

Mainframes And Super Computers

Some of the early powerhouse computers 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.

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

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The NORC



- 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: the NORC is generally regarded 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 though it wouldn't make any money.
- Ready for delivery for the US navy at the end of 1954.

Image: IBM

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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 0.06 milliseconds
 - Multiplication 0.3 milliseconds
 - Even so 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 (mid 1950-1953_ "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 tape).
- 1953: The 701 was complete
 - Working out these design issues had given IBM an advantage over its competitors.
 - Original quote was \$8,000/month with **50 pre-orders**
 - After completing the 701 the quote had to be revised to \$15,000/month (**actual signons dropped to 5**).

Image: IBM

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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).

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IBM 701: Successors

- 702 (along with 701 was part of the first group)
- 704, 705 (second group)
- 709 (replacement for machines in the second group)

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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
- 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 (x10 speed increase over the 704).
 - Used improved high speed core memory employed in the SAGE.
- Technical improvements coming out of work the Stretch.
 - Improved magnetic storage devices (multiple read/write arms in a disk pack over magnetic drum).
 - Pipelining (next)

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

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The Stretch: Instruction Pipelining

- 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.

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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/>

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The Stretch: Technical Specifications

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

NORC and the IAS

- Addition: 15 microseconds (0.015 milliseconds).
- Multiplication: 31 microseconds (0.031 milliseconds).
- Comparison (IAS Machine: 1952)
 - Addition 0.06 milliseconds
 - Multiplication 0.3 milliseconds

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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.

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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)

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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

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LARC: Success?

- Technical specifications (raw speed): fast! (Previous screen)
- 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).

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Ferranti Atlas

- University of Manchester: Fred Williams and Tom Kilburn produced the initial 'Manchester machine'.
 - Joined with Ferranti to produce several others: Mercury (JT: Greek?!), Pegasus, Orion etc. "Greek series"
- 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

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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 of ~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).

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

Ferranti Atlas: Speed

- Comparable computational times (updated to include the Atlas):
 - Stretch < Atlas < LARC¹
- 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"
 - Dr. Brian Wyvill's account of his work in the Atlas lab (last accessed Oct. 2024):
 - <http://www.chilton-computing.org.uk/acl/applications/animation/p014.htm>
- 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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Video: The Ferranti Atlas

- Background about the computer as well as background information.
 - <https://www.youtube.com/watch?v=6TRfy70DqD8>

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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 (addition in 1 microsecond) to ones more powerful than the Stretch (addition in 200 microsecond or faster).
 - Each would run the same operating system (variants of 360 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.
 - Eventually a number of different machines had similar operations to the IBM System/360 line.

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IBM 360 Machines (3)

- This resulted in many other companies producing their own lines of machines that were compatible with the IBM 360:
 - RCA Spectra 70.
 - National Cash Register Century series.
 - Etc.

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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":
 - Burrows
 - UNIVAC
 - NCR
 - Control Data
 - Honeywell
 - This group remained stable until the 1980s and the advent of the microcomputer.

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High End Competition: Seymour Cray

- 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.
 - Even IBM was unable to effectively compete on this high end.

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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 (now as 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

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

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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 i.e. you could "do it" but not well and probably not without issues).
- Timesharing: multiple users on one computer.
- Allowed access to a computer to groups who couldn't afford to buy one.
- Reduced inefficient computer use (e.g. rare that any one developer would really push the hardware).
- Late 1960s: The IBM System/370 came out as a replacement for the 360 design.
 - It provided better/actual 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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Speed Comparison: Super And Other Computers

	Year	Addition time	Multiplication time
IBM 701	1953	0.06 milliseconds	0.456 milliseconds
IAS machine	1952	0.06 milliseconds	0.3 milliseconds
IBM NORC	1954	0.015 milliseconds	0.031 milliseconds
UNIVAC LARC		0.004 milliseconds	0.008 milliseconds
Ferranti Atlas		0.0014 - 0.002 milliseconds	0.0047 milliseconds
IBM Stretch	1961	0.001 milliseconds	0.0018 milliseconds

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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

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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

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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

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

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