Brief Computer History & DEC PDP-8 Information

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Intro

- I’ve been playing with electronics since little and computers since high school
- Worked in those fields
- Some of the information will likely be gobbledygook. Feel free to ask questions or talk to me after the presentation.

Computer History

- There is no one right sequence of significant computer developments. This is a random sampling I liked.
- Anything you say such as this is the first, someone will point out something else that might be earlier

Mechanical

- A number of mechanical calculating devices were made but most not programmable.
- Charles Babbage designed mechanical computer called Analytical Engine starting in 1833 but was never completed.
  - Ada Lovelace wrote program for it in 1843 to compute Bernoulli numbers; considered first computer program.
  - Henry Babbage completed the mill – central processor in 1910.
- Konrad Zuse Z1 was mechanical programmable calculator. Completed 1938 but didn’t work well.

Electromechanical

- Z3 designed by Konrad Zuse in Germany first “true” Computer
  - Didn’t have conditional branches. Tricks to simulate but not practical.
  - Design started 1938 completed 1941.
  - 2,600 relays implementing 22 bit floating point calculations.
  - Programs stored on celluloid tape.
- Z4 added conditional forward branches so true computer. Sold to ETH Zurich 1950 then Research Institute of Saint-Louis.
  - Still sequential execution from tape. Only looping by joining ends of tape.
  - About 1000 floating point operations per hour.

Z3 Destroyed during WWII.

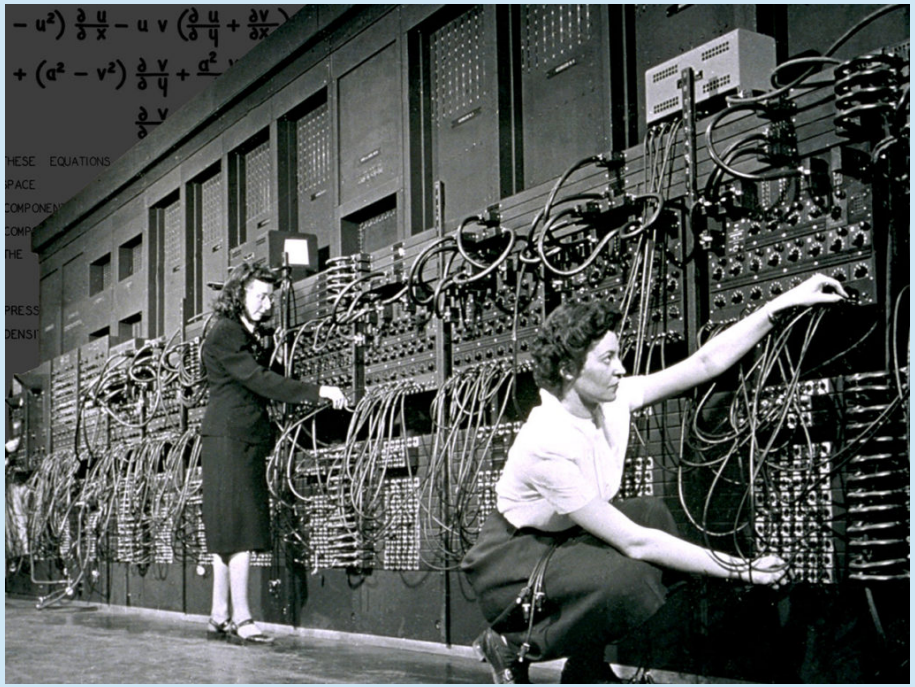
Z4 shown. Transferred to German museum 1960.

Electronic - Tubes

- A number of specialized electronic calculation machines but not true computers – Not Turing Complete
  - Atanasoff–Berry computer 1942
  - Colossus code breaking computer 1943
- ENIAC 1945 was first Turing Complete
  - Initial programming was plugging in cables
  - 1947 had primitive stored program using switches
  - 1948 added ability to program with punch cards
  - Core memory added 1953
  - Used till 1955.

ENIAC

- First used for WWII calculations including atomic bomb
- Publicly demonstrated in 1946 to become well known
- 18,000 vacuum tubes
- 27 tons
- 5,000 additions per second.
- 3 square roots per second.
- Could do parallel computation.
- Longest period of operation between failures 116 hours.
  - Typically 48 hours with repair taking 15 minutes.



ENIAC

- Original programmers were women
  - Little recognition given to them until reasonably recently
- Took weeks to map problem to implementation for machine
- Took days to reprogram with cables and switches

Experimental Machines

- Many machines made to explore architecture and implementation technology.
  - Manchester Baby 1948
    - First stored program or possibly ENIAC
    - Tested Williams Tube (special CRT) for memory. First high-speed electronic random access memory for computers.
    - Previous were serial devices such as drums and delay lines.
  - Whirlwind 1951 – First use of core memory
  - 49 different computers with 1 to 5 instances each through 1955 worldwide.

Early Commercial

- United States Census Bureau UNIVAC in 1951. Used til 1963
- My mom was on a team that used it on night shift when not down for maintenance
- 14 tons, $1 million, $12.8m in current dollars

IBM

- Start of IBM mainframe computers IBM 701 Electronic Data Processing machine 1952. 19 sold
- Had a number of incompatible machines each targeted at separate market segment
- Consolidated in System/360 line in 1964
- IBM was largest computer manufacturer in 1960’s and 1970’s at one point producing 80% of computers sold in USA

Mainframes

- It was common to have one or a few big computers called mainframes that were shared by all users at the company/college etc.
- Normally you would punch a deck of cards and submit the job to be run. Frequently would be an hour to a day later depending on number of jobs submitted.
- Had to be much more careful due to the turnaround. Getting printout back saying compile failed due to a syntax error wasted time.
- Machine was normally behind glass window. You could see but not touch.
- I used them at Comsat Labs in the mid 80’s and at college. Had switched to terminals by then. My wife caught the end of the punch card era in college.

Mainframes

- Keypunch machines were typewriter like machines that punched holes in computer cards to create programs and data

Minicomputers

- A number of companies decided to compete at the lower end of the computer market since difficult to compete with IBM mainframes.
- Digital Equipment
- Data General
- Pr1me
- Hewlett Packard
- 100 companies tried competing
- Smaller lower cost and more interactive than IBM batch systems

Workstations

- Xerox Alto 1973
  - Research machine
  - First raster graphics GUI system with mouse and WYSIWYG editing
  - Ethernet networking
  - Xerox Star 1981 was commercial product. Several later models but not that successful.
  - Inspired a lot of later systems

Microcomputers

- Based around the new microprocessor (6502/8080 etc)
- Altair was kit $439 ($2892) assembled $621 ($4091). 256 bytes memory no I/O.
- Teletype was $1500 ($9882)
- Video cards available later
- Little software available early
- CP/M most common OS with disk drives

Microcomputers

- Many more companies offered microcomputers later such as Ohio Scientific that my high school had two in early 80's.
- Picture from Courier article. Computers were still novel.

BIG 3 Microcomputers

- Apple II, Commodore PET 2001, and Tandy TRS-80 Model I made home computers practical.
- Introduced in 1977
- Used cassette initially for storage with floppy disks later
- CRT for display
- Large software library became available
- More companies and models later

BIG 3 Micros


commodore
PET
2001 Series
personal computer
MEMORY SIZE?
MEMORY SIZE?
RADIO SHACK LEVEL II BASIC
READY
>?MEM
 31595
READY
>_

Digital Equipment Corporation (DEC)

- Had a number of incompatible computer lines
- 18 bit PDP-1 (1959), PDP-4, PDP-7, PDP-9, PDP-15. 1072 sold.
- 12 bit PDP-5 (1963), PDP8, and versions with LINC. Over 50,000 sold.
- 36 bit PDP-6 (1964), PDP-10, DECsystem-10, DECsystem-20. About 1,500 sold. Large timesharing
- 16 bit PDP-11 (1970). Many models. About 600,000 sold.
- Consolidated in VAX 32 bit computer (1977) with 11's continuing for 13 years. Half a million sold.
- Was second largest computer company for a while after IBM

What is a PDP-8

- A family of mostly compatible computers sold by Digital Equipment Corporation (DEC) from 1965 to 1990.
- 12 bit instruction and data.
- Capable of addressing up to 32k 12-bit words*.
- 8 instruction classes. Fastest instruction 1.2 microseconds.
- Was low cost starting computer in product line. Goal of new models was cheaper not faster.
- Best selling computer 1973 til TRS-80 (~1977).

*Statements cover most machines. For example 8/A had 128k memory option.

What is a PDP-8

- 1965 Straight 8 $18,000/$139,000 Mine contains 230 cards, ~10,148 diodes, 1409 transistors, 5615 resistors, and 1674 capacitors
- A pain to move so brought a somewhat later lighter model PDP-8/M introduced 1972.

My 8/M

- DEC computer sold by educomp which targeted educational market.
- Computer made 1976.
- Originally used by administration of Kent School in Kent Connecticut till 1986
- DEC out 4 times a year for PM in addition to fixing failures
- My uncle wrote accounting system for the school
- Above computer are 1.6 million word removable disks. That is less than one millionth of modern terabyte drive.
- Basic 8/M $4490 ($29,581). Well equipped around 3 times more.

PDP-8 Instructions

- Instruction set is the lowest visible level of operations the processor executes
- PDP-8 has 8 Instructions
  - AND – Binary AND
  - TAD – Two’s complement add
  - ISZ – Increment memory location and skip if result zero
  - DCA – Deposit to memory and clear accumulator
  - JMS – Jump to subroutine
  - JMP – Jump
  - IOT – Input/Output Transfer to peripheral
  - OPR – Operate microcoded instruction, encodes about 22 instructions
    - Conditional skips, rotates, increment, clear, complement

PDP-8 Instructions

- 8 Instructions, how hard can it be to program:

- Missing many instructions you would expect from later processor.
- Need to go back to basic math and Boolean logic.
- No subtract – Need to negate and add. Negate is complement and add 1.
- No OR – A OR B is NOT (NOT A AND NOT B).
- No stack, return address written to first location of subroutine. Recursion difficult.
- No conditional jumps, only conditional skip next instruction.
- Original code has lots of tricks to save memory such as using instructions as data and self modifying code.

PDP-8 Assembly Hello World

- Example in PAL syntax

```
    1          0010             *10
    2 00010    0213   IPTR,     TXT-1           / -1 since auto-increment
    3
    4          0200             *200
    5 00200    7200             CLA
    6 00201    1410   LOOP,     TAD I IPTR       / Get character
    7 00202    7450             SNA              / Halt if zero
    8 00203    7402             HLT
    9 00204    4206             JMS PRT
   10 00205    5201             JMP LOOP
   11                          / Prints a character to teletype
   12                          / AC and link zero on return
   13 00206    0000   PRT,      0
   14 00207    6046             TLS              / Send character
   15 00210    6041             TSF              / Done sending?
   16 00211    5210             JMP .-1          / No
   17 00212    7300             CLA CLL
   18 00213    5606             JMP I PRT
   19 00214    0310   TXT,      "H;"e;"l;"l;"o;" ;"W;"o;"r;"l;"d;15;12;0
…
   20                           $
```

Code from this period frequently had fewer comments

PDP-8 Languages

- Assembler
- FOCAL (Formula Calculator)
- BASIC
- FORTRAN
- Pascal
- DIBOL – COBOL competitor
- LISP – List Processing
- ALGOL
- SNOBOL – Old text processing language.
- Some DEC supported, others created by user community
- Digital Equipment Computer Users' Society (DECUS) distributed user contributed software at nominal cost. Some binary some with source.
  - 1961-2008
- Tended to be limited implementations due to limited computer resources

8/M Front panel

- Computer can’t do anything without using front panel to boot.
- Top row lights instruction executing or memory address
- Next row selectable by switch. Displaying accumulator.
- 60 Pounds

- Switches control operation of computer and reading/writing to memory
- 8k word core (non volatile) and 24k word solid state memory

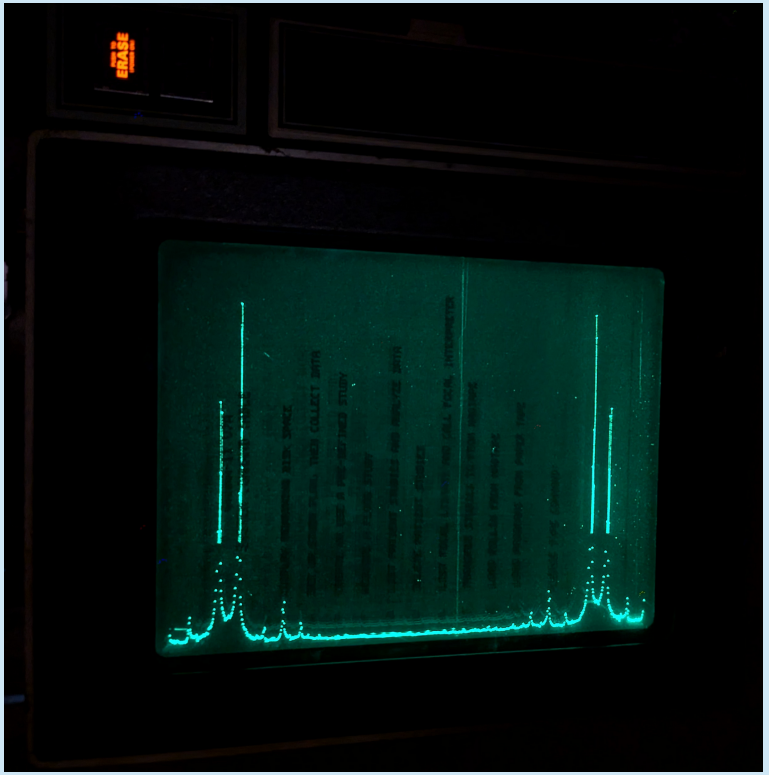
Floppies & Console

- Bottom is floppy drives. Each 8” floppy stores 262,144 12-bit words
  - Head moves back and forth to access concentric tracks (77)
- Top is printing terminal.
  - Terminals, serial CRT display were available but more expensive.
  - Text only video board was available for 8/M but rare

Printer 29 pounds
Floppy 58 pounds

Graphics Monitor

- High resolution storage monitor
  - PDP-8 can only draw dots. Moves CRT beam to location and tells it to intensify
  - 1024x1024 resolution
  - CRT can store what was drawn in CRT. Can only erase entire screen
  - Didn’t have the best lifetime. You can see burn in from previous use in this picture taken in dark



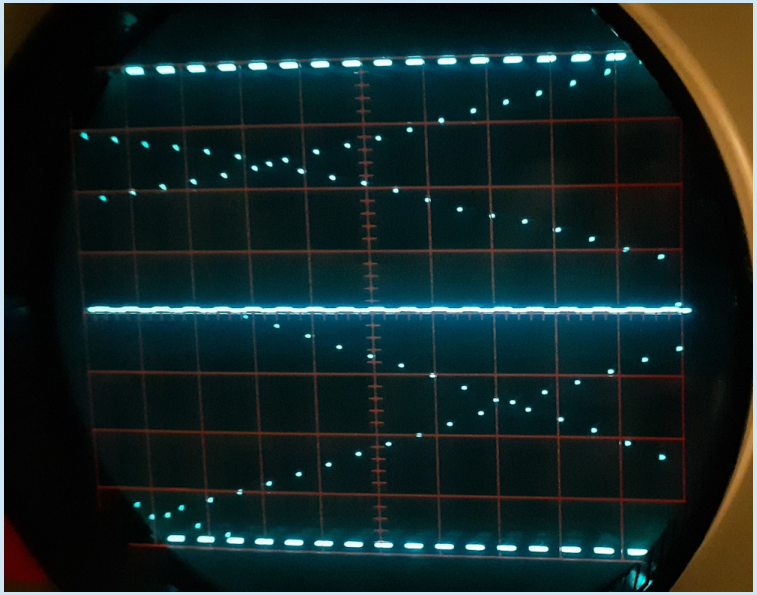
51 pounds

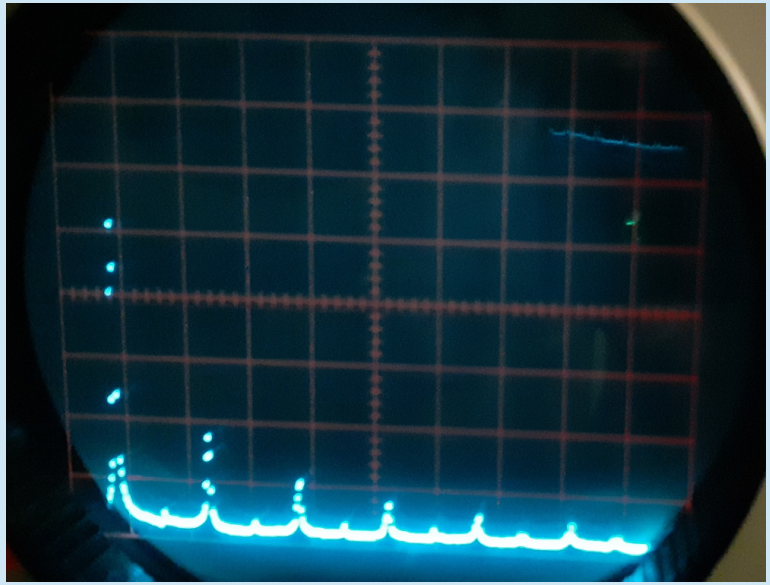
PDP-8 Demo/Digital Signal Processing

- PDP-8's were used for laboratory and industrial control, business automation, education etc. Not home computer.
- People always wrote games etc. for computers they had access to. Education tolerated, businesses discouraged.
- Digital Signal Processing (DSP) is critical to modern technology.
- For showing technical usage showing DSP algorithm Fast Fourier Transform (FFT) to decode phone touch tones
- Touch tone phone introduced in 1963

PDP-8 Fast Fourier Transform

- Converts between time and frequency domain
- Showing square wave and frequency spectrum with odd harmonics. 600 Hz fundamental, 1800 Hz (3*N), 3000 Hz etc.





8/M Demos

- Feel free to come up and look at the stuff and try the demos after the talk.
- Wash hands after handling food if you’re going to touch my stuff
- FFT Demo
  - Touch tone (1963) decoding
  - See how well you can hum a note
- Pick parameters for bouncing ball simulation

8/M Demos

- Graphic games
- Text games
- Music
- ASCII art
- List with descriptions at my table

Credits

- en.wikipedia.org
- By File:Zuse-Z4-Totale deutsches-museum.jpg: Clemens PFEIFFERderivative work: Georgfotoart - This file was derived from: Zuse-Z4-Totale deutsches-museum.jpg:, CC BY 2.5, https://commons.wikimedia.org/w/index.php?curid=158873845
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Credits

- https://cs.uwaterloo.ca/40th/Chronology/1967.shtml
- https://cse.engin.umich.edu/wp-content/uploads/sites/3/2021/03/women-computers-1024x768.jpg