Mainframes And Super Computers

Some of the early powerhouse computers in the time leading up to the development of the microprocessor

James Tam

IBM

- (As previously discussed): Around the early 1900s IBM developed a reputation producing large calculators.
- By the 1950s they produced several different lines of scientific and business computers.
- They were a leader with a U.S. market share of 70% from the 1950s onwards.[1]
- This was done by extensive spending on research and development, estimated to be around $500 million with laboratories from coast to coast (US) and in Europe.
  - This created high entry barriers to the industry (R&D $$$).
  - Almost no manufacturers save IBM made a profit selling large computers in the 1950s.

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1 "The US Computer History: A Study in Market Power" (Brock Gerald: Cambridge MA 1975)

The NORC

Image: IBM

- Naval Ordinance Research Calculator
- IBM's goal was to produce the fastest machine possible
  - There were few customers for such an expensive undertaking.
  - The fastest computers of the time: some regard the NORC as the first super computer.
- The US Navy's Bureau of Ordnance was having trouble finding someone to produce a machine capable of this type of large scale computational problem.
- (To help generate good-will and a positive corporate image):
  - IBM agreed to development the machine even thought it wouldn't make any money.
- Ready for delivery for the US navy at the end of 1954.

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The NORC: Technical Specifications

- Memory:
  - 264 Williams tubes.
  - 3,600 words x 16 bit words (17th bit for error checking).
- Speed:
  - Addition: 15 microseconds (0.015 milliseconds).
  - Multiplication: 31 microseconds (0.031 milliseconds).
  - Comparison (IAS Machine: 1952)
    - Addition 60 microseconds (0.06 milliseconds)
    - Multiplication 300 microseconds (0.3 milliseconds)
  - However the focus was on reliability over brute speed for this machine.

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NORC: Significance

- Changes in technology that came about as a result of the work on the NORC:
  - Significant improvements in the design of the magnetic tape drives (x5 speed).
  - Improvements in the design of the memory ("read around problem").

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IBM 701

- Designed at the same time as the NORC.
- Targeted towards defense agencies for the Korean War effort "Defense Calculator" (eventually known as the 701 computer).
- 1951: the decision was made to produce the 701
  - Many design issues had been worked out earlier: feasibility of Williams' tube memory and the desire for improved input (replacement of standard punched cards with magnetic tape).

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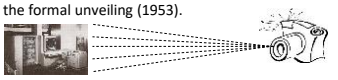
Image: IBM

IBM 701 (2)

- 1953: The 701 was complete
  - Working out the design issues beforehand had given IBM an advantage over its competitors.
  - The machine was leased out at the rate of $15,000 per month (~30 contracts = $450,000/month)
  - Remarkable:
    - Original quote was $8,000/month with 50 pre-orders ($400,000/month)

IBM 701: Technical Specifications

- Memory:
  - Williams tubes.
  - 4,096 words x 36 bit word size.
  - Unfortunately the memory tubes were visible through glass and doors and problems arose during the formal unveiling (1953).



- Speeds (according to IBM)
  - Addition: 60 microseconds (0.06 milliseconds).
  - Multiplication: 456 microseconds (0.456 milliseconds).

NORC
- Addition: 15 microseconds (0.015 milliseconds).
- Multiplication: 31 microseconds (0.031 milliseconds).

The Stretch

- After the completion of the NORC, IBM initiated a research project to determine the feasibility of developing a machine at least 100 times faster than the current technology (IBM 704: SAGE).
- Official name: IBM 7030
- Commonly applied name (official): Stretch ("Stretch the state of the art in processing speed")[1]
- Technical improvements employed in the Stretch.
  - The use of high speed transistors in the process (this alone x10 speed increase over the 704).
  - Improved high speed core memory.
- Technical improvements coming out of work the Stretch.
  - Improved magnetic storage devices (multiple read/write arms in a disk pack over magnetic drum).
  - Pipelining

1 "A History of Modern Computing" (Paul Ceruzzi)

The Stretch: More On Its Technical Improvements

- Memory is sometimes idle.
- To increase speed as one instruction was decoded and executed the next 5 would be accessed and partially decoded.
- Memory locations that were numerically adjacent were stored in different banks.

The Stretch: Completion

- 1961: first one delivered.
- Later: Seven others were delivered (mostly for atomic energy or defense-related research):
  - One was modified for use by the NSA (National Security Agency) for use in code breaking.
  - https://www.nsa.gov/

The Stretch: Technical Specifications

- Speed:
  - Addition: 1 microsecond (0.001 milliseconds)
  - Multiplication: 1.8 microseconds (0.0018 milliseconds)

Reminder: NORC's specifications
- Addition: 15 microseconds (0.015 milliseconds).
- Multiplication: 31 microseconds (0.031 milliseconds).

The Stretch: Success?

- As mentioned the work on the machine resulted in many technological advances.
- However the machine itself was not as fast as hoped (or promised) so it was not regarded as financially viable.
- Also there was not enough demand for such a high end (and expensive machine) to justify the development cost.

LARC

- Livermore Atomic Research Computer (LARC).
- IBM and UNIVAC were the only major players in the production of computers.
- While IBM was starting work on the Stretch UNIVAC was working on the LARC for the Lawrence Radiation Laboratory (Livermore, California).

Image: "A History of Computing Technology" (Williams)

LARC: Technical Specifications

- Memory, divided into eight independent banks:
  - Each bank could store 2,500 words x 11 decimal digits/word = 20,000 words (upgradable to 97,500 words).
- Two computers
  - #1: Input/output
  - #2: Arithmetic
- Speed:
  - Addition: 4 microseconds (0.004 milliseconds)
  - Multiplication: 8 microseconds (0.008 milliseconds)
- Comparable computational times:
  - Stretch < LARC < UNIVAC 1103A < IBM 704

LARC: Success?

- Technical specifications (raw speed): fast! (Refer to previous page).
- Similar to the Stretch: there was a combination of high development costs and minimal demand:
  - Lawrence Radiation Labs (Livermore, California),
  - US Navy Research and Development Centre (Washington DC).

Ferranti Atlas

- University of Manchester: Fred Williams and Tom Kilburn produced the initial 'Manchester machine'.
  - Joined with Ferranti to produce "The Greek series" computers: Mercury, Pegasus, Orion etc.
  - 1956: Kilburn leads a team to investigate the construction of the Ferranti Atlas.
  - Atlas = "Holds up the world" (powerful titan, powerful machine)
  - A powerful machine requires a great deal of memory

Ferranti Atlas: Memory

- "…[it used a] design that gave the illusion of a single-level fast memory of large capacity [virtual memory]"[1]
  - Its implementation of virtual memory allowed for a total memory with over 100,000 words x 48 bits/word
    - 16,000 words in magnetic core memory.
    - 96,000 words in magnetic drum memory.
    - (Up to 1 million locations were addressable).

1 "A History of Modern Computing" (Ceruzzi: page 245)

Ferranti Atlas: Speed

- Comparable computational times (updated to include the Atlas):
  - Stretch < Atlas < LARC[1]
- Addition:
  - 1.4 – 2 microseconds (0.0014 - 0.002 milliseconds)
- Multiplication:
  - 4.7 microseconds (0.0047 milliseconds)

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1 "A history of computing technology" (Williams)

Atlas: Success?

- Not a commercial success either: only three were installed
  - University of Manchester
  - University of London
  - Atlas Computer Laboratory (Chilton Oxford shire, England)
    - "Alien"

- One of the planned abilities: time sharing terminals was scrapped due to budget limitations:
  - This could have made the design financially feasible and made mass time-sharing available earlier.

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IBM 360 Machines

- Problems with the existing computer market:
  - Machines were not backward compatible (incompatible peripherals and software).
  - Most computers were designed either for commercial data processing or scientific applications (massive calculating power needed).
    - Yet for many organizations there was often a need to solve problems in both areas.

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Image (March 2016): http://www-03.ibm.com/ibm/history/exhibits/mainframe/mainframe_intro2.html)

IBM 360 Machines (2)

- 1961: IBM decided to produce a family of computers (360)
  - Small and inexpensive computers (e.g. 360/Model 30 could perform ~13,300 – 34,500 additions per second[1] or 28-75 microseconds for each addition) to ones more powerful than the Stretch (Stretch would take 1 microsecond for an addition)
  - Each would run the same operating system (variants of 360 i.e. 360 Model X) e.g., Basic operating system 360, Tape operating system 360, Disk operating system 360 etc.
  - That ensured that all the machines would be capable of the same operations.
  - Character and numeric information were stored in a standard form: 8 bit bytes:
    - IBM: EBCDIC (Extended Binary Coded Decimal Interchange Code).
    - Everyone else: ASCII was also in use at the time.
  - Thus a number of different machines had similar operations to the IBM System/360 line.

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1 Source https://www.ibm.com/ibm/history/exhibits/mainframe/mainframe_PP2030.html

IBM 360 Clones

- IBM provided a great deal of technical specifications to its customers and to software developers.
- IBM became powerless from preventing others from building what it referred to as a 'clone' of the 360.
  - Companies like RCA could sell their own clone versions of the 360 for less than IBM.
    - No development costs.
  - Later UNIVAC (part of Sperry-Rand) bought out RCA's market and sold their own 360 clones
  - Soviet Union: building 360 compatible computers became a quick way for the USSR to construct powerful mainframes.[1]

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1 "A History of Modern Computing" (Paul Ceruzzi)

IBM 370

- Finally the 360 architecture could no longer meet with the needs of the times.
  - Timesharing (the IBM System/360 wasn't incompatible with timesharing but neither was it built to take advantage of it).
    - Timesharing: multiple users on one computer.
    - Allowed access to a computer to groups who couldn't afford to buy one.
    - Reduced inefficient computer use (rare that anyone developer would really push the hardware).
- Late 1960s: The IBM System/370 came out as a replacement for the 360 design.
  - It provided better support for time sharing.
  - Among other things it helped IBM's problems with 360 cloning (RCA sold its market to Sperry-Rand after the withering effect from the release of the 370).

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IBM And Computers Of The 1960s – 1970s

- As mentioned IBM dominated the mainframe (computer) market in and around the 1950s – 1960s.
  - 70% market share with yearly sales in the billions.
  - The next closest competitor was Sperry Rand (UNIVAC) with sales ~one hundred million.
  - By the 1970s other companies like General Electric and RCA left the market leaving: the "BUNCH":
    - **B**urrows
    - **U**NIVAC
    - **N**CR
    - **C**ontrol Data
    - **H**oneywell
    - This group remained stable until the 1980s and the advent of the microcomputer.

High End Competition: Seymour Cray (Super Computers)

- Initially he helped designed super computers for CDC (Control Data Corporation).
- Eventually he left to form his own company: Cray Computers.
- On the high end of computing for customers like the NSA sheer performance over compatibility was of importance.
  - IBM was unable to effectively compete on this high end.
  - The current fate of Cray Inc.
  - It became an acquisition of Hewlett Packard:
    - https://www.hpe.com/us/en/newsroom/press-release/2019/09/hpe-completes-acquisition-of-supercomputing-leader-cray-inc.html

References

- History of Computing Technology: Chapter 9
- A History of Modern Computing: (Paul Ceruzzi): Chapter 4, 5, Chapter 8 (pp. 245 - 246)
- IBM history website: http://www-03.ibm.com/ibm/history
- A brief history of Cray Inc. from its beginning to its takeover by HP:
  - https://www.hpe.com/us/en/compute/hpc/cray.html
- "The US Computer History: A Study in Market Power" (Brock Gerald: Cambridge MA 1975)

After This Section You Should Know

- The names and history of the early super computers (reasons for its development, approximate time, major players involved)
- The general appearance and technical specifications of the early super computers
- IBM's transition from selling calculating devices to computers and how they came to dominate the large computer market (and by how much)
- Speed rankings of the early super computers
- The NORC:
  - What was the motivation behind its development
  - What was its significance

After This Section You Should Know (2)

- IBM 701:
  - What was its purpose/use
  - What benefits came from its creation
- The Stretch
  - The motivations behind its development
  - What technical improvements were part of the design
  - Some of the uses for this machine and its successor machines
  - The impact of this machine
- The LARC
  - Who was its creator and intended customer/user
  - Some of the uses for this machine and its successor machines
  - The impact of this machine

After This Section You Should Know (3)

- The Ferranti Atlas
  - Who was the intended customer/user
  - What were some of its peer machines
  - The impact of this machine
- IBM System/360
  - Motivations for its design
  - Benefits and consequences of the design/market approach
  - How the clone market came into being
  - Who were some of the clone makers

After This Section You Should Know (4)

- IBM System/370
  - The motivations for the new computer line
  - Impact of its release
- Who were the major computer manufacturers in the 1950s - 1970s
- Seymour Cray and the Cray computers
  - The history behind the formation of this company
  - Impact on the computer market

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