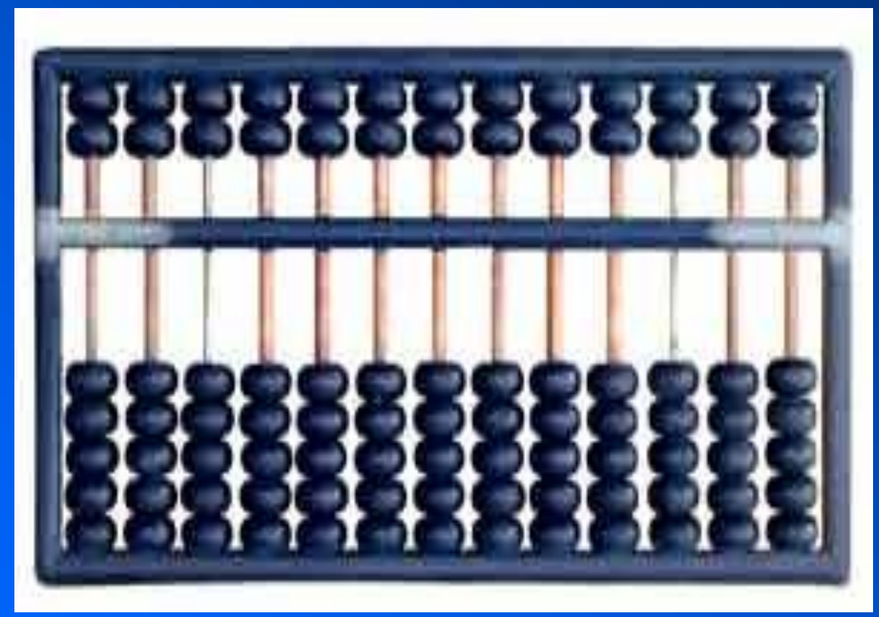
- A brief history
- The guts of a computer
- Hardware / Software
- BASIC/Excel/HTML . . .
- Networks



John White
School of Physics, UCD

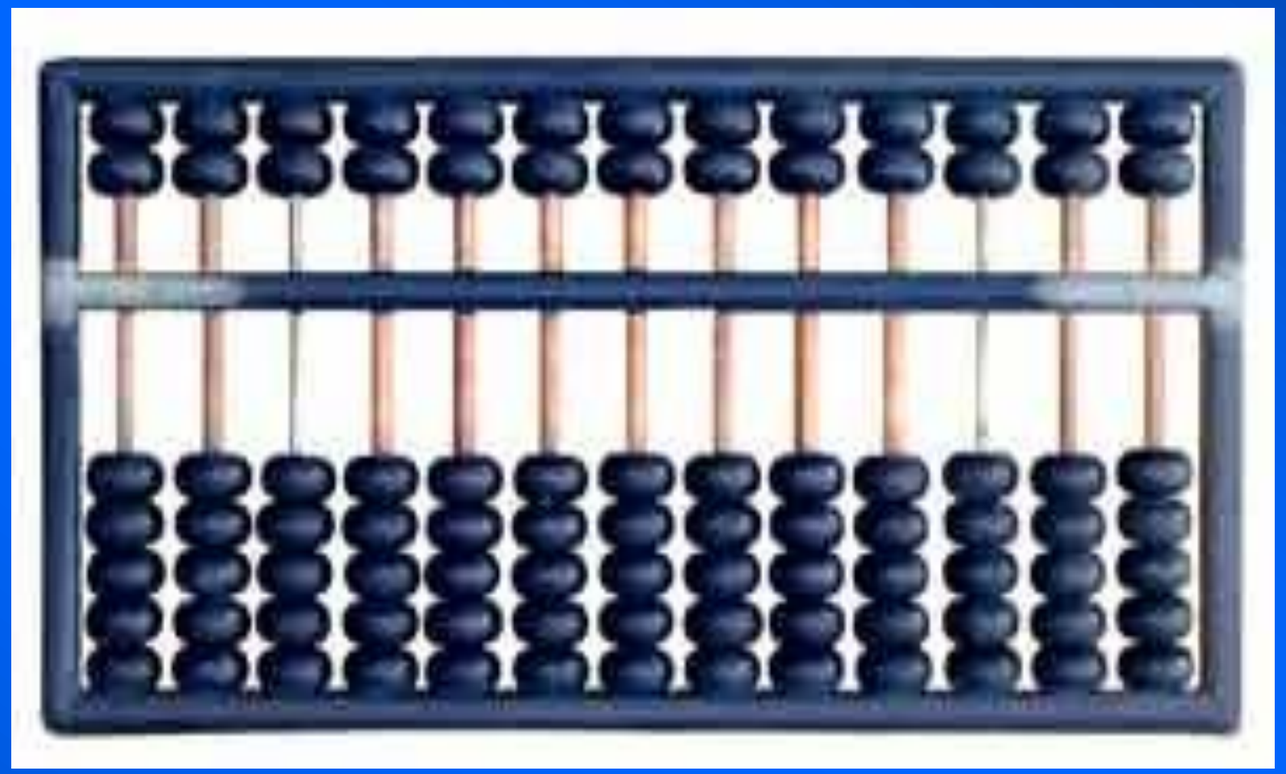
Along the way. More about …

- Abacus and ENIAC
- Sputnik and the PC
- Boole and binary
- Computer programming
- The internet



To err is human

To completely foul things up … takes a computer



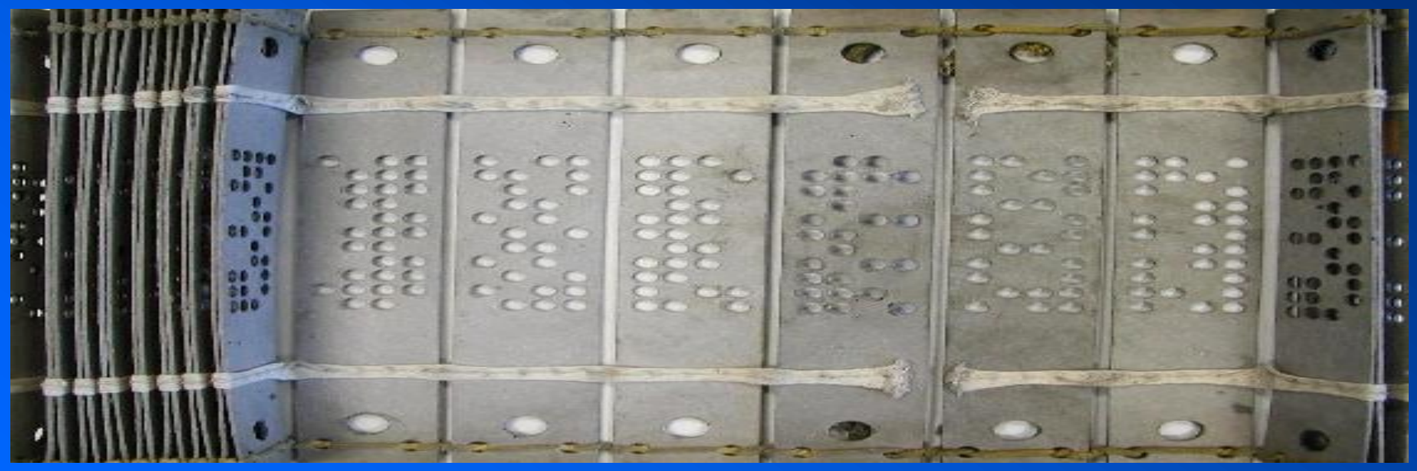
600 BC

Chinese abacus

- add, subtract, multiply, divide, take the square root
- from the Greek *abax* for “calculating board”
- *suan pan* in Mandarin, meaning "calculating plate"
- called the **first computer**

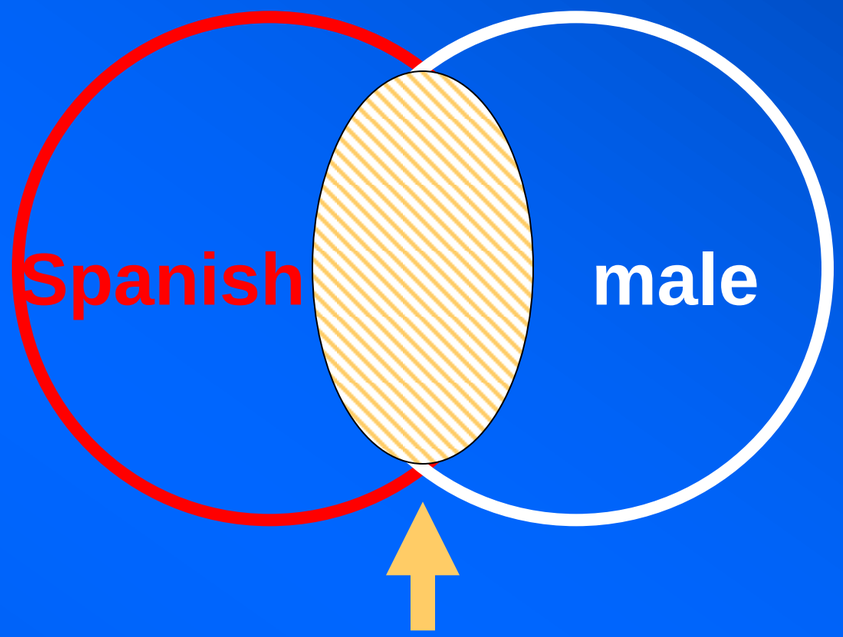
1801

Jacquard loom

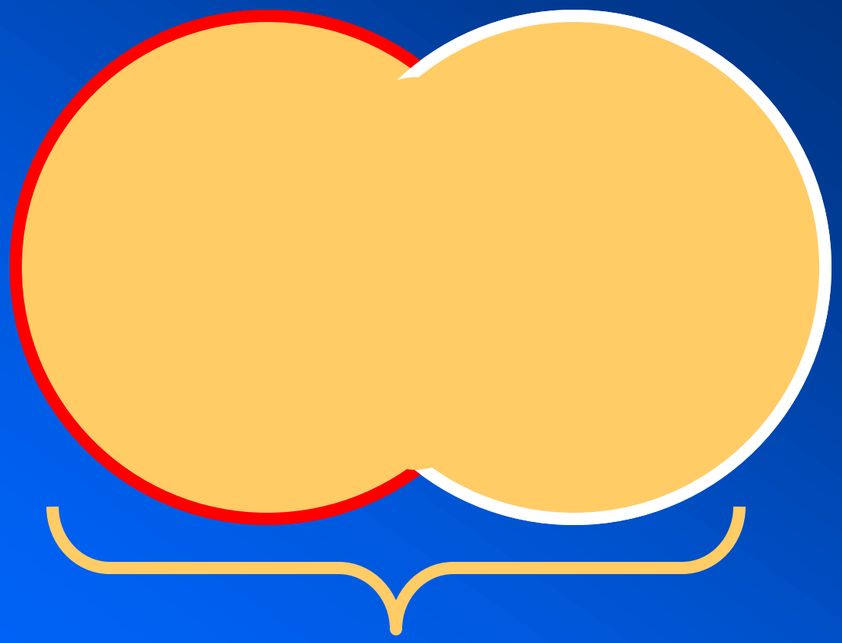


- The Jacquard loom controlled the weaving with pattern-encoded, **punched cards**. A hole determined the loom action.
- Only very simple patterns were woven with the mass-production fabric-making machines of the Industrial Revolution.
- Up to 10,000 cards made up a "**program**."

1854 George Boole (Boolean logic)



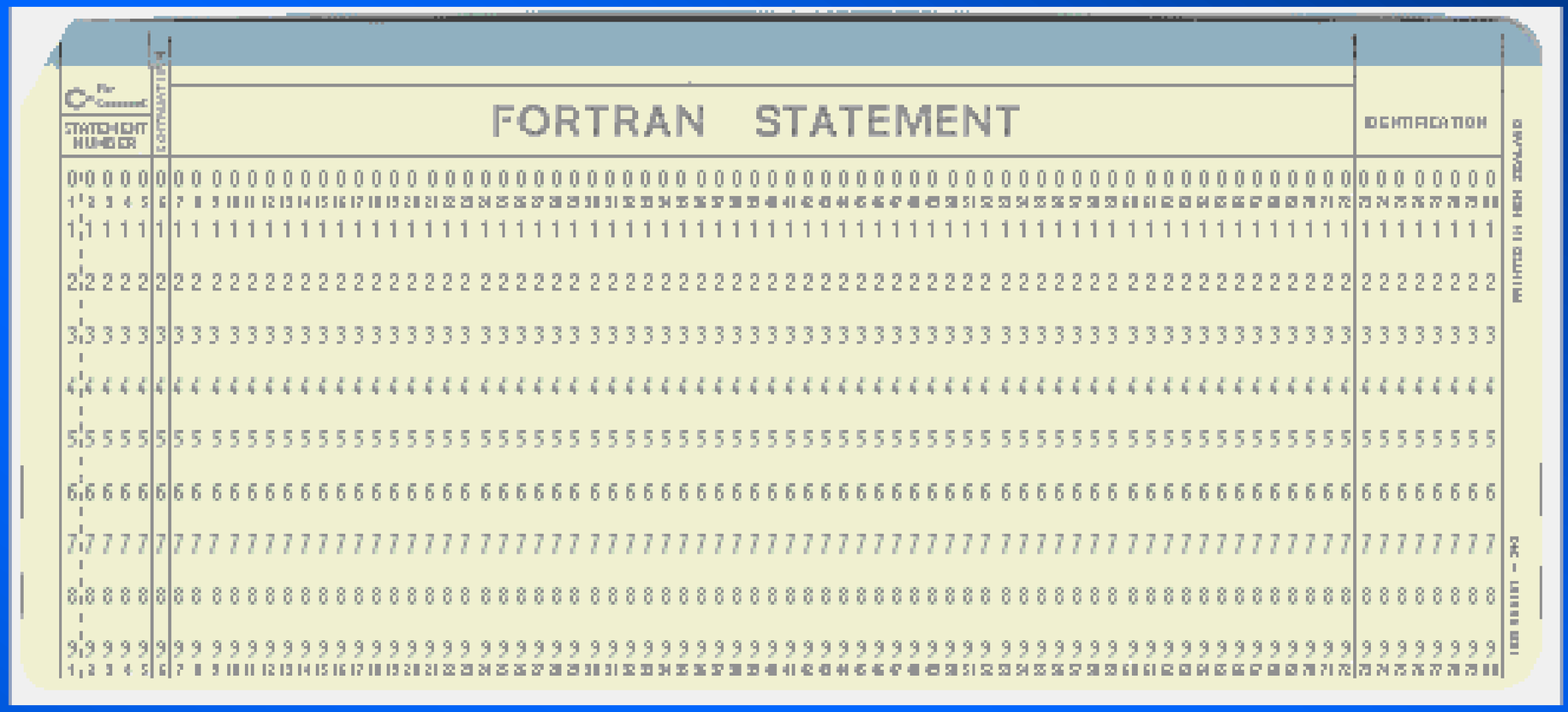
Spanish and male **A AND B**



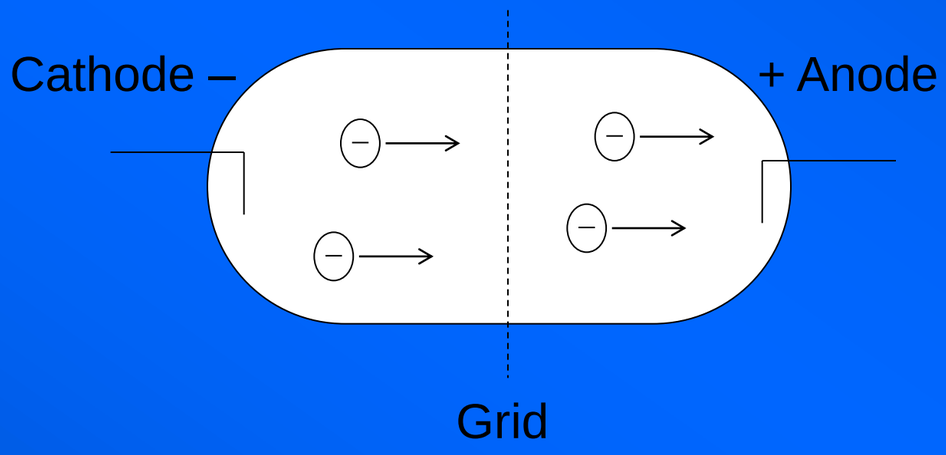
Spanish or male **A OR B**

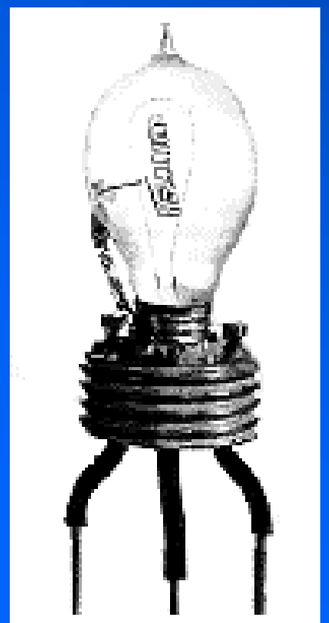
- **Simple algebra: AND and OR**
- **A AND B is the intersection (restricts)**
- **A OR B is the union (expands)**
- **truth tables, binary logic, search parameters**

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).



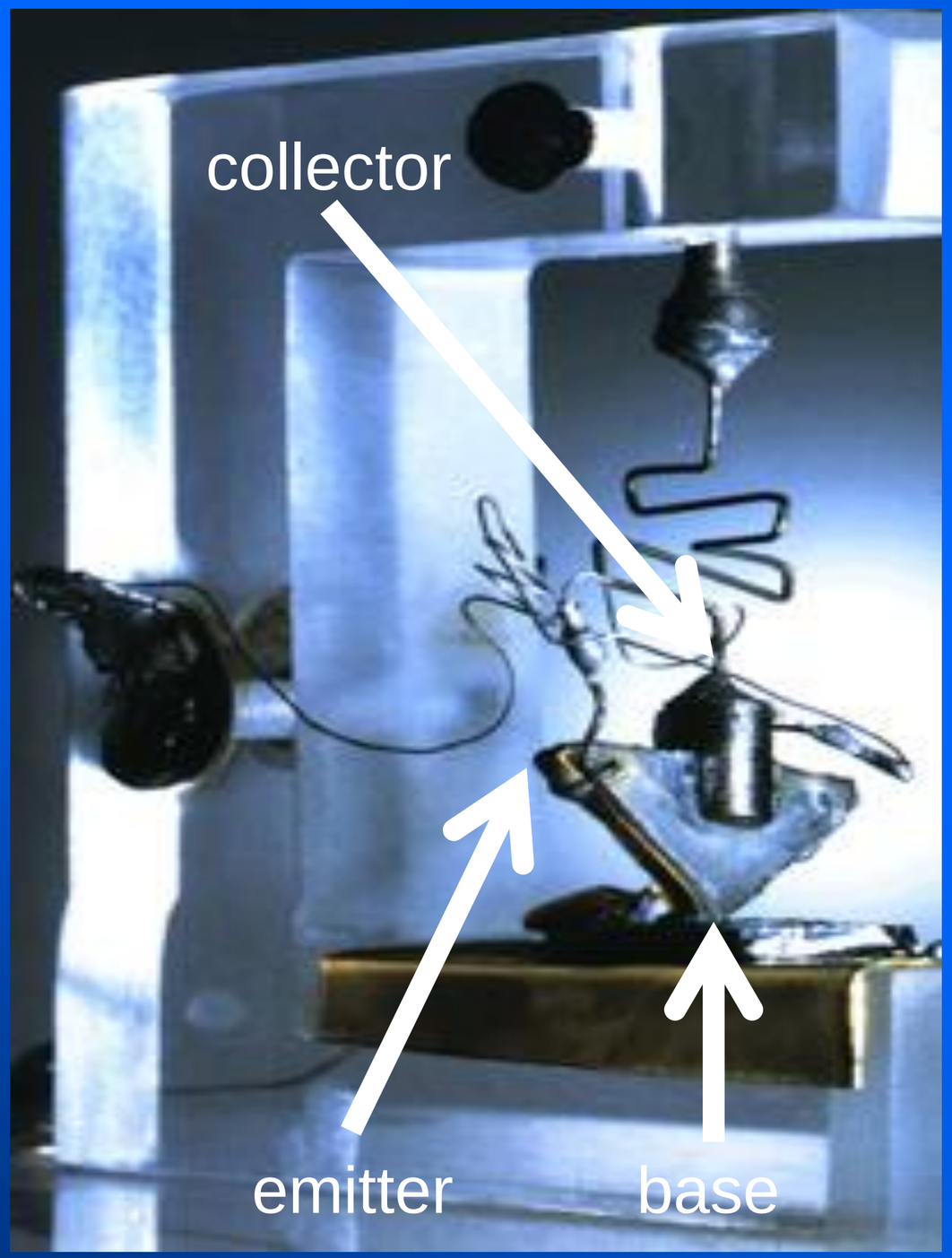


vacuum tube from the early 1900's

1912

Triode vacuum tube

- **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.)

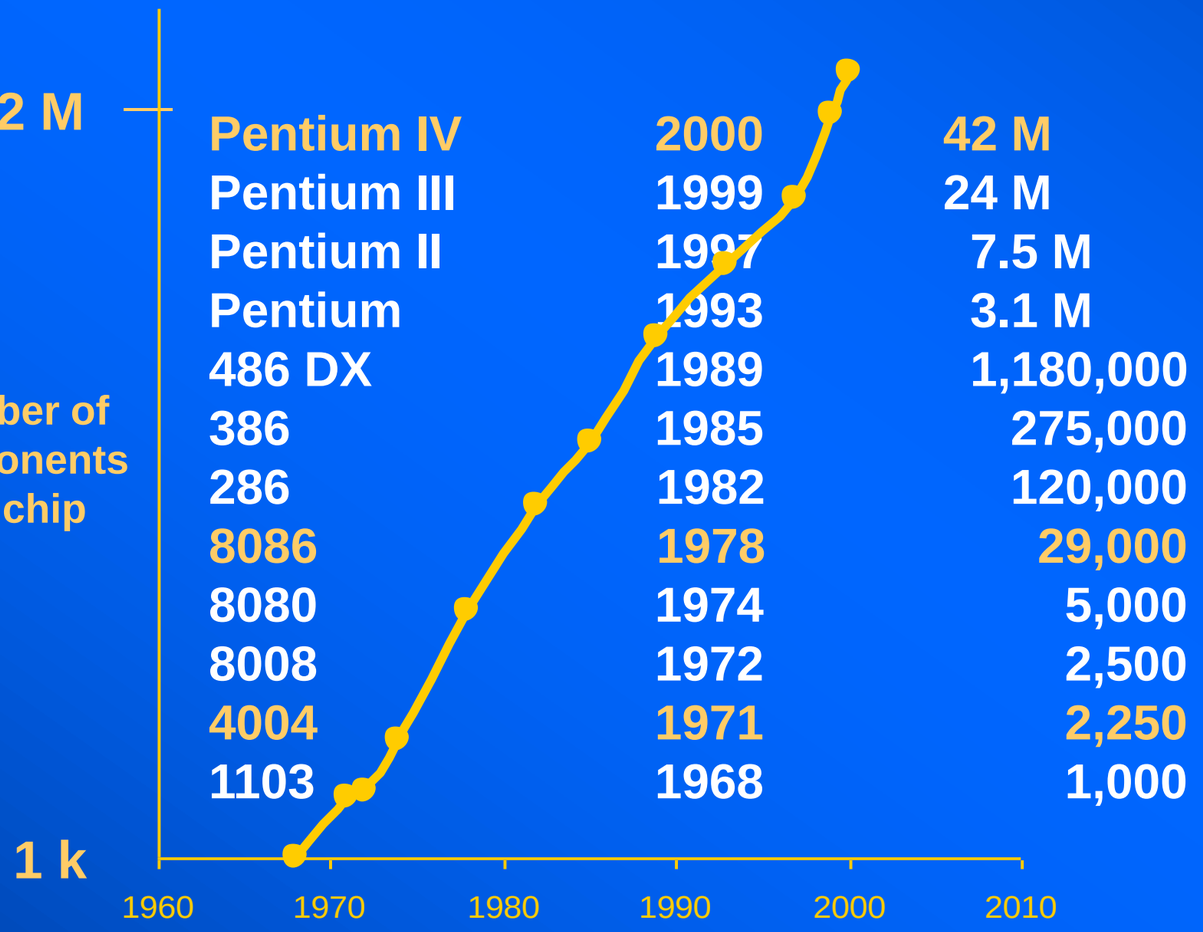
Amplified a current as in a vacuum tube (but not prone to breakdowns).

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

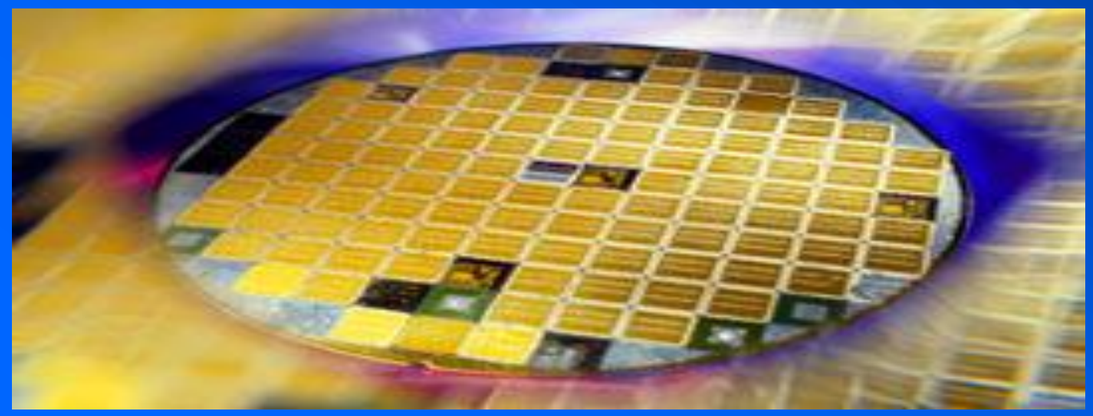
1958 Integrated circuit

- 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.

Moore's Law (1964)

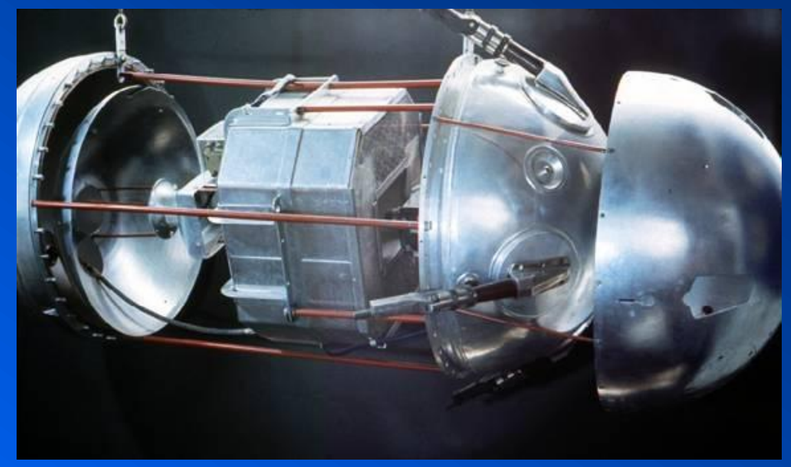


Pentium IV	2000	42 M
Pentium III	1999	24 M
Pentium II	1997	7.5 M
Pentium	1993	3.1 M
486 DX	1989	1,180,000
386	1985	275,000
286	1982	120,000
8086	1978	29,000
8080	1974	5,000
8008	1972	2,500
4004	1971	2,250
1103	1968	1,000



- "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)

1957-1969-1971 Sputnik-Apollo-Intel

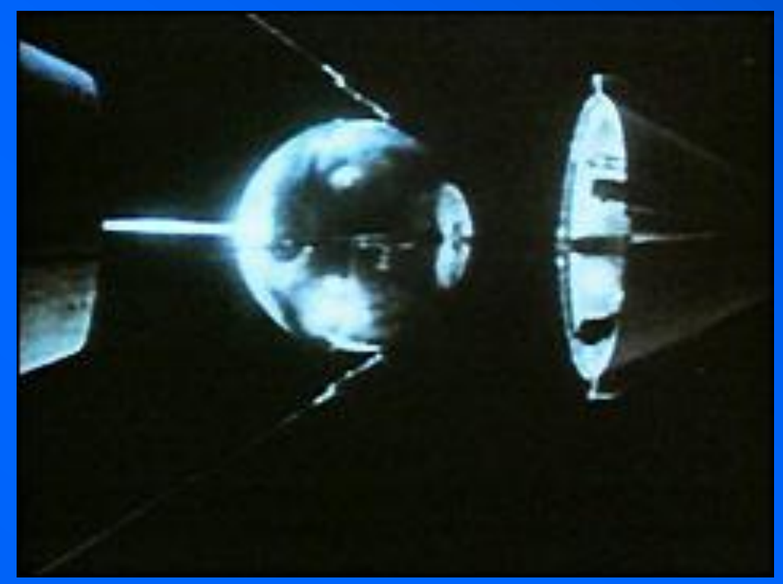


- The USSR launched Sputnik (meaning satellite) … and the space race had begun.

- 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.

A recent computer spec (specification)

- **Pentium IV: 2.53 GHz, 1 GB, 64 GB, ISDN modem (desktop)**

- Intel Pentium III
- 650 MHz
- 128 MB
- Windows 2000
- 10 GB
- 8 MB
- 3.5 floppy drive
- CD-ROM or CDRW
- 100 Base-T
- V.90 or 56Kflex
- 2 USB
- 17" SVGA CRT
- keyboard, mouse

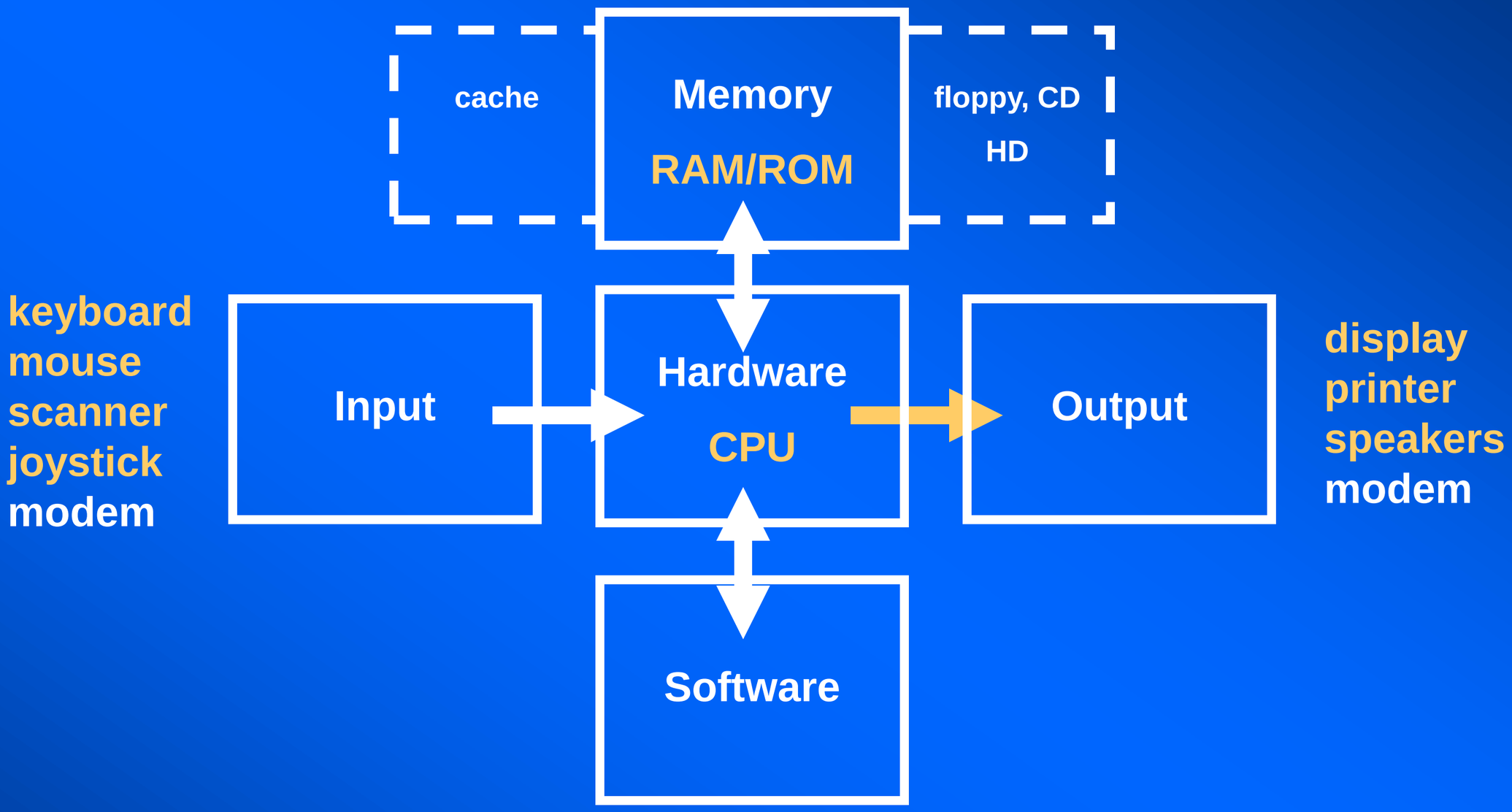
Unpacking the jargon

speed, size, memory, bandwidth

- Intel Pentium III
- 650 MHz
- 128 MB
- Windows 2000
- 10 GB
- 8 MB
- 3.5 floppy drive
- CD-ROM or CDRW
- 100 Base-T
- 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

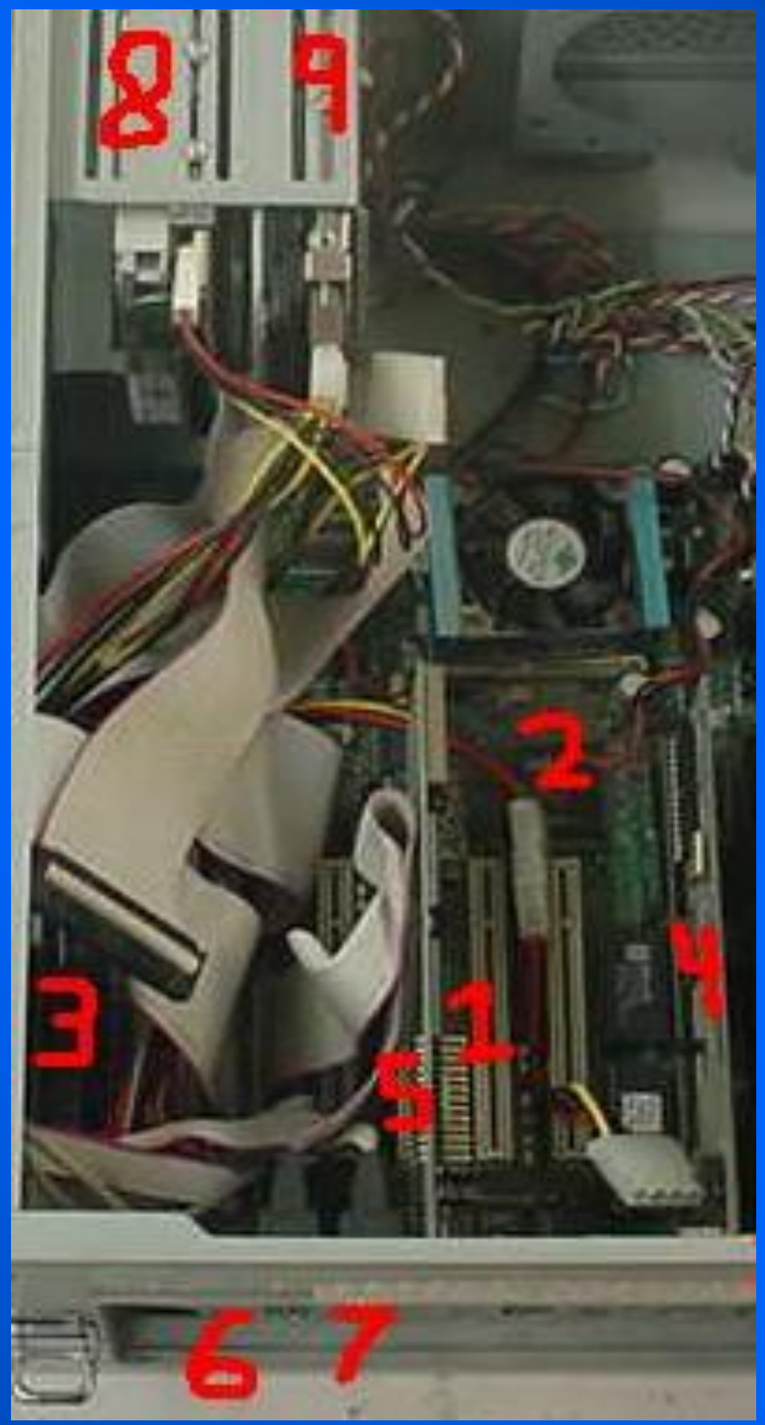
A computer The basics (in-->operate-->out)



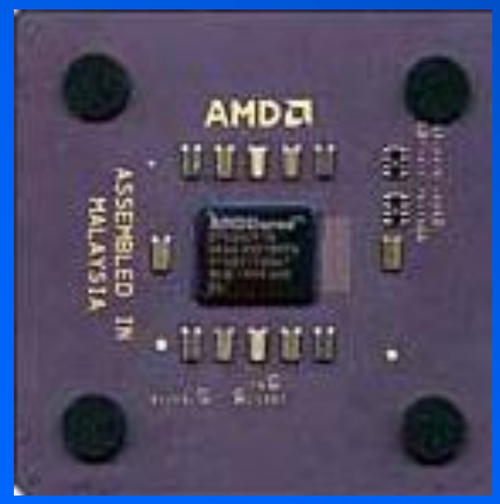
- memory/input/output connected by data buses 8-bit/16-bit/32-bit
- stand-alone or networked (LAN/WAN)

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



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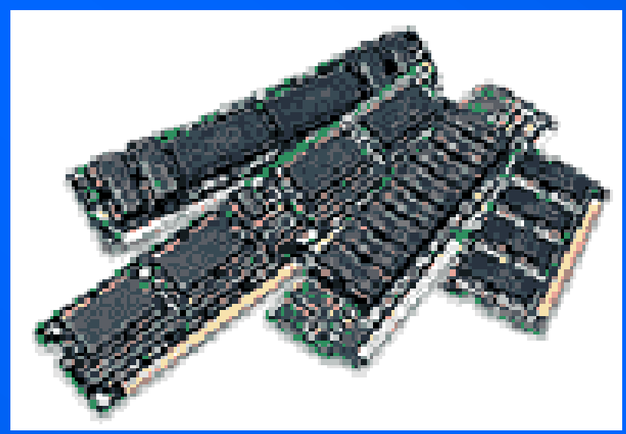


3

Hardware is hard -- can crush your fingers

Software The “language” of a computer

Assembly
APL
BASIC
C
C++
COBOL
FORTRAN
HTML
Java
JavaScript
Visual Basic
Visual C
…

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
```

EXCEL Plot the trajectory of a rocket or projectile in

Excel

Microsoft Excel

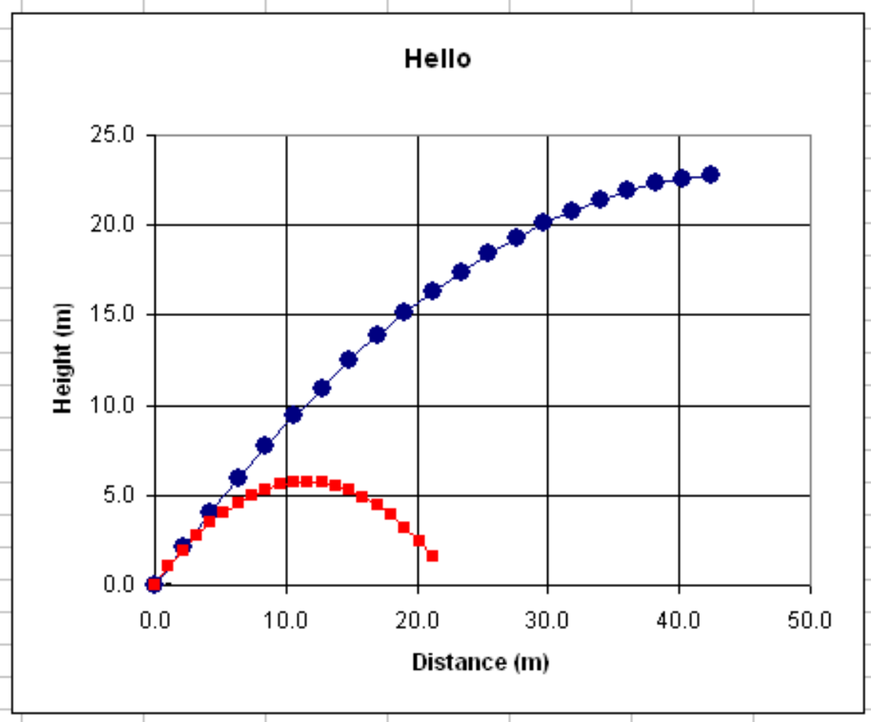
File Edit View Insert Format Tools Data Window Help

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

HTML The "soft" wiring

What you see is
not what you get

A simple HTML program first.html

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

More HTML 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**

Binary The first “language” of a computer

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

$2^{10} = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 1{,}024 \approx 1{,}000 = 1\text{ k}$

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

…

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

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")

Computer characters

256 = 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 ╣

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.**

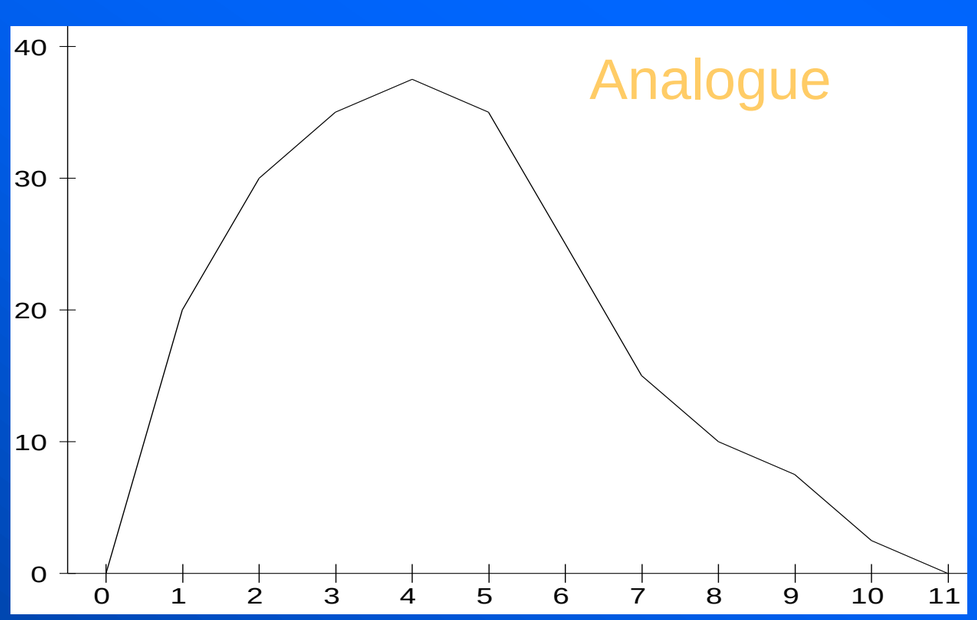
"Watson come here I need you"
312 bits or 39 bytes

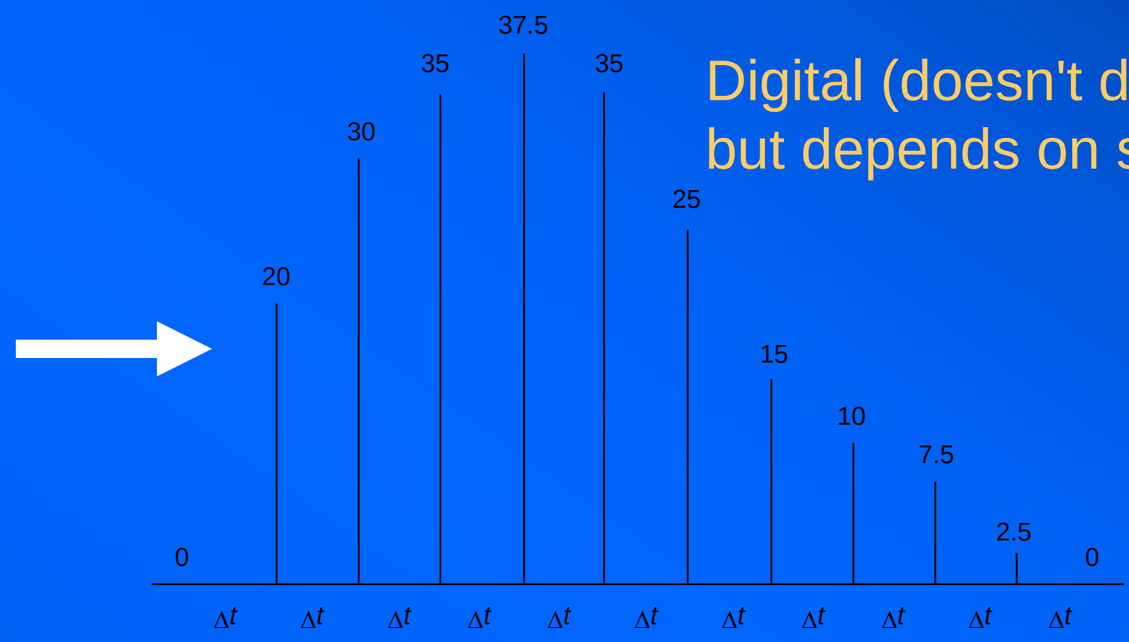
000010000111000010010001000100010110000100010101000100010001000100010000
000010011001000100010001000100001001000100000001000000010000010000010000
000100010001010000010000000100000111001100000001000100000001000000010000
00010001000000010001000000000000000100100001000100010001000100010111
000010000111000010010001000100010110000100010101000100010001000100010000
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.

Information I How much of a message is needed?

gbobledigook rlues ok

why typos won't matter in tmoorrow's wrold

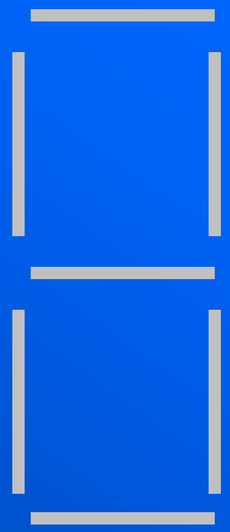
orus is the age of sbusttiutes: intsaed of lagnuage, we have jragon intsaed of pirncpiles, solgans and, intsaed of gneuine iedas, Birght Idaes.

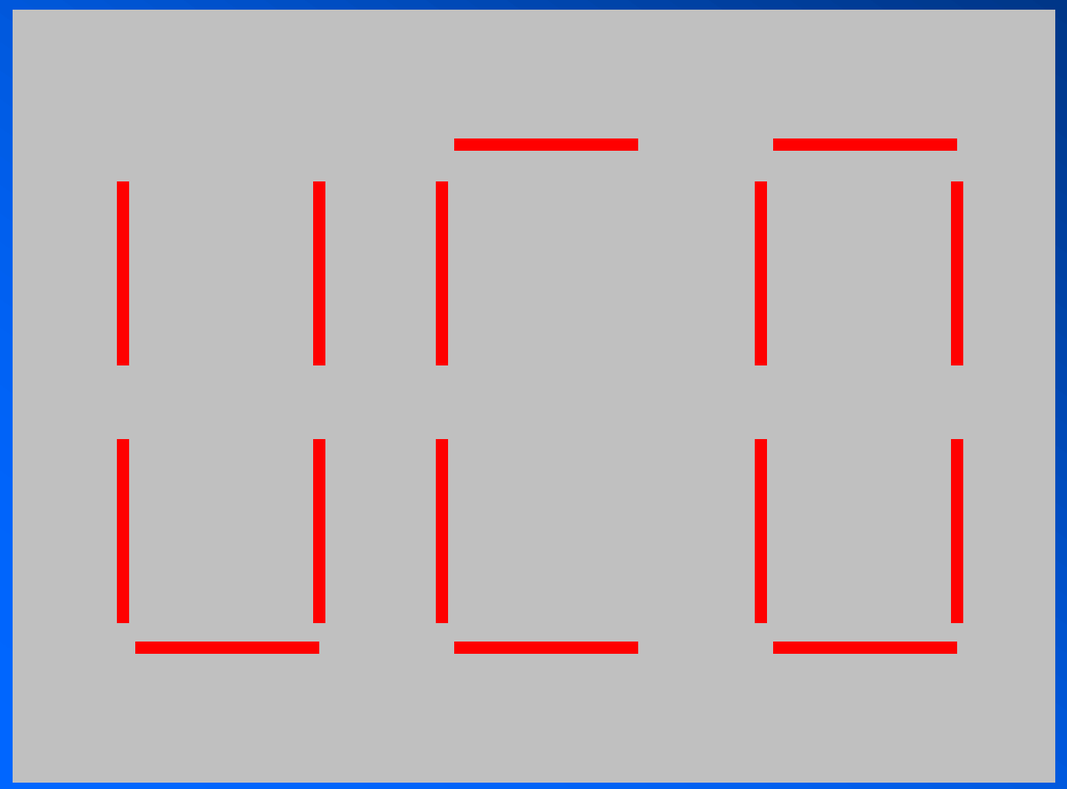
Eric Bnetley mdae a btiter obsrevation alnog thsee lnies in the *Nwe Rpeublic* bcak in 1952. Eevn he mghit have ben apaplled to dicsover that, just hlaf a cnetury laetr, our brians would hvae leraned to do whtiout acucrate spleling too.

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?

Encoding 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)

More encoding 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

Sound files No more records, tapes, or CDs

Marvin the martian -- . wav
(49 kB)

Oh drat …

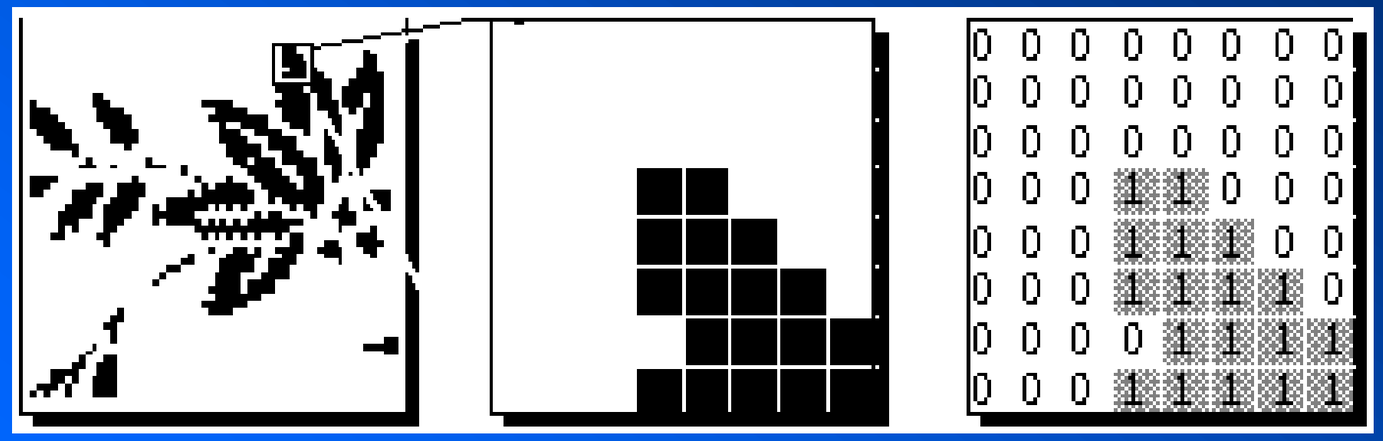
WAV file	**(top-quality stereo, uncompressed) about 10 MB**
MP2	**reasonable-quality stereo) about 1 MB**
MP3	**(acceptable-quality stereo) as low as 200 kB / minute**
RealAudio	**(acceptable mono) about 100 kB / minute**
WMA	**Windows Media (Microsoft) smaller than MP3**
AAC	**Advanced Audio Coding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

MP3 (formally MPEG Layer III) compresses digital audio

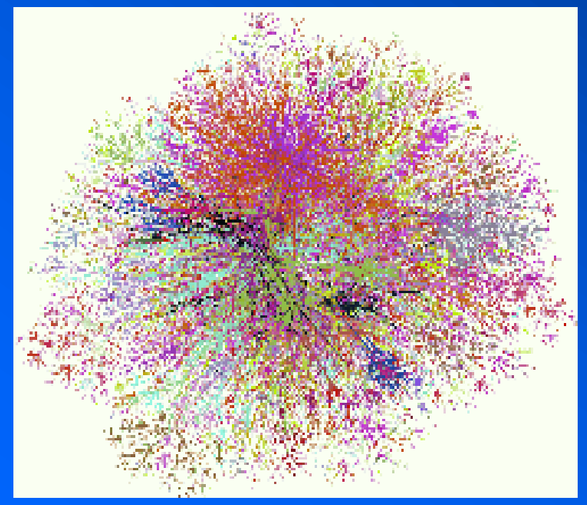
Picture files Illustrations/photos (.bmp, .jpg, .gif)

www.webopedia.com

- **.bmp (bitmap)**
  columns of dots stored in memory. Resolution = density of dots in dots per inch (dpi) --> pixels (display) ink dots (printer).

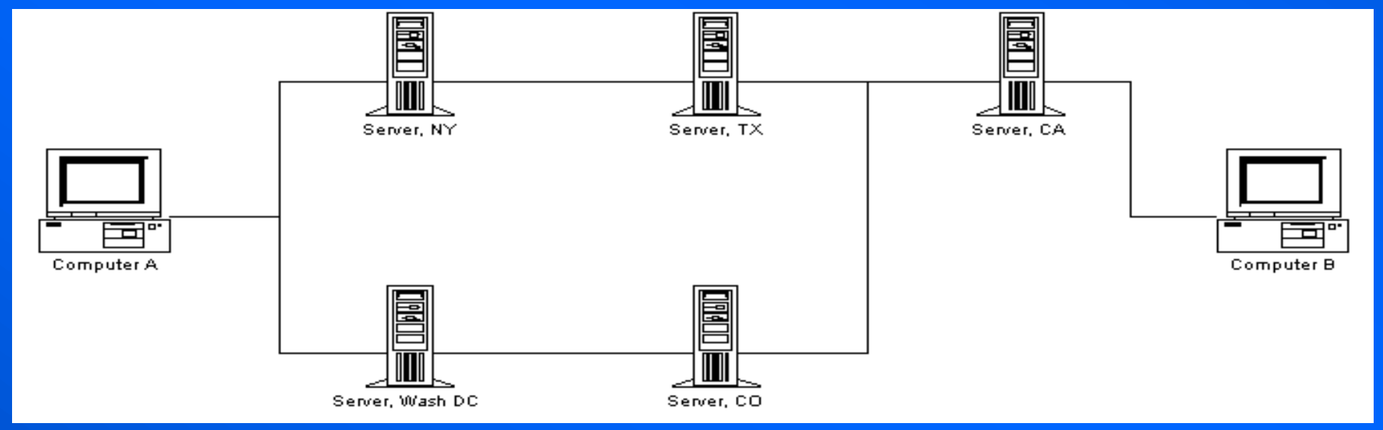


- **.jpg/.jpeg (joint photographer experts group) 256 x 256 colours (FF = 2 bytes).**
  a lossy compression method standardised by ISO (reduces redundant information) (*cf*. mpeg)



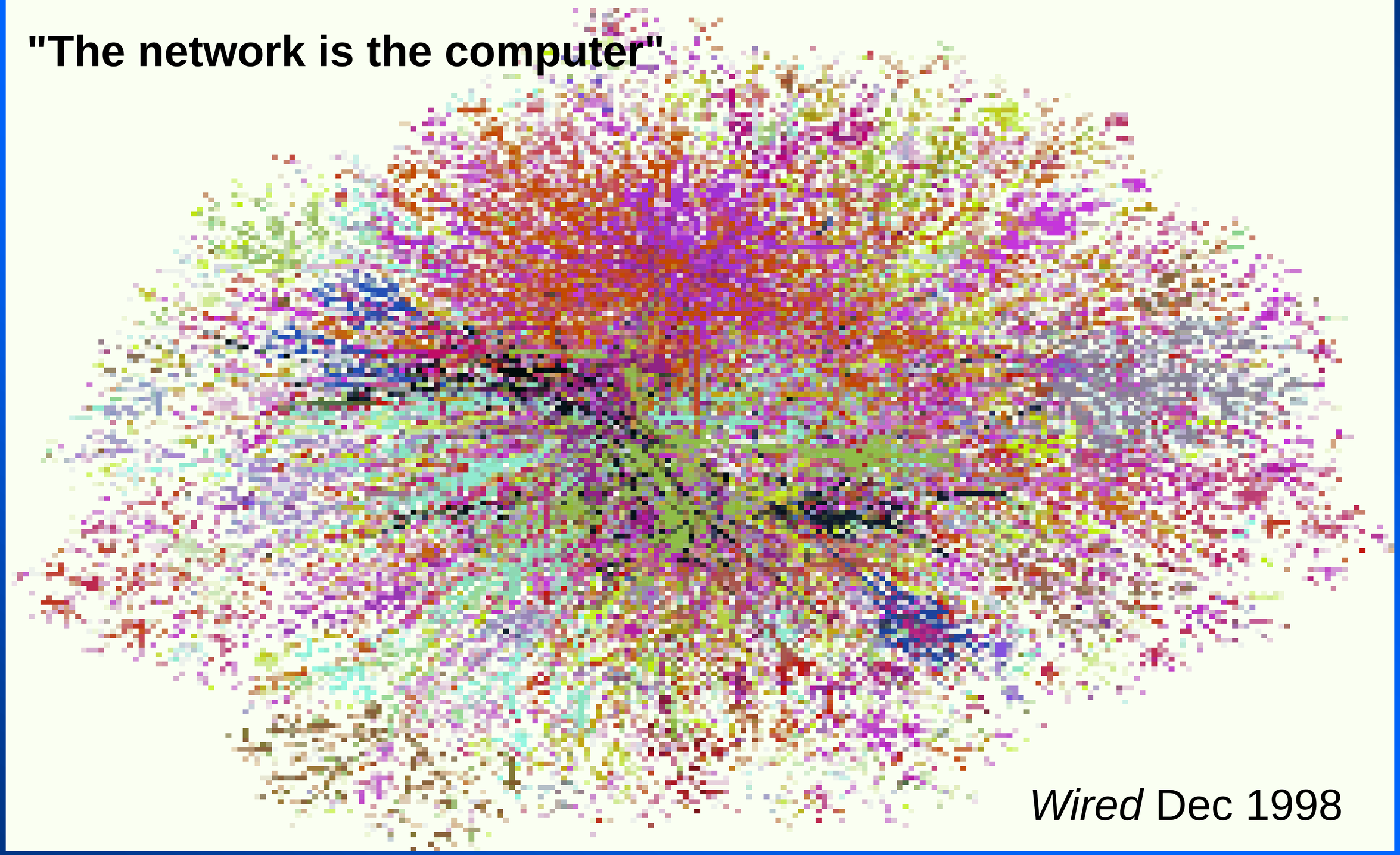
- **.gif (graphics information file)**
  CompuServe proprietry web file. More suited for illustrations.

Compression a trade-off between file size and visual quality.
Resolution a function of file size.



Wired to the net The "global village"

"The network is the computer"



Wired Dec 1998

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

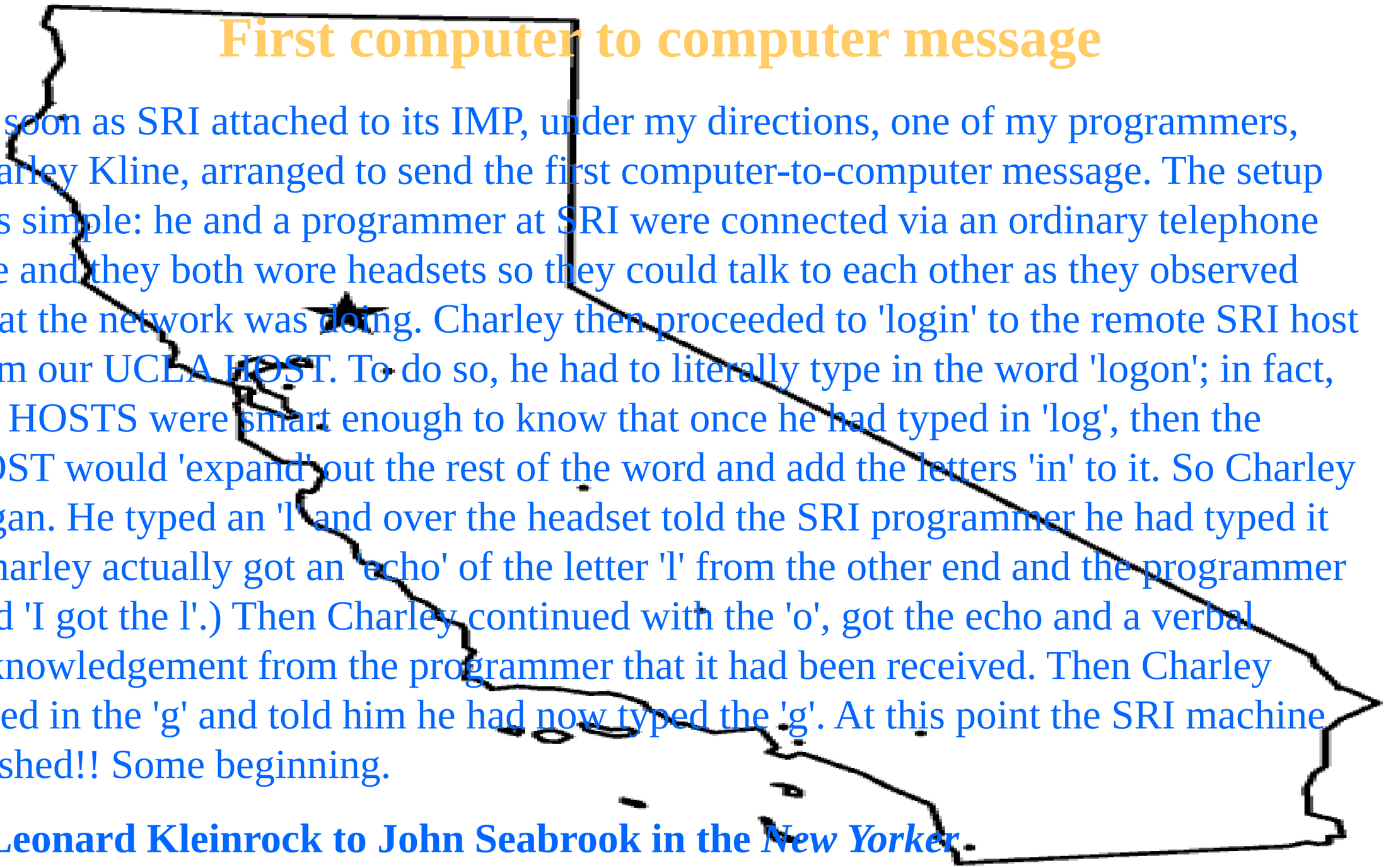
1972 37 nodes

...

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*.

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

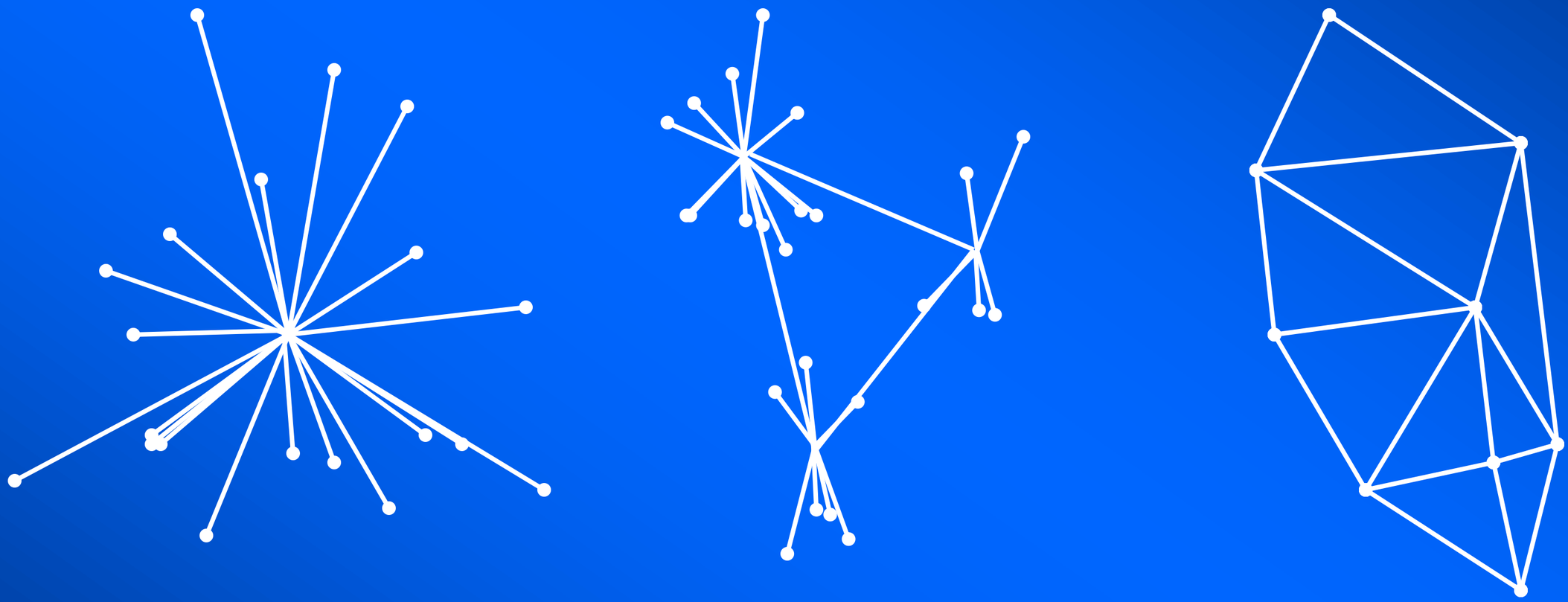
get through along any route

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

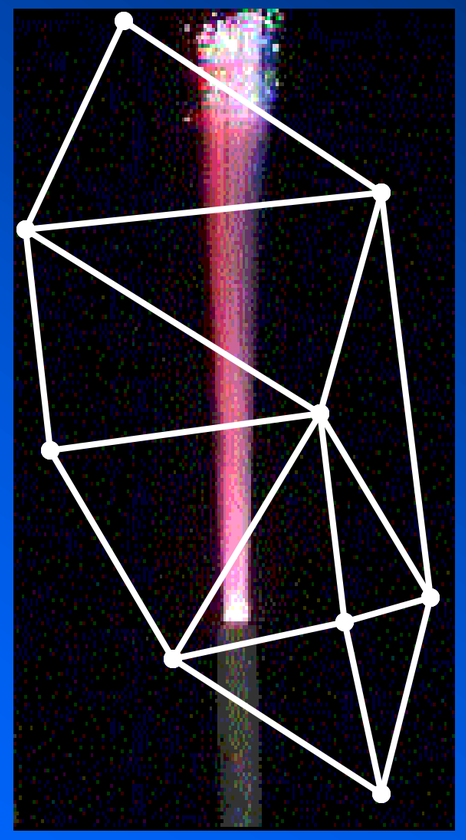
decentralised

distributed

distributed, redundant, multiple paths

The world wide web (www)

So, what is the internet?



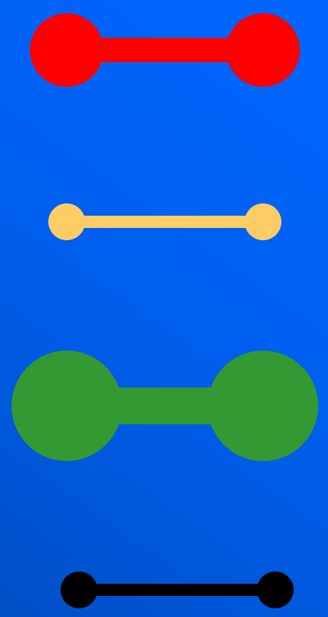
- the internet is a game of **"pass the packet"**
- the message protocol is TCP/IP
- the transfer protocol is HTTP
- 24/7 with billions of packets flying around
- reassembled in different order: some get lost and are re-sent
- Machine or an organism?

What is needed to get on the web (to surf)

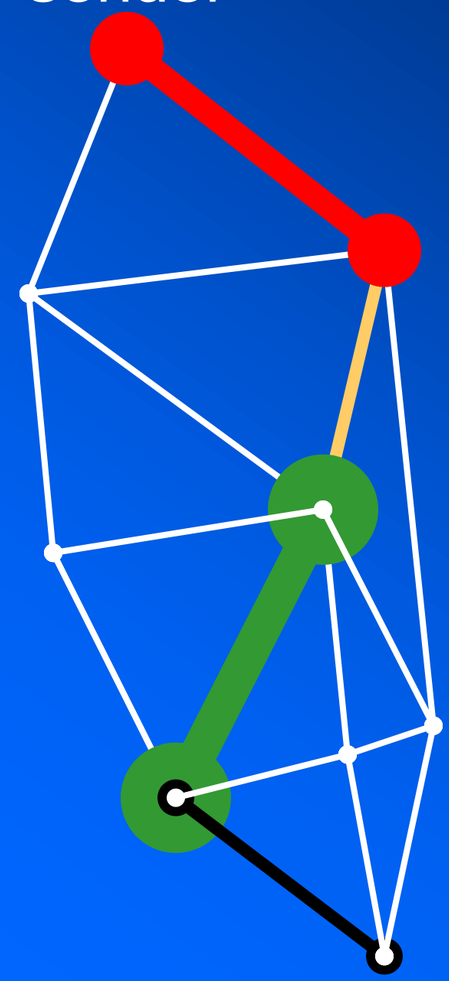
- ISP (internet service provider): eircom, iol, unison, oceanfree
- a computer, modem, IP address (2^{32} or 4 billion)
- Visual browser (Netscape, Explorer), e-mail, file transfer

Bandwidth I 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 II 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

Internet security I Encryption

Internet → commerce e-bay **But is the internet safe?**

Cryptography -- The Science of Secrecy

As long as there are creatures endowed with language there will be the desire for confidential communication -- messages intended for a limited audience. Governments, companies and individuals have a need to send messages in such a way that only the intended recipient is able to read them. Generals send battle orders, banks wire fund transfers and individuals make purchases using credit cards.

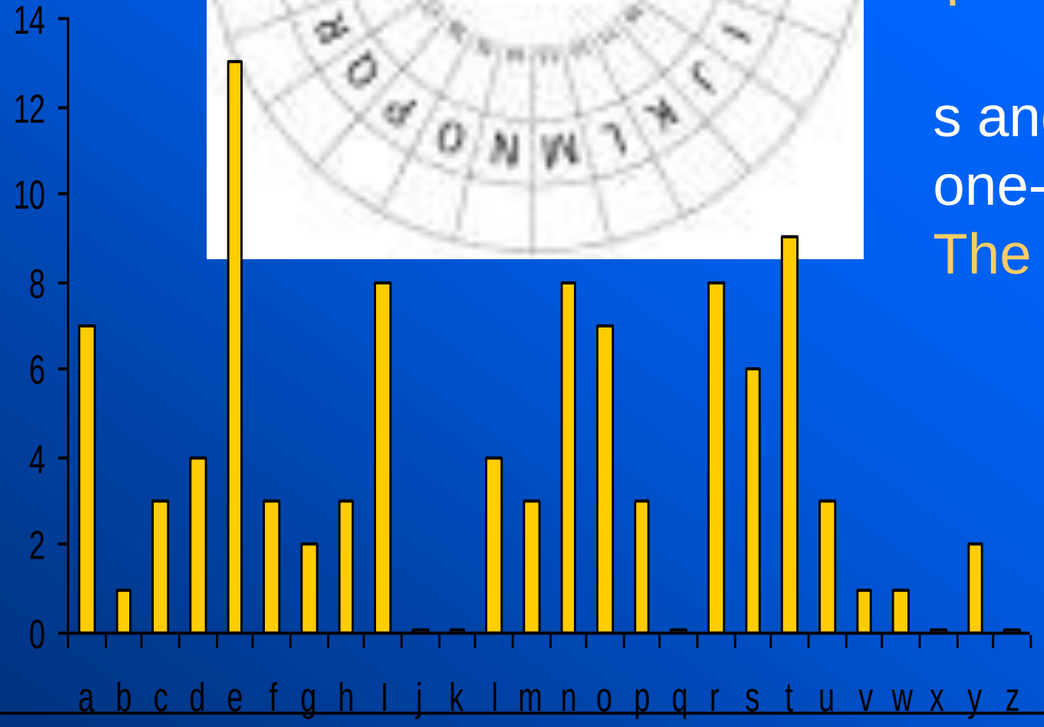
How can a message be transmitted secretly to its intended recipient so that no unauthorised person obtains knowledge of its contents?

Sarah Flannery -- *In Code*

Internet security II Encode-send-decode

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

Caesar's wheel --> shifts text (IBM --> HAL)



C = (P + s) mod 26 (Crypto text --> Plain text)

watson come here i need you
xbutpo dpnf ifsf j offe zpv (s = 1)
ycvuqp eqog jgtg pggf aqz (s = 2)

P = (C - s) mod 26 (Plain text --> Crypto text)

s and -s are the "keys" K_E = <s> K_D = <-s>
one-to-one correspondence between crypto and plain set
The problem? Frequency of letters are easy to figure out

One solution: two keys
C = (mP + s) mod 26
K_E = <m,s> K_D = <26-m,-s>
where m is relatively prime to 26

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.**

- **Sarah Flannery**, "***In Code***," **Profile Books, London, 2000.**

- **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 (http://realserver.princeton.edu:8080/ramgen/special/20030907classassemblyVN300K.rm)**

- **http://www.webopedia.com/**