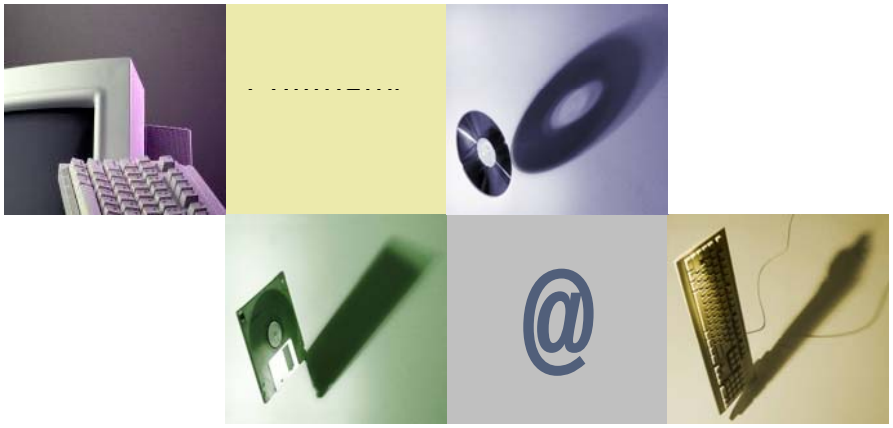
Introduction to Computers



Digital Computer Concept and Practice

What is a Computer?

Accepts **data**

Raw facts, figures, and symbols

Processes data into **information**

Data that is organized, meaningful, and useful

Produces and stores results

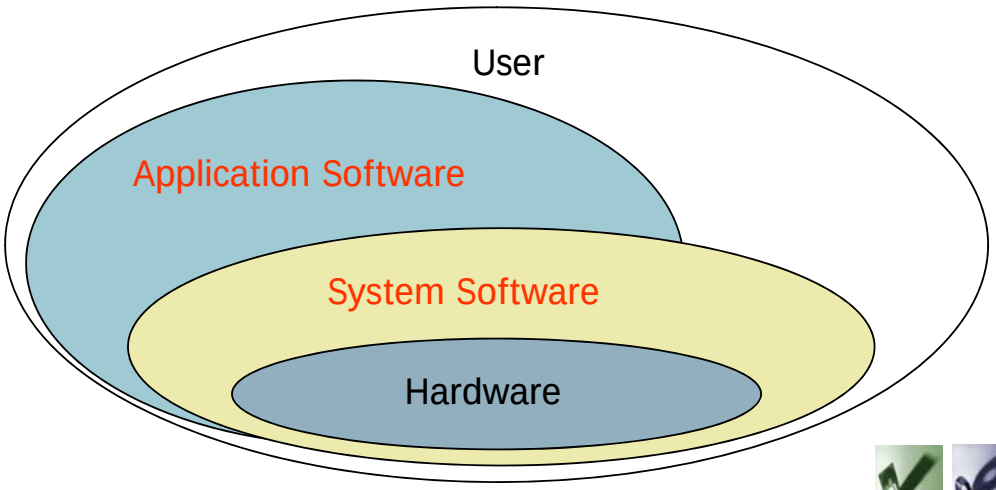
- Components: Hardware + Software
- Generally, the term is used to describe a collection of devices that function together as a system.

Computer System (Hardware)

Input devices + Processor (CPU) + Output devices

Software

- How does a computer know what to do?
  - It must be given a detailed list of instructions (computer program or software) that tells it exactly what to do ➔ Software



Software

- System software
  - Programs that control or maintain the operations of a computer and its devices
    - Operating system (OS)
      - MS Windows, Mac OS X, Unix, …
- Application software
  - Program that perform specific tasks for users
    - Word processing software, graphics software, moving picture players, …

Categories of Computers

Types

- Data type
  - Digital computers (vs. analog computers)
- Purpose
  - General (vs. domain-specific)
- Size (processing capacity)
  - Personal computer (PC)
  - Mainframe
  - Supercomputer

Personal Computer (PC)

- Computer systems developed for individuals
  - Price, size, and capabilities

Personal Computer (PC)

- Desktop
- Laptop
- PDA (Personal Digital Assistant)

Mainframe

- Mainly used by large organizations
- Focusing on business problems and reliable operations
- Census, industry or consumer statistics, and financial transaction processing

Supercomputer

- Employed for specialized applications that requires massive amounts of mathematical calculations
- Weather forecasting, nuclear energy research, etc.

Mainframe vs. Supercomputers

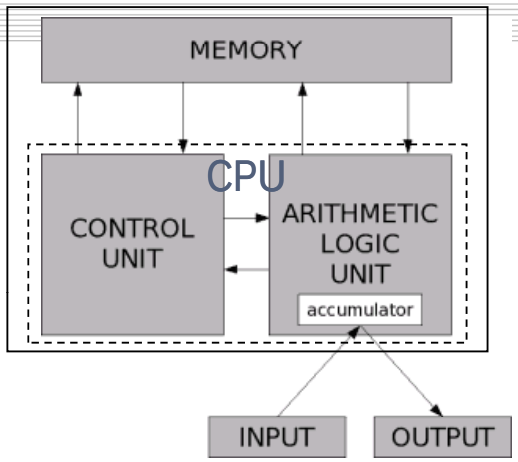
- Mainframe
  - Execute many programs concurrently
  - Business purpose
- Supercomputer
  - Execute a few programs as fast as possible
  - Scientific purpose

Theoretical Models

Von Neumann Architecture

- Modern computer → "Programmable"
- Computers are controlled by stored programs (algorithms) → Stored program architecture
- Nearly all modern computers implement some form of the stored program architecture

- Contributions of John von Neumann (1903-1957)
  quantum physics, functional analysis, set theory, economics and game theory, computer science, numerical analysis, hydrodynamics (of explosions), statistics, …



(1) Fetch an instruction from memory

(2) Fetch any data required by the instruction from memory

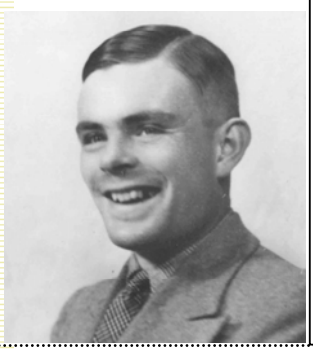
(3) Execute the instruction

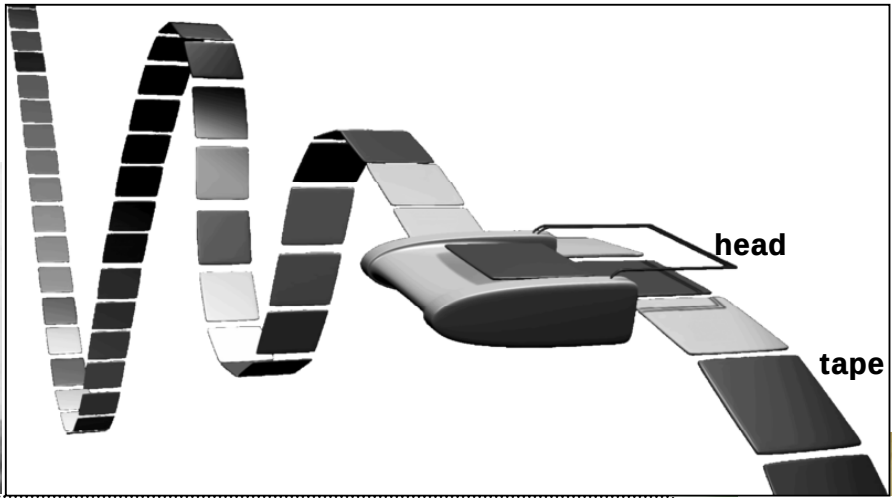
(4) Store results in memory

(5) Go back to Step (1)

Turing Machine

- Abstract symbol-manipulating device
- Not a practical computing technology





Turing Machine

- A *tape* which is divided into cells, one next to the other. Each cell contains a symbol from some finite alphabet.
- A *head* that can read and write symbols on the tape and move left and right one step at a time.
- A *state register* that stores the state of the Turing machine.
- An *action table* (or *transition function*) that tells the machine what symbol to write, how to move the head and what its new state will be, given the symbol it has just read on the tape and the state it is currently in.

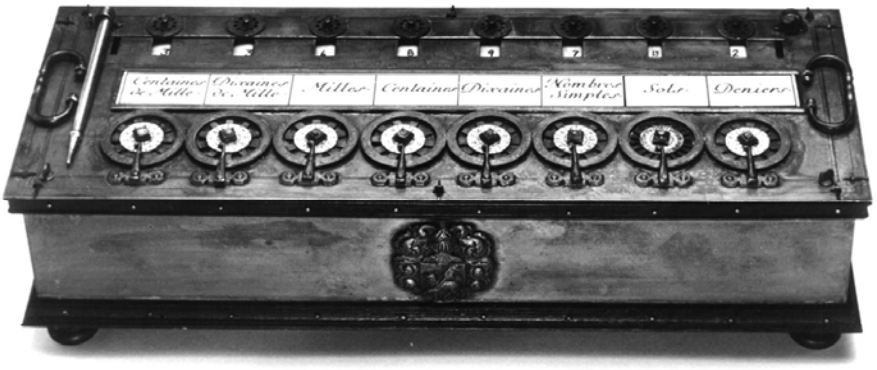
Church's Thesis

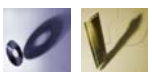
- Every '*function* which would naturally be regarded as *computable*' can be computed by a **Turing machine**.
- Any computer with a certain minimum capability is, in principle, capable of performing the same tasks that any other computer can perform.

History of Computer Hardware

The Early Period: Up to 1940

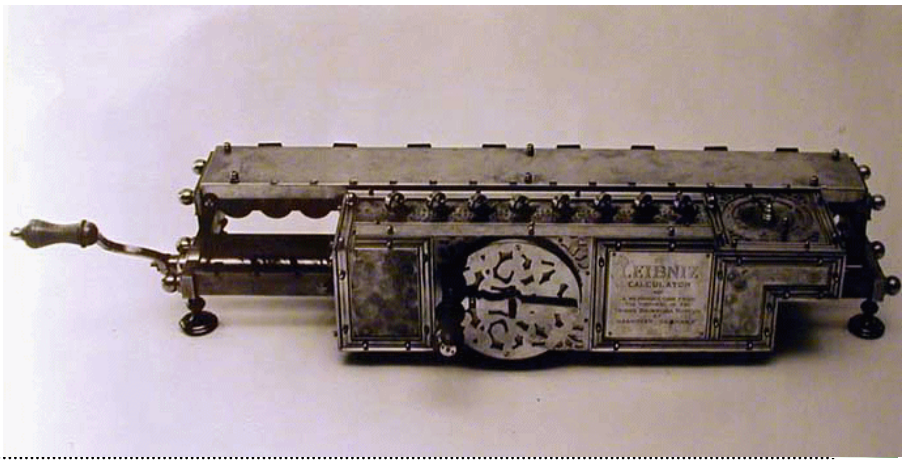
- 1672: The Pascaline
  - Designed and built by Blaise Pascal
  - One of the first mechanical calculators
  - Could do addition and subtraction





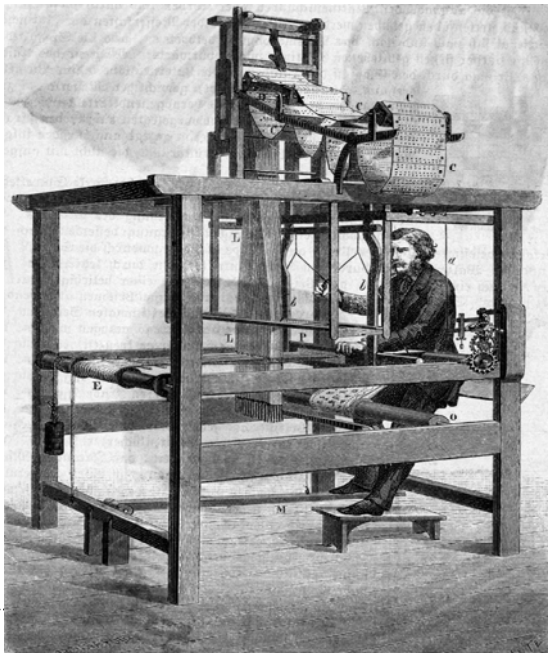
The Early Period: Up to 1940

- 1674: Leibnitz's Wheel
  - Constructed by Gottfried Leibnitz
  - Mechanical calculator
  - Could do addition, subtraction, multiplication, and division



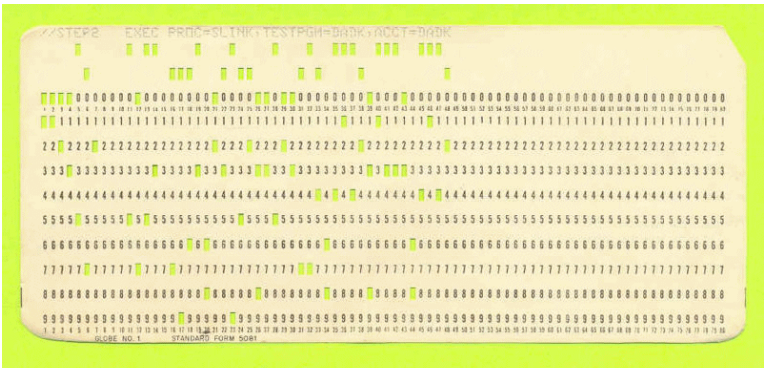
The Early Period: Up to 1940

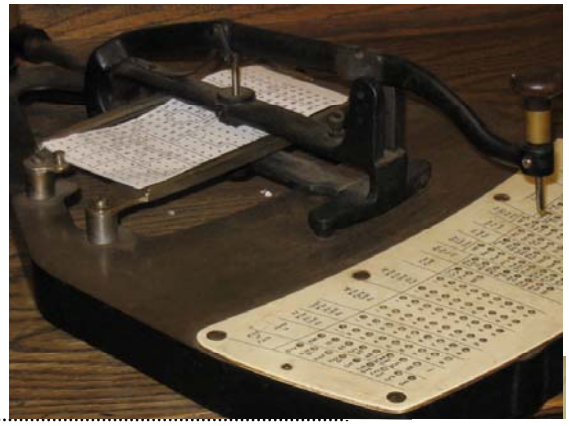
- 1801: The Jacquard loom
  - Developed by Joseph Jacquard
  - Automated loom
  - Used punched cards to create desired pattern



Punched Cards

Jacquard Loom





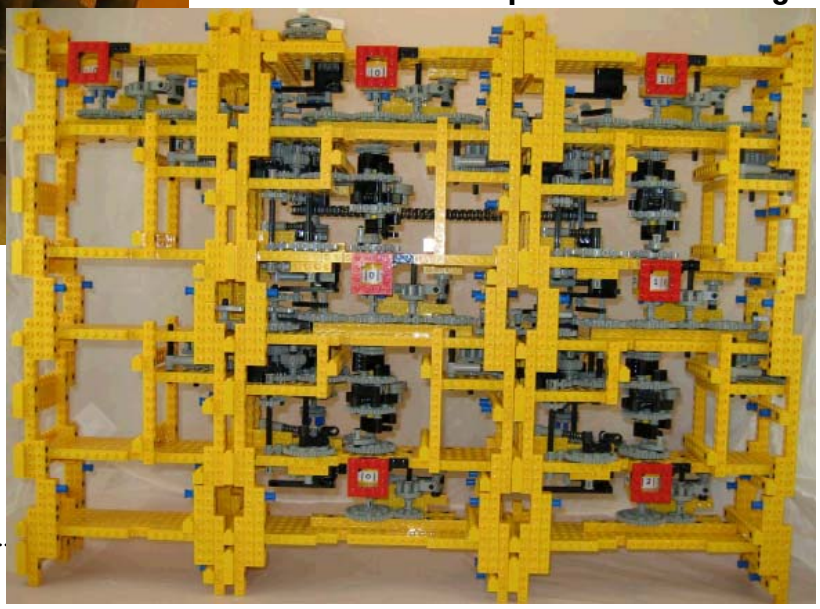
CTR Census Machine

The Early Period: Up to 1940

- 1823: The Difference Engine
  - Developed by Charles Babbage
  - Did addition, subtraction, multiplication, and division to 6 significant digits
  - Solved polynomial equations and other complex mathematical problems

Difference Engine

http://acarol.woz.org

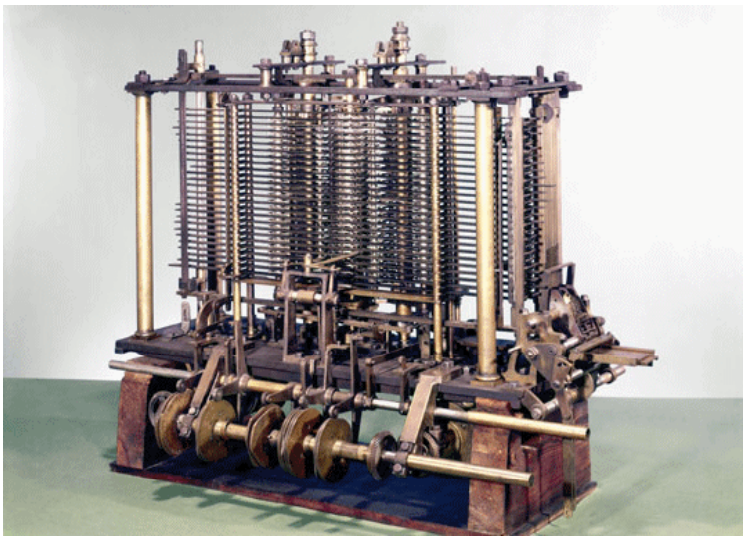


The Early Period: Up to 1940

- 1830s: The Analytic Engine
  - Designed by Charles Babbage
  - Mechanical general-purpose computer
  - Components were functionally similar to the four major components of today's computers
    - Mill → arithmetic/logic unit
    - Store → memory
    - Operator → processor
    - Output → input/output

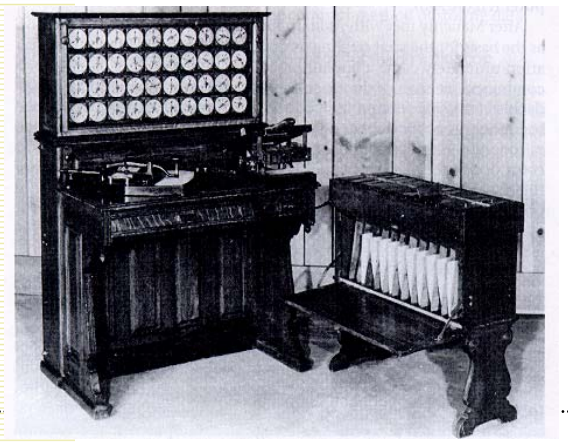
Analytic Engine

- First computer programmer: Ada Byron
  - The modern computer programming language, "Ada" is named in her honor



The Early Period: Up to 1940

- 1890: U.S. census carried out with programmable card processing machines
  - Built by Herman Hollerith
  - These machines could automatically read, tally, and sort data entered on punched cards
  - 1880 census: 8 years → 1890 census: 1 year

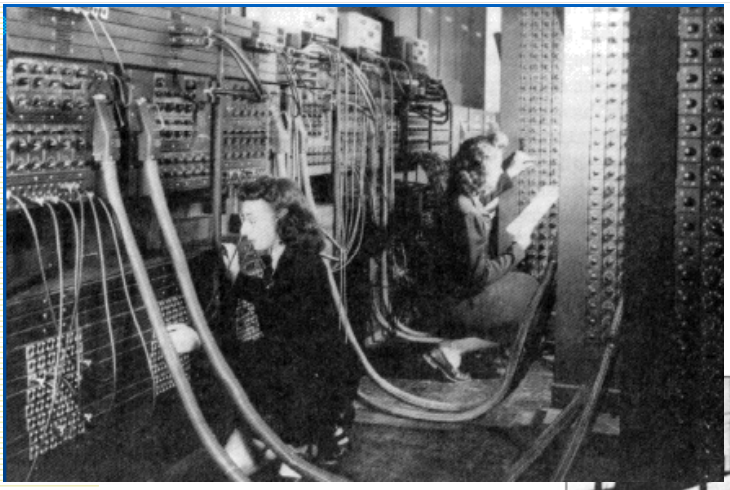


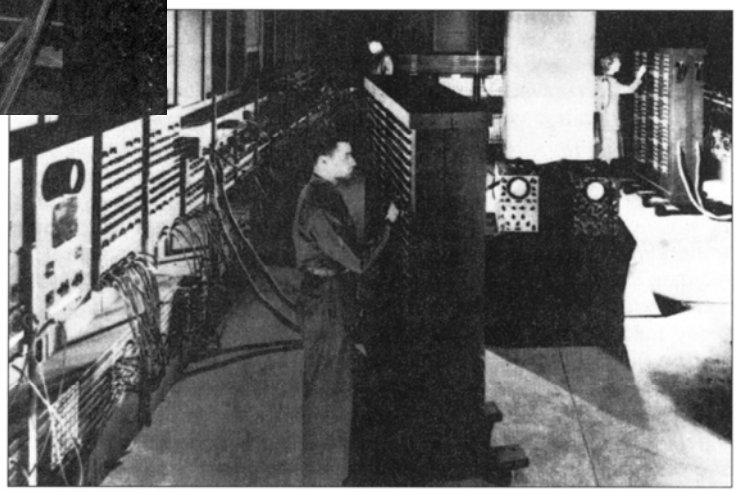
Tabulating Machine Company (1896)
→ Computing Tabulating Recording Corporation (1911)
→ IBM (1924)

The Birth of Computers: 1940-1950

- Development of electronic, general-purpose computers
  - Did not begin until after 1940
  - Was fueled in large part by needs of World War II
- Early digital computers
  - Mark I
  - ENIAC (Electronic Numerical Integrator and Calculator)
  - ABC (Atanasoff-Berry Computer)
  - Colossus
  - Z1

ENIAC



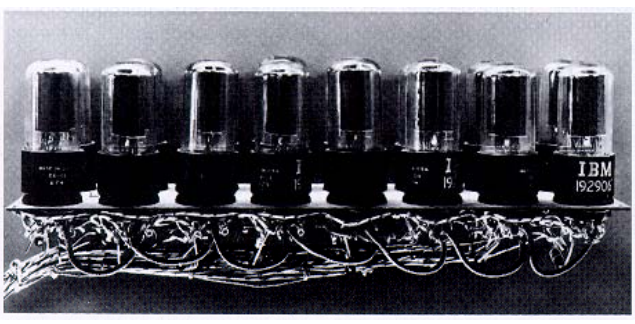


The Birth of Computers: 1940-1950

- Stored program computer model
  - Proposed by John Von Neumann in 1946
  - Stored binary algorithm in the computer's memory along with the data
  - Is known as the Von Neumann architecture
  - Modern computers remain, fundamentally, Von Neumann machines
  - First stored program computers
    - EDVAC
    - EDSAC

The Modern Era: 1950 to the Present

- 1st generation of computing (1950-1959)
  - Used vacuum tubes to store data and programs
  - Each computer was multiple rooms in size
  - Computers were not very reliable
  - ABC, ENIAC, EDSAC, EDVAC, UNIVAC



The Modern Era: 1950 to the Present

- 2nd generation of computing (1959-1965)
  - Vacuum tubes → transistors and magnetic cores
  - Dramatic reduction in size
  - Computer could fit into a single room
  - Increase in reliability of computers
  - Reduced costs of computers
  - High-level programming languages (FORTRAN, COBOL)
  - The programmer occupation was born

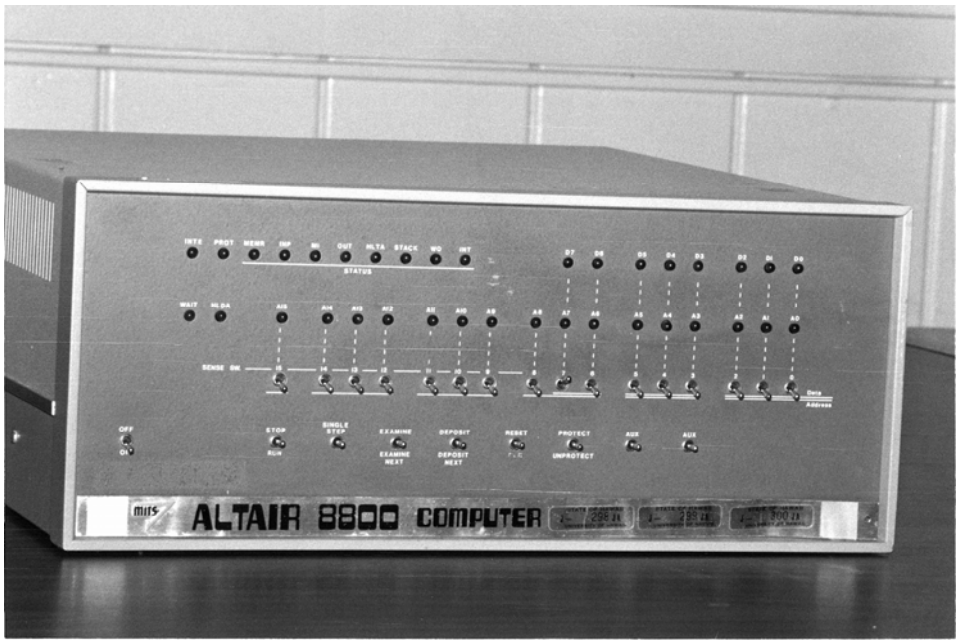
The Modern Era: 1950 to the Present

- 3rd generation of computing (1965-1975)
  - Used integrated circuits (ICs) rather than individual electronic components
  - Further reduction in size and cost of computers
  - Computers became desk-sized
  - First minicomputer developed
  - Software industry formed

The Modern Era: 1950 to the Present

- 4th generation of computing (1975-current)
  - Reduced to the size of a typewriter
  - Appearance of
    - Computer networks
    - Electronic mail
    - Graphical user interfaces (GUIs)
  - Apple Computer (Steve Jobs and Steve Wozniak, 1977)
  - IBM PC (1981)
  - Microsoft: MS-DOS

The Modern Era: 1950 to the Present



The Altair 8800: world's first microcomputer

Future?

- Quantum computer
- DNA computing
- Chemical computer