Computer Science 1400: Part #3:

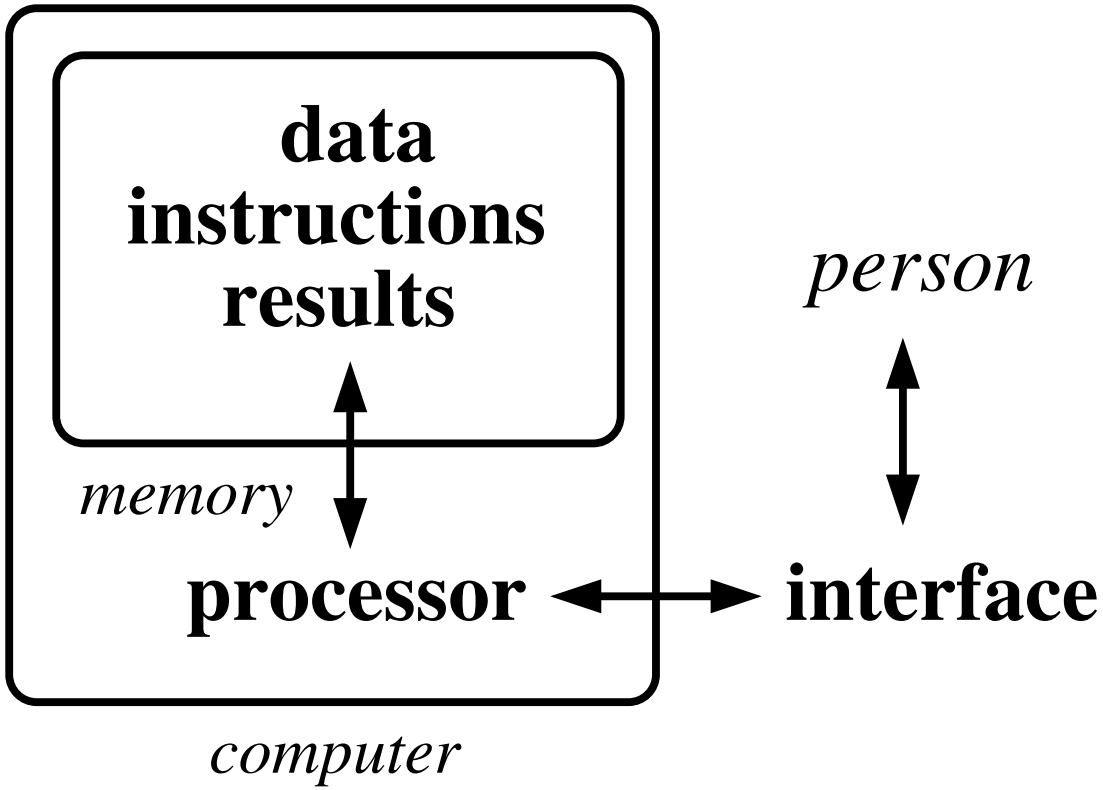
Getting Here:
The Rise of the Machines (1950–1970)

THE COMMERCIAL COMPUTER WARS

MAINFRAMES AND MINICOMPUTERS

THE COMPUTER SOFTWARE CRISIS

What *is* a Computer? (Take III)



Computing in 1950: The State of the Art

- Stored-program computers (experimental)
- Stored-program computers (commercial (sort of))
- IBM mechanical / electronic calculators (business / government / scientific)
- Differential analyzer (scientific)

The First Computer Companies

- Over 30 computer companies by end of 1940's.
- Three types of computer companies:
  1. Electronics-based, *e.g.*, RCA; develop computer expertise in collaboration with academia, *e.g.*, RCA and von Neumann's computing group at Princeton.
  2. Business-machine-based, *e.g.*, IBM; develop computer expertise on top of existing products, *e.g.*, Card Programmable Calculator (CPC).
  3. Entrepreneur-based, *e.g.*, ECC; commercialize founder computer expertise (academia / industry)
- Third type requires start-up funds; was riskiest until well into the 1960's with the advent of venture capital.
- Focus here on business path taken by ECC.

The First Computer Companies (Cont'd)

- ECC initially financed in 1946 on pre-sales of UNIVACs to government and industry; contracted sales price ($300K) on par with ENIAC cost ($400K) but dramatically less than final development cost ($1M).
- ECC saved in 1947 by deal with Northrop Aircraft to develop BINAC, an early missile guidance computer.
- ECC saved again in 1948 by deal with American Totaliser, which provides additional financing for 40% share of Eckert-Mauchley Computer Corporation (EMCC).
- EMCC saved in 1950 by deal with Remington Rand, which in exchange for all shares and assets makes EMCC an in-house division with Eckert and Mauchley retained as paid consultants.

The First Computer Companies (Cont'd)

UNIVAC I
(1951)

Ferranti Mark I
(1951)

- Ferranti Mark I available first, but tradition-bound European commercial market not as receptive to computers as North American market.

The First Computer Companies (Cont'd)

- UNIVAC correctly predicts outcome of 1952 US Presidential Election; outperforms human pollsters.

IBM Enters Electronic Computing

Thomas Watson Jr. (1914-1993)

IBM Enters Electronic Computing (Cont'd)

IBM Selective Sequence Electronic Calculator (SSEC) (1948)

- Designed before *EDVAC Report*; only one machine made.

IBM Enters Electronic Computing (Cont'd)

IBM CPC (Original)

IBM CPC (Final)

- Card Programmed Calculator (CPC) created in 1947 in collaboration with Northrop Aviation and available in 1949.
- Due to low cost and superior reliability, outsold stored-program computers (700 units) until the end of the 1950's.

IBM Enters Electronic Computing (Cont'd)

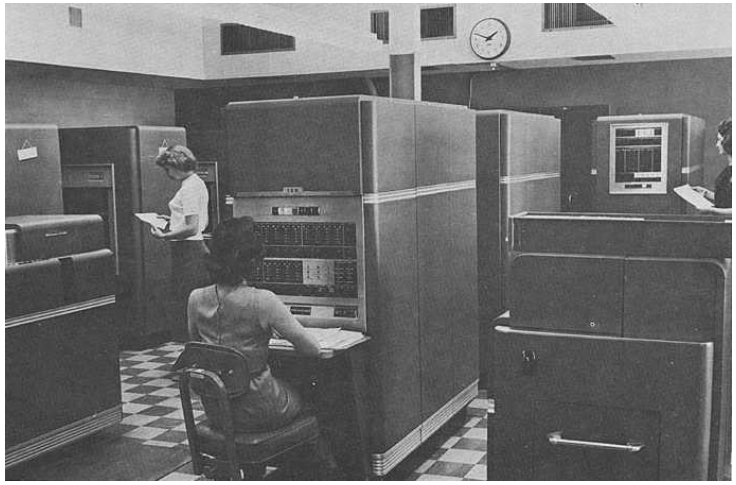
- Two UNIVAC competitors in development in 1949:
  1. Tape Processing Machine (TPM): UNIVAC-equivalent.
  2. Magnetic Drum Calculator (MDC): CPC extension giving basic low-cost ($100K) stored-program capability for small businesses.
- At start of Korean War, Watson Sr. puts IBM at the US President's disposal; as part of this, Watson Jr. pushes development of IBM 701 Defense Calculator.
- Watson Jr. puts TPM on hold to devote resources to 701; this allows early commercial-computing market capture by UNIVAC.

IBM Enters Electronic Computing (Cont'd)

IBM 701 Defense Calculator (1952)

IBM Enters Electronic Computing (Cont'd)

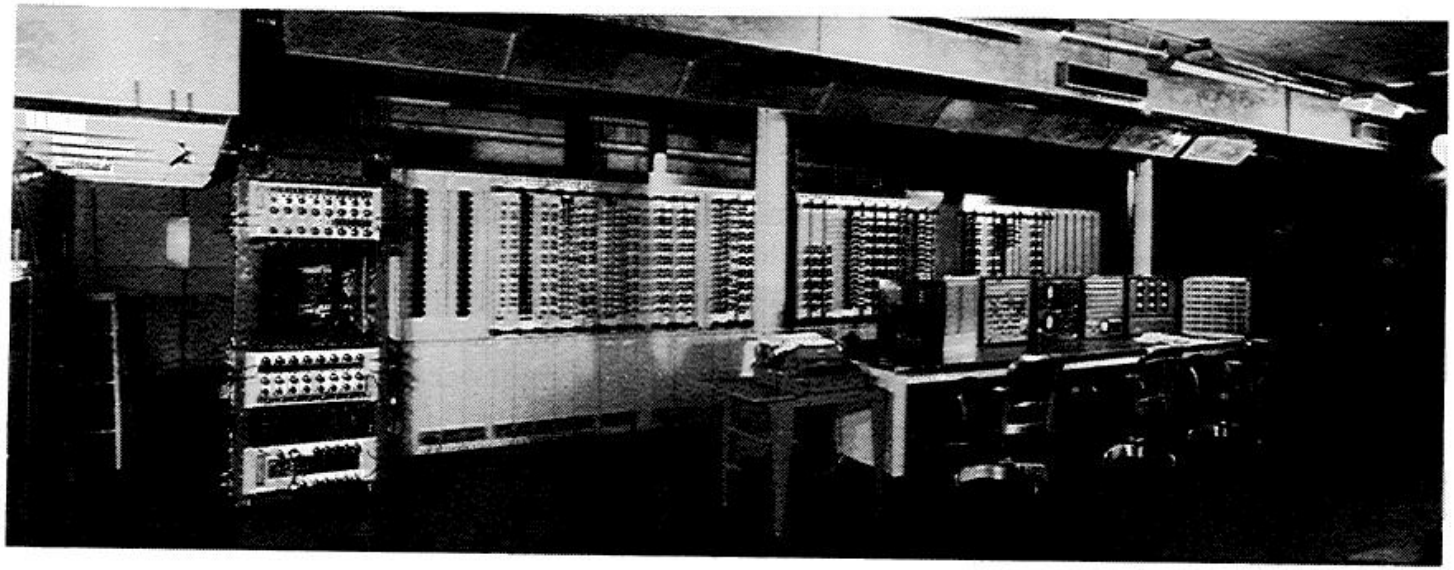
IBM 702 (1955)



IBM 650 (1953)

- TPM development re-started in 1951 and available (IBM 702) in 1955; however, cheaper MDC (IBM 650) is ultimately major source of IBM revenue, outselling all 700-series machines to become "computing's 'Model T' ".
- Key marketing strategy: Place 650s in universities at discount, creating future IBM users and buyers.

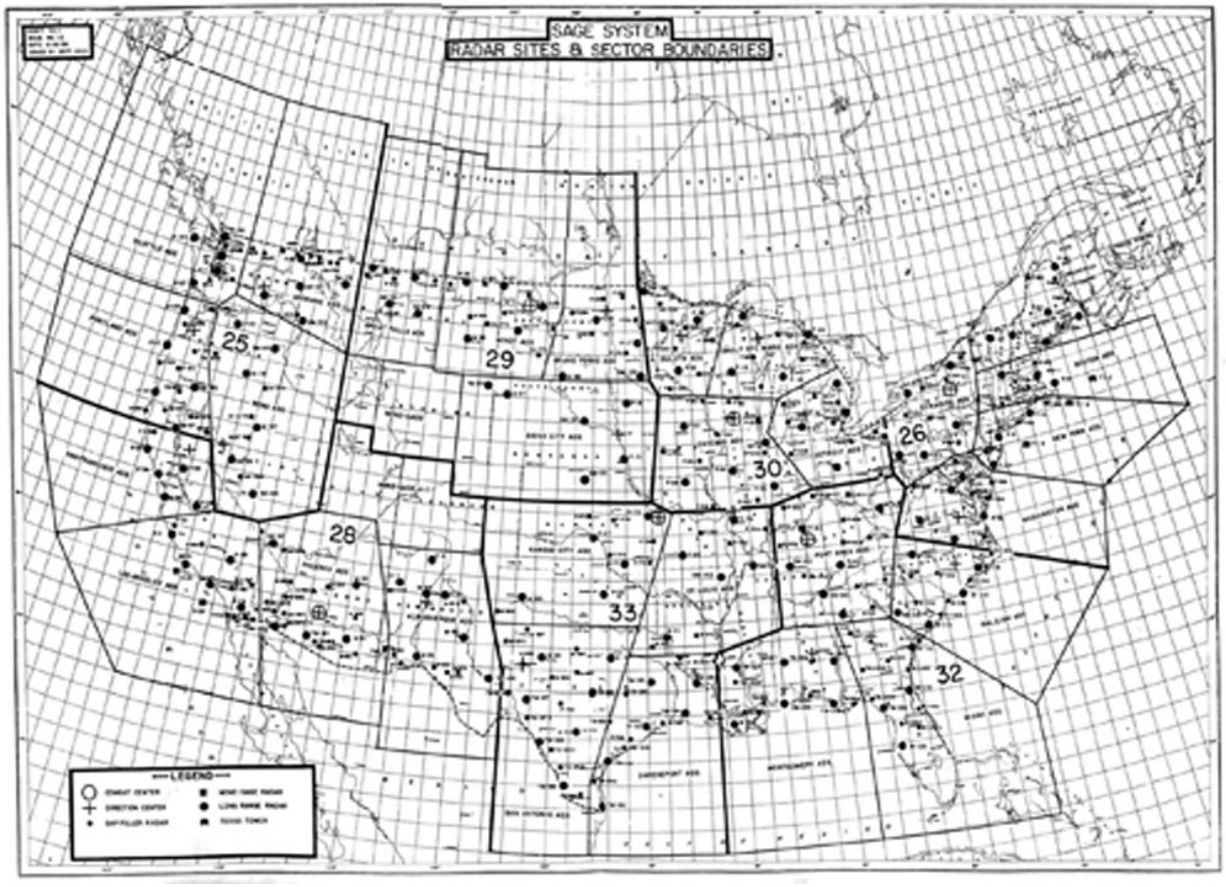
IBM Enters Electronic Computing (Cont'd)



MIT Whirlwind (1951)

- Whirlwind proposed in 1946 as digital stored-program computer for aircraft simulator/trainer; real-time rather than batch operation required 10x faster processing time.
- Subject to massive delays and cost overruns.

IBM Enters Electronic Computing (Cont'd)



Semi-Automatic Ground Environment (SAGE)
Air Defense System

IBM Enters Electronic Computing (Cont'd)

IBM AN/FSQ-7 (1955)

- Whirlwind proposed for SAGE in 1950; in 1952, IBM contracts to combine Whirlwind and 701 to create AN/FSQ-7 to implement SAGE.
- SAGE major revenue source for IBM ($500M); is also invaluable source of hardware and software expertise.

IBM Enters Electronic Computing (Cont'd)

The First Computer Movie: *Desk Set* (1957)

IBM Enters Electronic Computing (Cont'd)

The First Computer System: IBM 1401 (1959)

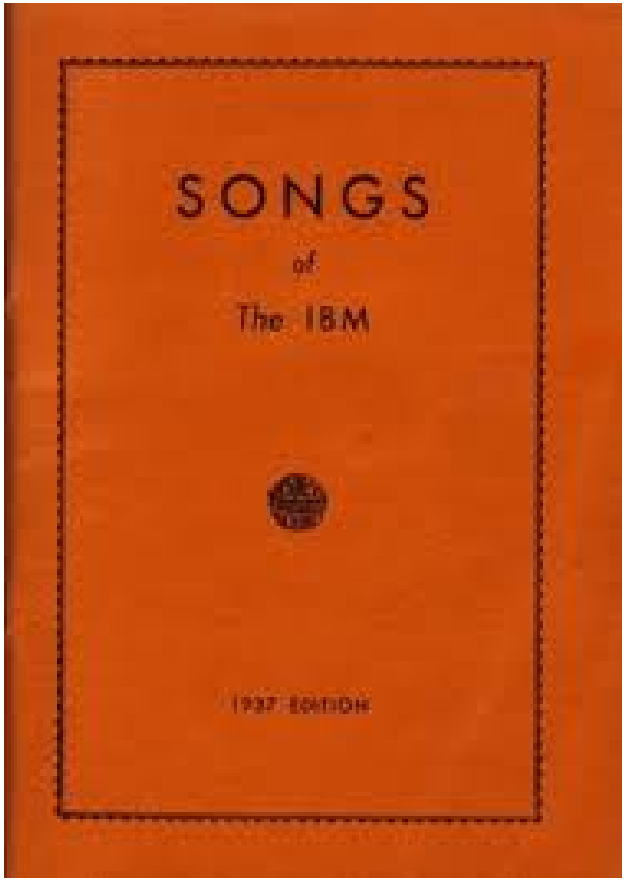
- Decisive factor in 1401 success is advanced printer.

IBM Enters Electronic Computing (Cont'd)

- By 1960, only computer survivors are IBM and the Seven Dwarves (UNIVAC, Burroughs, NCR, Control Data Corporation (CDC), RCA Honeywell, General Electric).
- IBM has over 50% market share; many Dwarves survive by exploiting niche markets, *e.g.*, CDC and scientific supercomputing, NCR and business applications.
- UNIVAC loses early lead by 1950s due primarily to lackluster management and sales support at Remington Rand and later Sperry Rand.
- While often not in technical forefront, IBM computers dominate by reputation for reliability and IBM's highly-trained sales force and service / systems orientation.

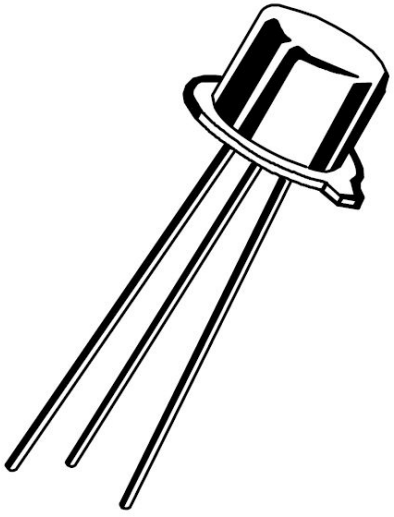
IBM Enters Electronic Computing (Cont'd)

IBM Salesman
(1950s)

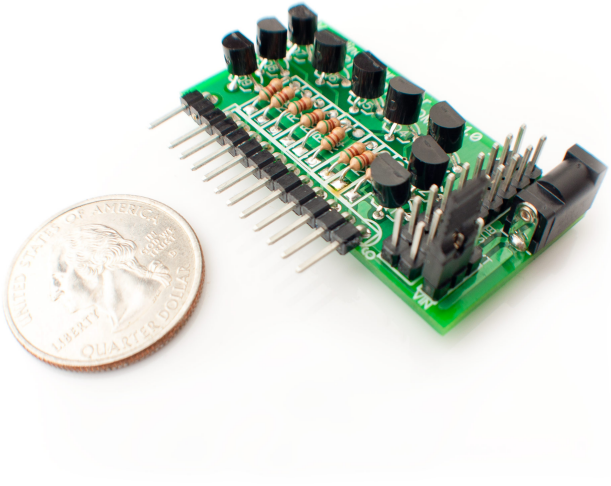


IBM Songbook
(1937)

The Rise of Silicon Valley



Transistor (1947)



Transistor Board

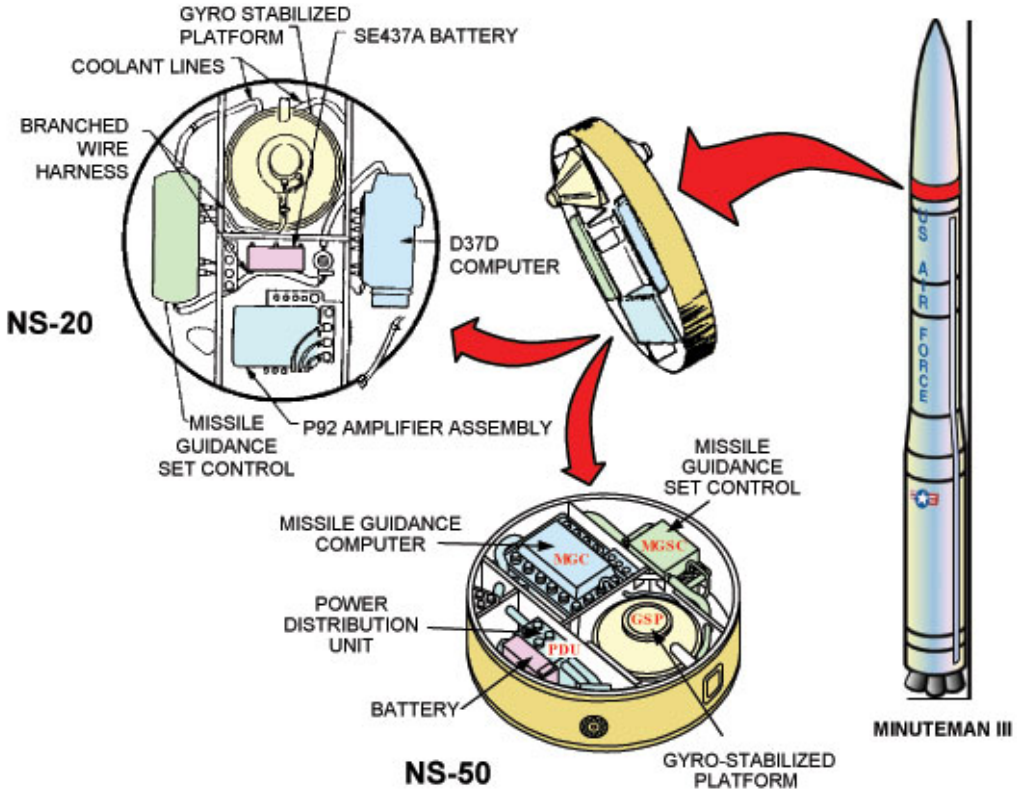
- Traditional electronics businesses based on US East Coast. Shockley establishes first transistor manufacturer on West Coast (Palo Alto, CA) in 1955; trend continued by spinoff (Fairchild Semiconductor) in 1957.

The Rise of Silicon Valley (Cont'd)

The First Hydrogen Bomb: Ivy Mike (1952)

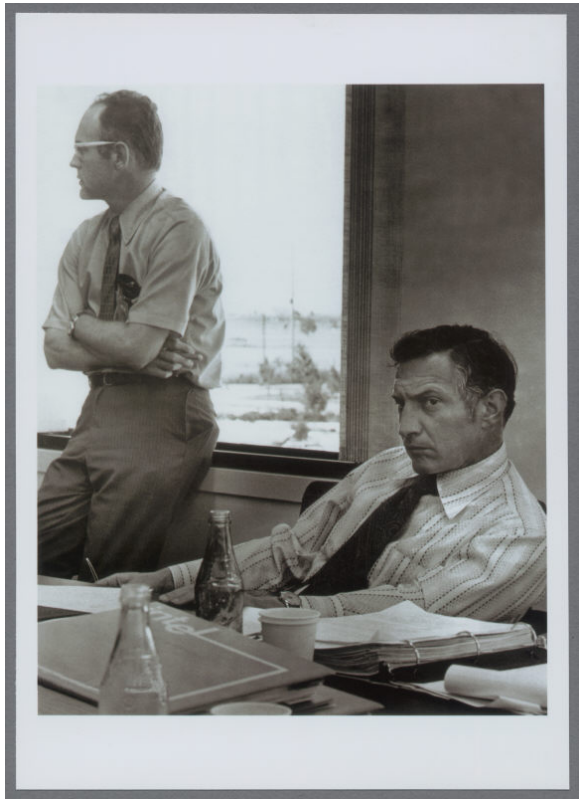
The Rise of Silicon Valley (Cont'd)

Minuteman I
(1962)



Minuteman Guidance Systems

The Rise of Silicon Valley (Cont'd)

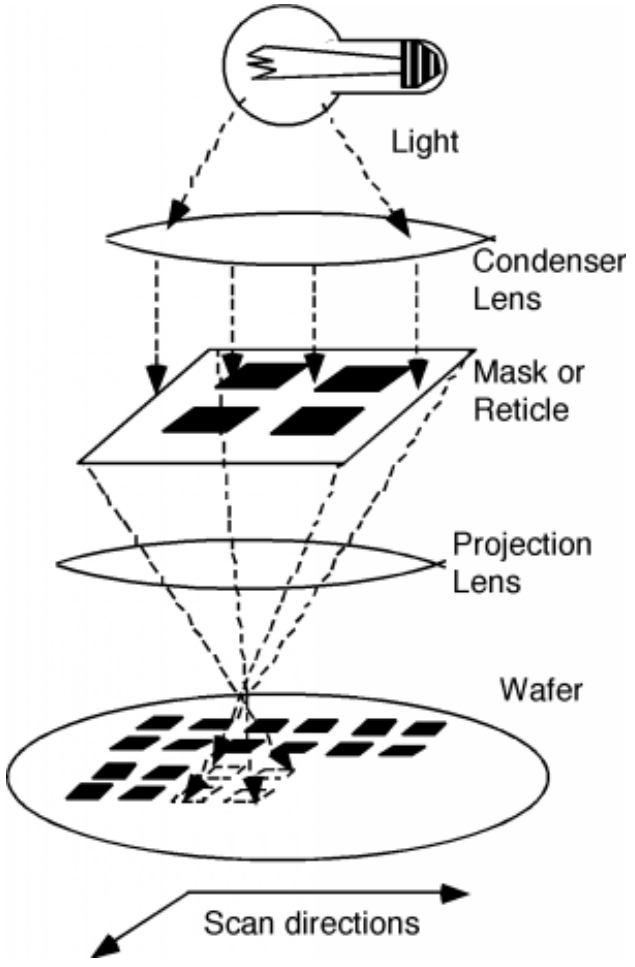


Gordon Moore (1929–) and Robert Noyce (1927–1990)

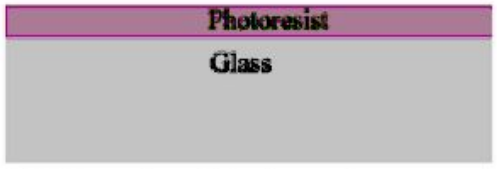
- Co-founders of Fairchild Semiconductor; in 1959, Noyce develops planar process for creating integrated circuits.

The Rise of Silicon Valley (Cont'd)

- Silicon is a natural semiconductor whose electrical conductivity can be chemically modified by doping.
- In the planar process, electrical components based on silicon and deposited metals are "micro-printed" photographically in separate stacked layers on wafers of pure silicon.

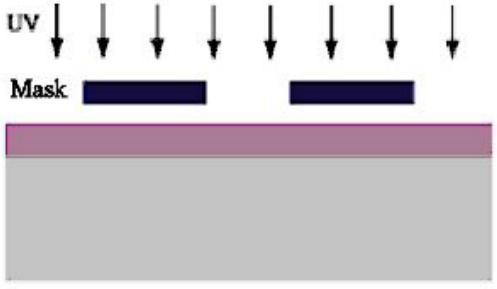


The Rise of Silicon Valley (Cont'd)

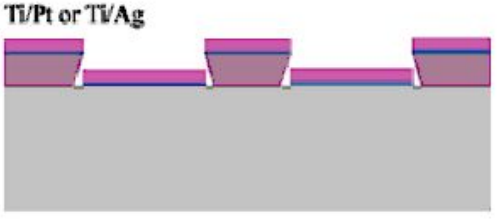


1. Spin coating of the photoresist.

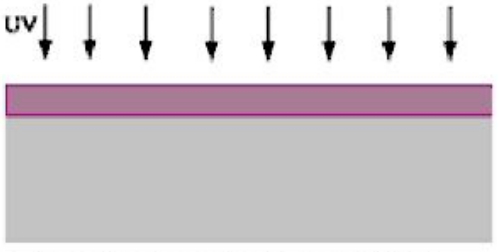
2. Developpement of the photoresist.



3. Exposure to UV light through the mask.



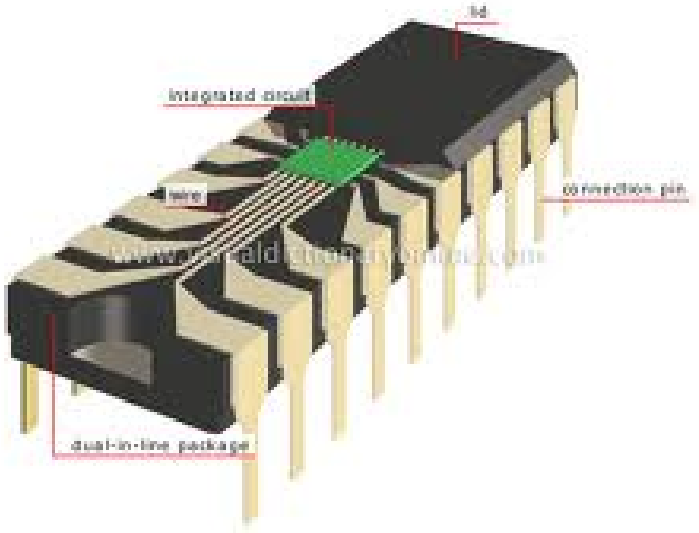
4. E-beam evaporation of the metals.



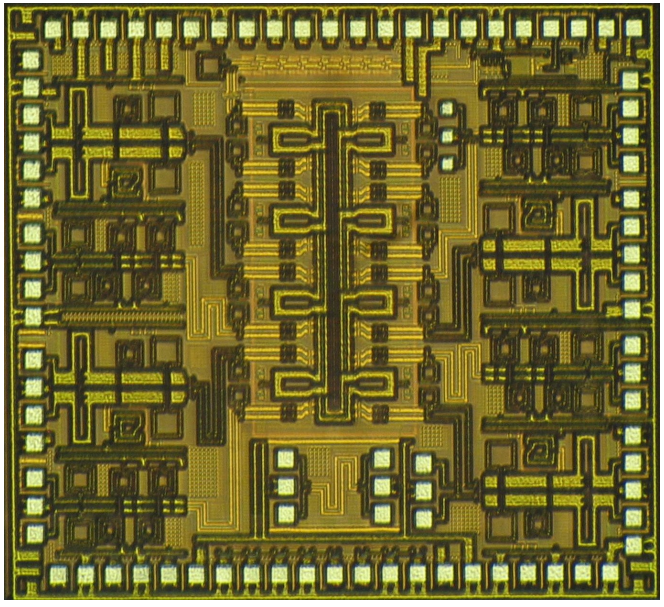
5. Second exposure to UV light without mask after baking.

6. Dissolution of the photoresist.

The Rise of Silicon Valley (Cont'd)



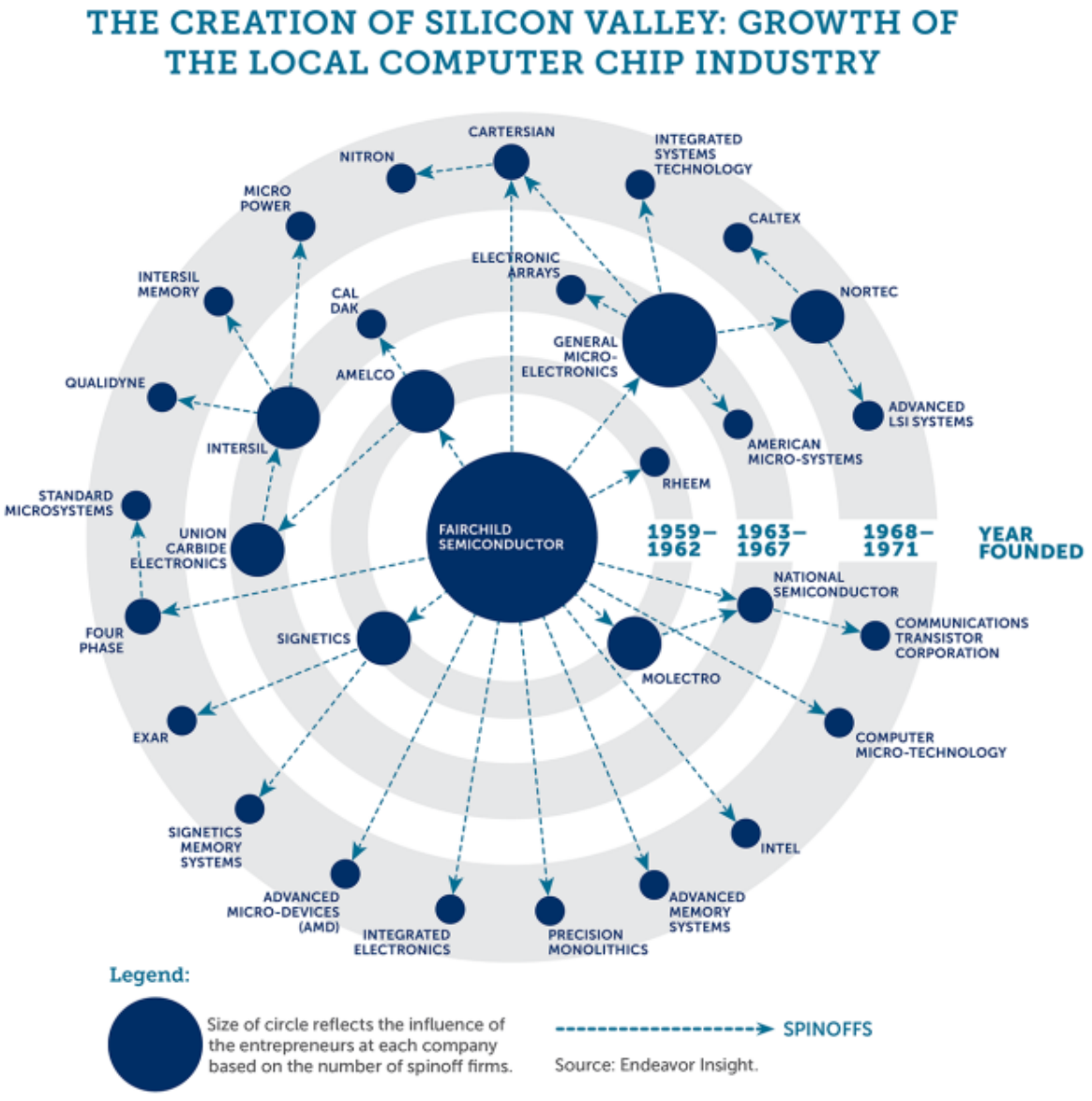
Integrated Circuit (IC) (1959)



IC Internals ("Chip")

- Noyce broadens transistor market beyond military by innovative verging on suicidal pricing policies.
- Moore's Law (1965): 2x transistor density every 18 months.

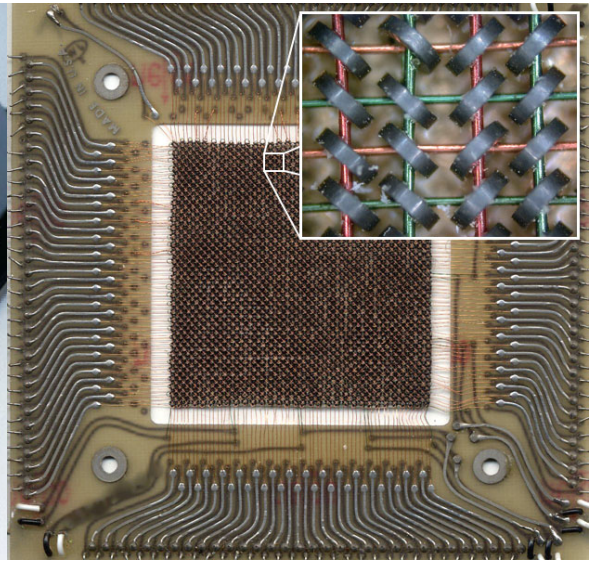
The Rise of Silicon Valley (Cont'd)



Computing Technology: Memory

Magnetic tape (1951)

Magnetic disk (1956)



Magnetic core (1953)

- Division into fast (primary) and slow (secondary) storage.
- Fast storage possible with transistors; however, still too expensive for use in memory in 1950's and 1960's.

Computing Technology: Memory (Cont'd)

- Word-sizes standardized in terms of 8-bit chunks (**bytes**).
- Memory size stated in terms of number of bytes:

Kilobyte	(KB)	$= 10^3$ (thousand) bytes
Megabyte	(MB)	$= 10^6$ (million) bytes
Gigabyte	(GB)	$= 10^9$ (billion) bytes
Terabyte	(TB)	$= 10^{12}$ (trillion) bytes
Petabyte	(PB)	$= 10^{15}$ (quadrillion) bytes
Exabyte	(EB)	$= 10^{18}$ (quintillion) bytes
		$\vdots$

Computing Technology: Software

- A **task** specifies how inputs are related to outputs.
- An **algorithm** is a sequence of instructions that, given an input, specifies how to create the associated output
- A **program** is an encoding of an algorithm in a language that can be executed by a computer.

```
PROGRAM BakeIt:
INPUT Ingredients
combine in bowl
WHILE not smooth DO
   mix ingredients
preheat oven to 350o
put mix in pan
put pan in oven
FOR every 10 min DO
   IF cake done THEN
      remove cake
turn off oven
OUTPUT cake
```

Computing Technology: Software (Cont'd)

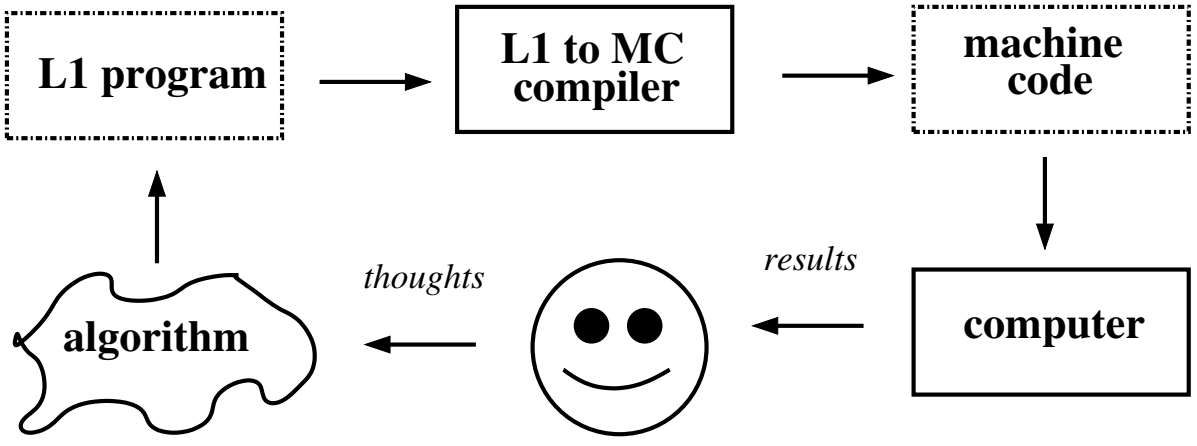
- The basic language of every computer is a set of sequences of low and high voltages that cause specific parts of the computer to do specific things; each such instruction-sequence can be viewed as a binary sequence, *e.g.*, `0110011110`.
- Algorithms are typically written in a mix of mathematics and natural human language, *e.g.*, `set x to (x + y)/5`.
- First programmers manually translated algorithms into into sequences of basic instruction mnemonics (**assembler language**), *e.g.*, `load R5 10; add R5 R7`, and then in turn manually translated the mnemonics into binary machine code.

Computing Technology: Software (Cont'd)

- Programming effort initially eased by being able to re-use frequently-occurring pieces of code (**subroutines**).
- First research (including first programming manual) done by Wilkes in England, but shifts to US by 1953.
- By mid-1950's, three key programming needs:
  1. Automatic translation of human-written programs into machine code.
  2. The ability to write programs using human-natural programming languages.
  3. Automatic handling of program translation and execution, I/O, and memory management.

Computing Technology: Software (Cont'd)

- A **compiler** is a program that translates a program in one language into an equivalent program in another language.
- Compilers can be cascaded, *e.g.*, translate high-level language into assembler and assembler into binary
- First compilers pioneered by Grace Hopper in early 1950s.



Grace Hopper
(1906–1992)

Computing Technology: Software (Cont'd)

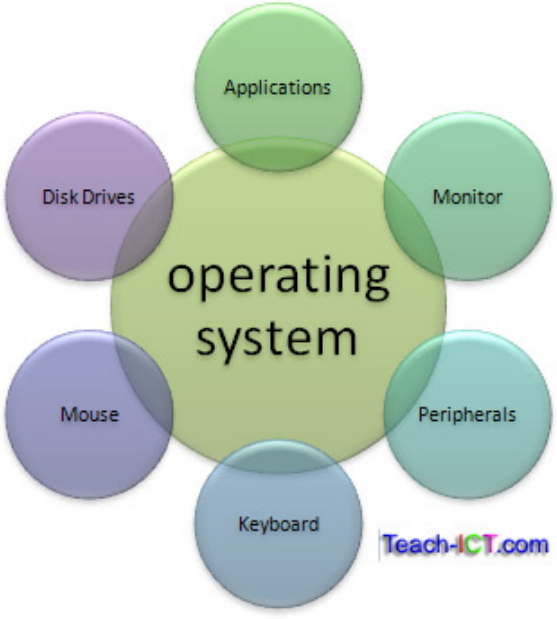
John Backus
(1924–2007)

Grace Hopper teaching
COBOL (early 1960's)

- FORTRAN (FORmula TRANslation) created by Backus team at IBM in 1957; designed for scientific computation.
- COBOL (COmmon Business-Oriented Language) created by industry / government committee in 1959; designed for business applications.

Computing Technology: Software (Cont'd)

- An **operating system (OS)** is a computer program that co-ordinates all communications between memory, processors, other devices and human computer users.
- First OS developed in the late 1950's (IBM SHARE).



The Rise of the Software Industry

- Two software markets by mid 1950's: large-scale (government / military / large commercial) and small-scale (low to mid commercial).
- Large-scale market typically handled by equipment manufacturers, *e.g.*, IBM, Burroughs, NCR; software "free" with purchase / lease of computer.
- First software contractor is RAND Corporation for SAGE; employs over half of all programmers in US in 1955.
- Due to expense in hiring programmers, small-scale market handled by small software contractors, *e.g.*, CUC.
- By 1967, estimated 45 large and 2800 small software contracting firms in US; focus is almost exclusively on building software systems for clients and not on products.

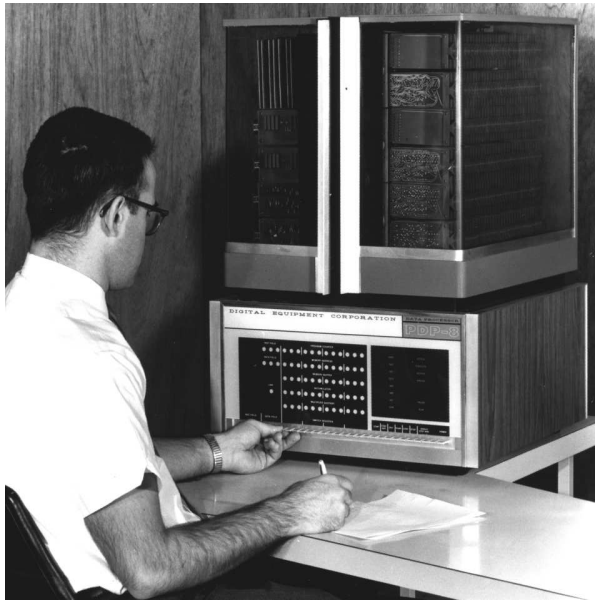
Computing for the People (Take I)

Ken Olsen
(1926-2011)

- Co-founded Digital Electronic Corporation (DEC) in 1957 with venture capital.
- Established in Massachusetts near traditional electronics manufacturers.
- Focus on small but powerful no-frills computers for scientific, engineering, and manufacturing markets (**minicomputers**).

Computing for the People (Take I) (Cont'd)

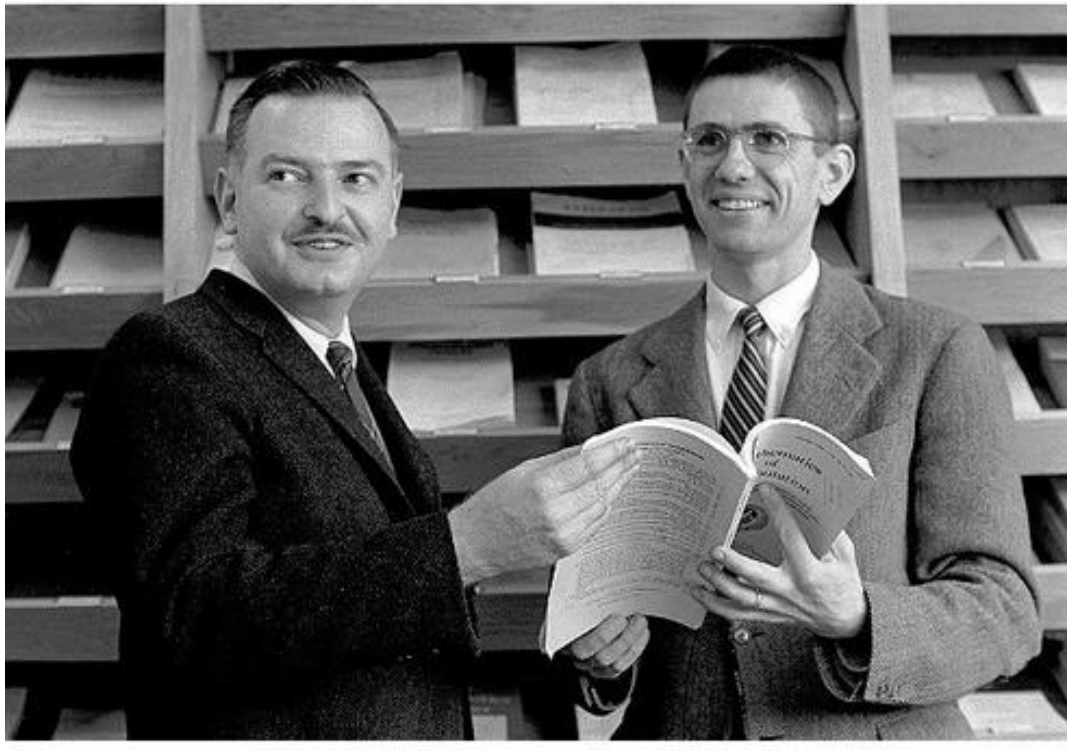
PDP I (1960)



PDP 8 (1965)

- Courtesy of discount, many DEC machines in universities.
- DEC machines treated by users as "personal" computers; critical in creating computer hobbyist culture in 1960's.

Computing for the People (Take I) (Cont'd)



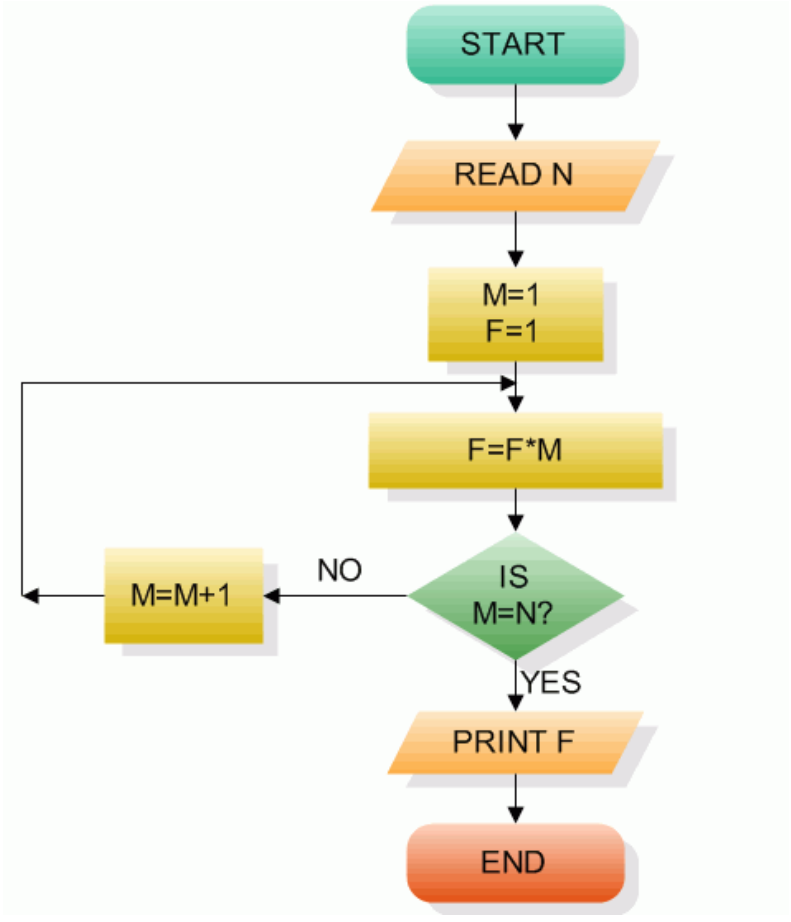
- BASIC (Beginner's All-purpose Symbolic Instruction Code) created by Thomas Kurtz (1928–) and John Kemeney (1926-1992) at Dartmouth College in 1964.
- Designed as programming language for *everyone*.

Computing for the People (Take I) (Cont'd)

J.C.R. Licklider
(1915-1990)

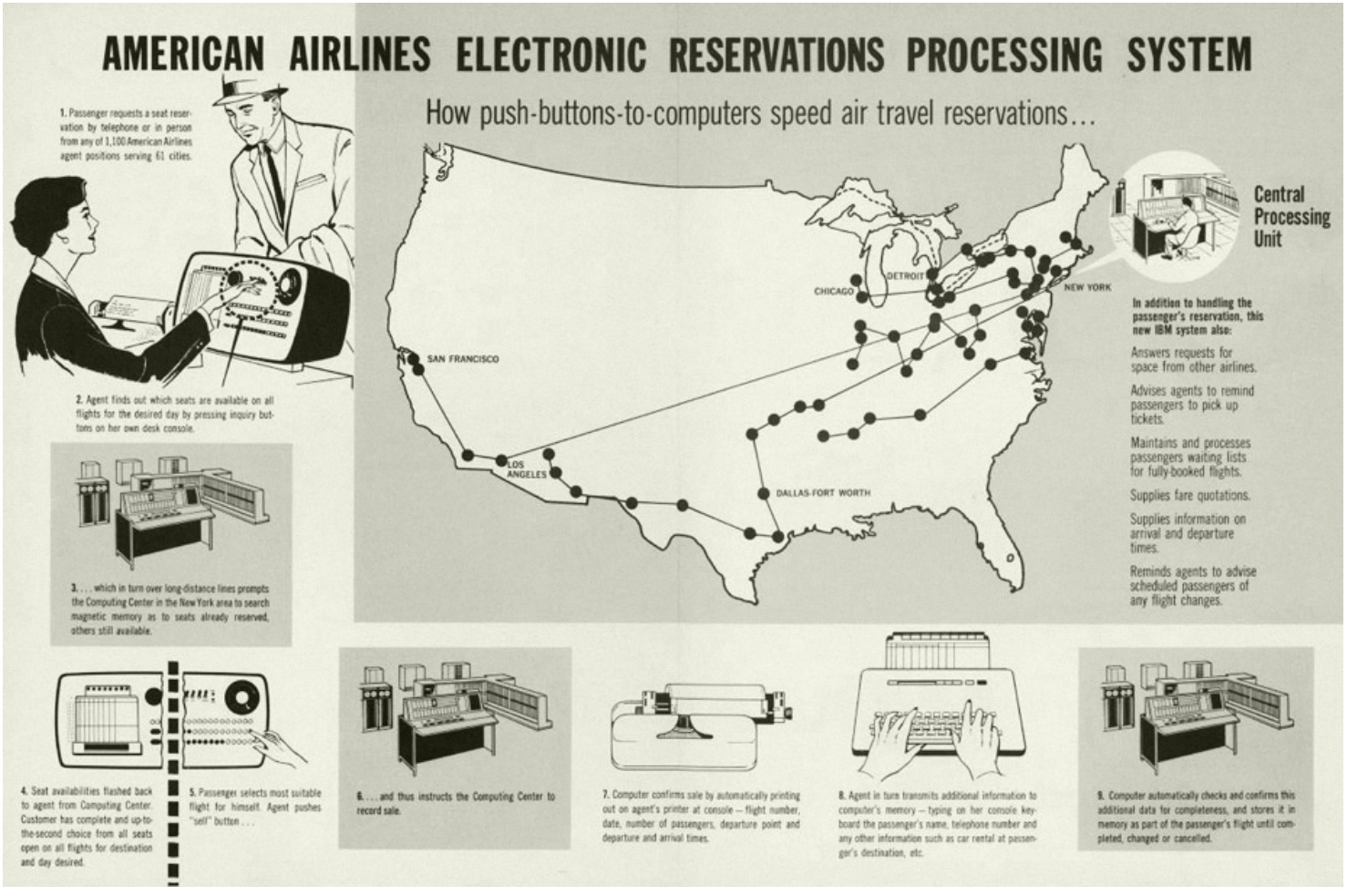
- Licklider pioneer in human-computer interaction (HCI).
- Established Information Processing Technologies Office (IPTO) at ARPA in 1962; provided funding to key academic centers to pursue long-range research, *e.g.*, HCI (GUI), computer graphics, computer networks.

The Software Crisis



- Act of programming made easier by compilers, languages, and operating systems; problem of developing algorithms remained.
- Special notations like flowcharts help with small- and medium-size programs; hope was that appropriate management would help with large ones.

The Software Crisis (Cont'd)



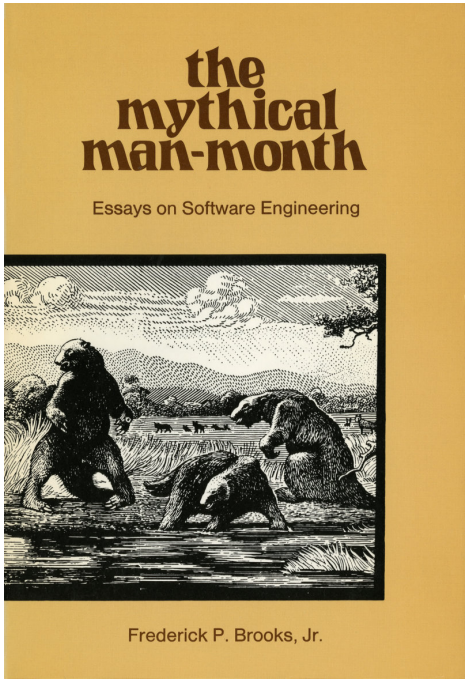
The SABRE Airline Reservation System (1964)

The Software Crisis (Cont'd)

IBM System/360 (1967)

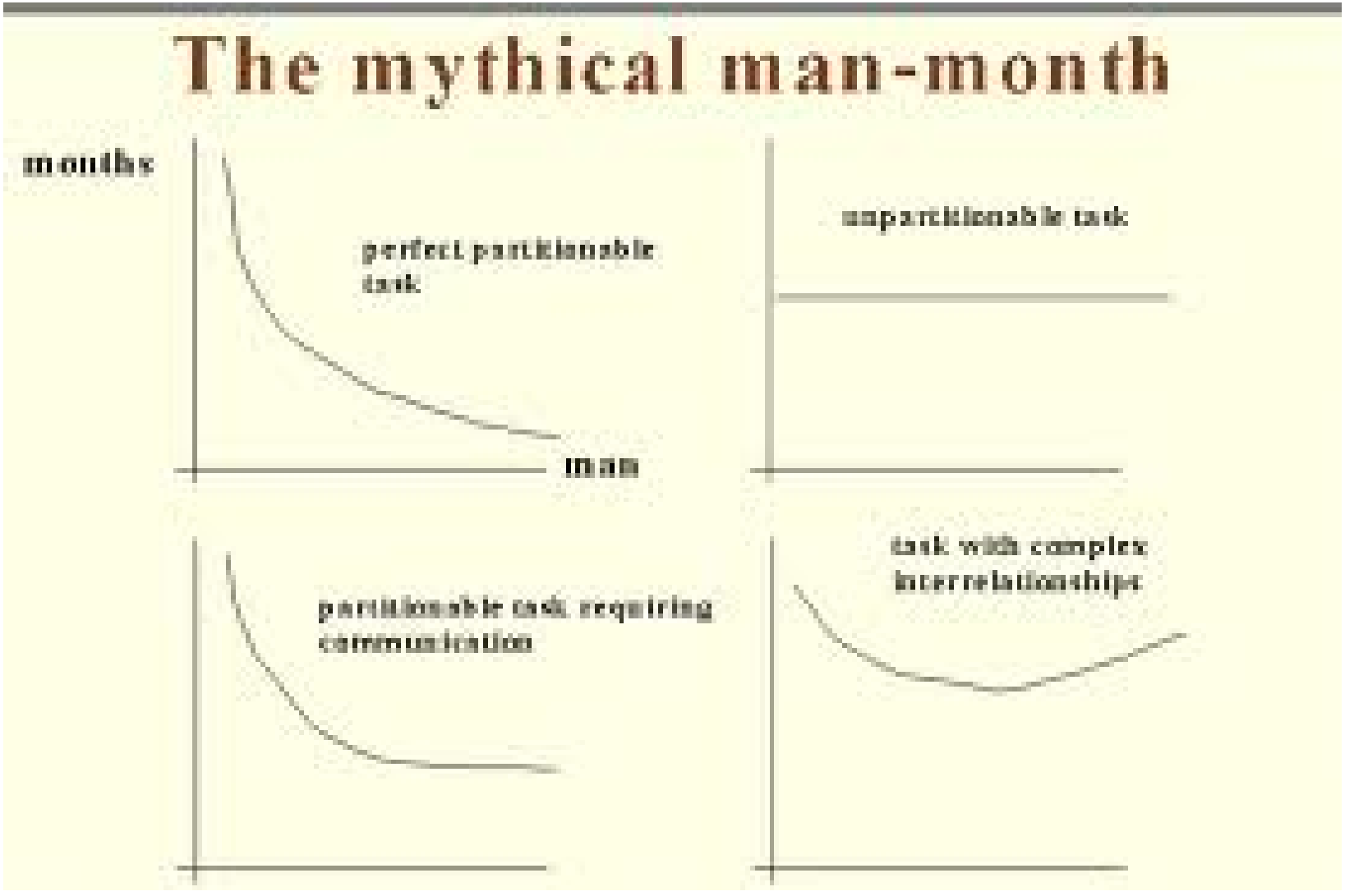
The Software Crisis (Cont'd)

Fred Brooks Jr.
(1931–)

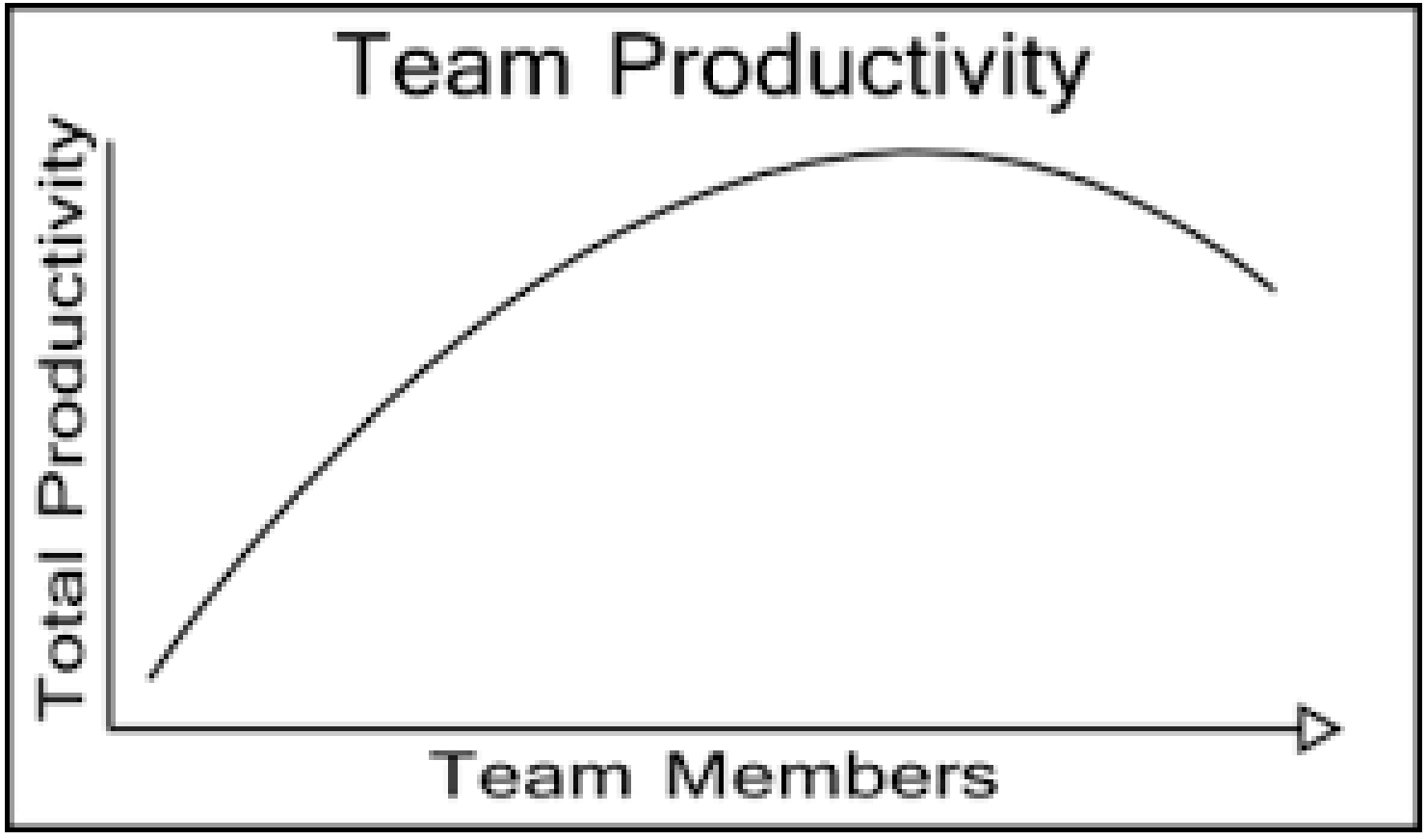


- OS/360 initially planned for 1965 costing $125M; limped to market in 1967 costing $500M, and virtually destroyed IBM's in-house programming division.
- Brooks discussed causes in *The Mythical Man Month*.

The Software Crisis (Cont'd)



The Software Crisis (Cont'd)



- As both larger programs and larger teams have more complex internal relationships, adding more programmers to larger projects makes things *worse*.

The Software Crisis (Cont'd)

- Software Engineering born at 1968 NATO-sponsored conference; goal of SE is to develop efficient processes for creating and maintaining correct software systems.
- Many types of processes proposed, *e.g.*, design and management methodologies, automatic software derivation methods; however, "No Silver Bullet" (Brooks).

The End of an Era

Gertrud Blanch (1962)