# Computer Systems History sample pages

**The most complex electronics systems**

## From Abacus to Super Computer

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## Early concept transition from calculator to computer

**Ancient people already invented abacus to help calculation from Egypt, Babylon, China, Japan, Greece and Rome almost all civilized ancient culture.** Abacus used for several thousand years even in '50 and '60 of 20th century many Chinese retail stores still use abacus to help transaction and inventory accounting before compact CMOS calculator fully proliferated.

**Both mechanical analog calculator (slide rule) and digital (by decimal, all the following mechanical calculators are digital calculators) calculators were invented in 17th century.** Pascal invented mechanical adder/subtracter in 1642 and he made 70 calculators during decade thereafter. Some are still surviving and demonstrated in French museums. **The key technique of his concept is carry ratchet for each decimal teethed wheel and carry propagating mechanism is mandatory step for any calculator/computer.**

But it has significant disadvantage---big torque on turning digit wheel during carry, especially on simultaneous multiple carry, e.g. from 9999 to 10000. Therefore, his concept is not initially used in commercial mechanical calculators which were emerged from mid-19th century to '70 of 20th century. Then it was adopted by American invented key driven mechanical calculators in late 19th century. Since simple implementation and reliable operation today you can find low cost plastic stylus-driven multiple-wheels adder/subtracter in toy or gift shops using Pascal invented concept almost 370+ years ago.

**Leibnitz invented adder/subtracter in 1672 using incremental-length teethed cylinder---named as Stepped cylinder or Leibnitz wheel.** It will avoid disadvantage associated with Pascal concept, but carry mechanism is much more difficult especially on simultaneous multiple carry situation. Single digit multiplication and division can be performed by repeating addition and subtraction per decimal digit. Multiple-digit multiplication and division are performed by shifting digits and repeating previous procedures.

He built one preliminary prototypes during 1674~1685 and another one on 1686~1694 and final one on 1690~1720 which is only one survived. In 1685 he also described pinwheel concept which can be variable teeth number wheel by inside auxiliary wheel and controlled by lever. All later mechanical calculators are used similar principle---either Leibnitz wheel or pinwheel. The final one was sent to Guttingen Univ. in 1775 for repair then forgot almost one hundred years. In 1876 it was found in the attic of one building at Univ. campus and returned to his hometown---Hangover in 1880. Then it was discovered that there is design flaw in carry mechanism. During 1894~1896 it was restored by one major Germany mechanical calculator company and exhibited in Germany museum.

**Basically there is no any calculator development after Leibniz until 1820 Colmar patented his arithmometer which adopted Leibnitz wheel concept** and then made a 6-digit prototype (collected and exhibited by Smithsonian Institute now) in 1822. But

during later 20 years he worked in one insurance company as managing director so he didn't have time to build any calculator until 1844. In 1844 he built one arithmometer for one of Paris exhibition. In 1851 he built another arithmometer for London Great Exhibition. Between these periods he made some improvement and filed new patents. Then he started manufacturing production models in 1851. **It is the first successful mass production mechanical calculator in world.**

In 1853 a 12-digit arithmometer sold as 300 Francs which equal to almost 30 sets of logarithmic table or 1500 times the first class stamp at that time. In one magazine of 1855 a 10 digit calculator advertised as 250 Francs and 16 digit machine as 500 Francs. In 1855 he built the largest (30-digit) arithmometer demonstrated in World Fair of Paris, later it was collected by IBM. In 1856 he estimated already spending 300,000 Francs from his money for 30 years development. And in 1872 he already manufactured and sold 1,000+ calculators. And there is no any competitor until 1886. In 1915 company closed since WWI and never recovered. The total quantities of Arithmometer sold are around 5,000 units.

**During 19$^{th}$ century there is strong demand for logarithmic table (mathematical function table include square root and trigonometric function values) to engineering design and calculation.** Before that time all the function values are calculated by human which is time consuming and easily making errors. Calculator invented by Colmar will have big help, but there is demanding machine can calculate these function values automatically. **These function values calculations greatly push from mid-19$^{th}$ century to mid-20th century development of programmable mechanical, electromechanical and electronic calculators then computers.**

Almost at same time frame with Colmar Babbage developed his difference engine by financial support from British government. The purpose of difference engine can calculate logarithmic and trigonometric function values by power series approximation which can be calculated by finite difference method--- only additions and subtraction. In 1822 he started difference engine design until 1842 given up his project he spent £17,000 from British government grants. He didn't finish his prototype since partially mechanical manufacturing technology not matching complex design and partially moving to more ambitious analytic engine design from 1837. Analytic engine is somewhat more like programmable mechanical calculator.

**Neither difference engine nor analytic engine are finished by Babbage, but later Scheutz in Sweden invented Scheutzian Calculation Engine in 1837 which is similar to difference engine from Babbage concept and finished in 1843.** He built another improved model demonstrated in 1855 for World Fair of Paris, then sold to British government in 1859. He also built the third one sold to US in 1860.

**In 1871 Swedish immigrant Odhner in Russia considered redesign of arithmometer while repairing it. In 1873 he used pinwheel replaced of bulky Leibnitz cylinder. During 1874~1876 he built 14 new calculators for his employer. Then in 1877 he filed patent. In 1890 he opened a workshop in St. Petersburg, then in 1891 another**

**factory at Brunsviga in Germany which was sold on next year. This mechanical calculator company is the longest lasting in all mechanical calculator companies---sustaining till '70 of 20th century and sold millions calculators.**

St. Petersburg's factory was nationalized after Russia revolution in 1917. This factory sold around 23,000 calculators before closed. Family members of Odhner returned to Sweden thereafter and continued Odhner brand calculator business. **Soviet Union moved his St. Petersburg's factory to Moscow and continued operation by changing to Felix brand which sold millions calculators until '70 of 20th century. There are also several famous Odhner's clones in Europe and Japan includes Busicom which is famous for first using microprocessor---Intel 4004 as calculator engine.**

**In 1884 Felt started comptometer which is key entry driven arithmometer.** Since every number in every digit has dedicated key the skilled operator can enter several digits simultaneously which may be faster than electronic calculator in some case. Please note typewriters are invented in US around 1865~1880. **Mechanical calculators have different developments under different technical culture background between Europe and US.**

**He finished the first prototype (collected and exhibited by Smithsonian Institute) by using a macaroni box in 1885.** Then he was hired by one workshop owner Tarrant, thereafter becoming his business partner. He filed for patent in 1886 and got patent in 1887 and at that time he already built 8 production machines ready for sale. In 1889 he invented comptograph with printing mechanism, sold to one bank in Pittsburg (collected and exhibited by Smithsonian Institute). During the first three years Felt & Tarrant Manufacturing Company sold around 100 comptometers. In '30 of 20th century electric mechanical models introduced. In 1947 this company goes to public and 1957 renamed as Comptometer Corporation. Then it was sold British right of design and trade mark to British comptometer clone company Bell Punch Company in 1960 before sold out US asset. The remaining portion of Comptometer Corporation merged to Victor Adding Machine Company in 1961.

**There are many mechanical calculator companies emerged during the first half of 20th century in the world. In US there are Monroe, Marchant and Friden three major companies.** Marchant founded in 1911 and the first calculator is Odhner's clone model. In 1918 his employee Friden redesigned it to avoid patent challenge and it is very successful. He promoted as chief engineer until he left this company and founded his company in 1934. Marchant calculator is famous for proportion gear mechanism which is fast and reliable operation. Monroe is also another famous calculator company founded in 1912 and acquired by Litton Industry in 1958 which is same year Marchant acquired by Smith Corona Typewriter company.

**In 1948 Curta---most compact mechanical calculator entered into market by Herzstark in Austria.** Type 1 has 8-digit data entry setting slide, 6-digit revolution counter and 11-digital result counter. It weighs about ½ lb and sold as $125 in '60. In 1954 launched Type 2 which has 11-digit data entry setting slide, 7-digit revolution to

lower the total maintenance cost at that timeframe instead of hiring more experienced validation engineers from silicon valley.

***Another ten years this company became the widest product models server MB designer/manufacturers in the world even the revenue is still not yet compared with other server giants such as HP, Dell or IBM and Intel has excellent special partner relationship to Super Micro Computer which is the current commercial secret and cannot be released now.*** Although this validation engineer is closing to retire age so he didn't have chance being promoted as any management position, he still enjoyed the highest salary in all non-management employees within company even higher than most of managers and approaching to that of VP for a long time.

In a nut shell computer evolved from mechanical calculators through generation 0 relay computer from late '30, generation 1 vacuum tube computer from late '40, generation 2 transistor computer from late '50, generation 3 ***monolithic*** integrated circuit computer from late '60, generation 4 microprocessor based computer from late '70, generation 5 *CMOS-only* based *initial* super computer-like microprocessor based computer from late '80 and generation 6 *multi-Cores* based and *CMOS-only* based *matured* super computer-like microprocessor based computer from the mid '00 in the 21st century.

Practical computer applications started from the beginning of generation 2 transistor computers with time-sharing system, their operating performance was around 1 MIPS magnitude (0.3~3 MIPS) till the beginning of generation 4 microprocessor based computer. The average performance of generation 1 vacuum tube computer was about 1/30 of later generation 2 transistor computer and it is low reliability (Every several hours it will have some vacuum tube burn out so halting all computer operations very frequently.) so basically in this era they are only research tools for computer science and many high-level language compilers such as FORTRAN, COBOL, ALGOL & LISP and low-level assemblers were developed in this era. The performance of generation 0 relay computer was around 300~3000 times slower than generation 1 vacuum tube computer so they were only early stage for exploiting calculating powers of computers or so called automatic calculators.

Generation 3 ***monolithic*** integrated circuit computer **marked** the computer practization so computer no more confined to the research/academic/government/big business areas. Several thousand dollars purchasing a complete computer system was never dreamed by the generation 1 & 2 computer users. During this era the most important office assistant beyond calculator---Word processor emerged here. Before this era there are already some entertainment game hardware existed and they are boosted and proliferated by the software versatile programmability. After 1977 microcomputer revolution marked the generation 4 microprocessor based computer which accelerated the popularity of computer to everybody.

***Since generation 5 microprocessor based computer is no more toy they are powerful as multi-million dollars super computer not long time ago.*** Intel **never** announced their recent microprocessors powerful as super computers since they are afraid of the living

descendants of those dead (bankrupted) super computer companies will request the *royalty* of super computer principles and methodologies. *Basically all science/engineering principles are belong to the wisdoms of all the people in the world you **can't** request patent or intellectual property ownership on any principle or expired/no applied methodology (They are already in public intellectual property.).* At most these principles you discovered or invented will be associated with your names in memory of your achievements, but that's it you can't obtain any private merits beyond it. *Once upon a time Sir Isaac Newton was admired to be the great scientist by the contemporary people he said modestly that he only stands on the shoulders of a giant.*

Only just emerged medium-level practical implementing methodology you can request patent, but you have risk after 17 or 20 years patent expiration it will still become the public intellectual property and more easily because already exhibited in public domain with details like general science/engineering principles. Except low-level implementation such as software codes have private intellectual property protection so 100% duplicating *commercially* document/graphics/picture/audio/video/software *even partially* **definitely** violates IP protection at anytime.

People are talking about Industry (revolution) 4.0 before the third wave of industrial (revolution) matured. It is surprised that all of three core technology domains of Industry (revolution) 3.0---**Computer architecture**, **Digital signal process (DSP)** and **(CMOS) VLSI** are developed by American companies **only** even many computer peripheral devices/equipments were developed by Japan, Taiwan and Korea. Considering the first industry revolution was nominally occurred from British on the end of 18$^{th}$ century/the beginning of 19$^{th}$ century and the Industry (revolution) 2.0 was happened on US during the late 19$^{th}$ century/the early 20$^{th}$ century, *but several major Europen countries such as German, France, Swedan and Italy still also contributed their similar developments.*

We already know since microprocessors emerged Motorola, Intel and several other US companies contributed a lot to **computer architecture** developments and ***last two generations super computer-like microprocessors*** Intel overshades all other competitors except AMD. For **digital signal process domain** during '90 several US companies contributed ***digital cellular*** *phone/future data* ***communication*** (***2G*** and future beyond) leading by Qualcomm & Motorola except some earlier GSM developments by European countries and ***digital television*** developments General Instruments was the major beginning player since she is the major cable television components/systems supplier since '60 based on long term other DSP application fields developments. **(CMOS) VLSI** developments were done by ***these microprocessor companies*** such as Intel, Motorola, AMD and etc. **plus** ***chip capital equipments manufacturing companies*** such as Applied Materials, KLA and etc. based on previous long term NMOS VLSI experiences.

***Why the core technology domains of Industry (revolution) 3.0 only happened on US?*** You can see US government welcomed world perspective intellectuals to study in US graduate schools and then work in major US enterprises policy **after WW II** ***worked***. Most contributors of these famous American electronics/computer companies are no longer native-born Caucasus Americans like (post-) Industry (revolution) 2.0, they speak

Hindustani or Mandarin look like those pioneers just after WW II spoke Germany. You shouldn't ignore these world talents' contributions. *Remember Albert Einstein's contribution so Adolf Hitler* ***definitely*** *hates and regrets his former prejudice* ***and malicious*** *racism (also the beginning ideologism) decision before he became the devil in the hell.*

The Industrial (revolution) 4.0 is regarding to intelligent motion movers or so called "smart" robots descending from the combination of Industry (revolution) 2.0 & 3.0. Many pioneers started studies since '50 from sense/motion, vision/pattern recognization, speech recognization/synthesis and to artificial intellectual principles since early neural networks, bionics, cybernetics, artificial intelligence, system identification (for learning process) till recent deep learning (or hierarchy learning) after WW II servo machines and automatic cartridge loading mechanisms populated on ship/air plane mounted gun fire control mechanisms *(You can remotely control these canons' azimuth and angles of elevation, amazing at that timeframe just like a robot sitting inside the turret remotely controlled by you.). No substantial artificial intellectual principles invented since the beginning neural networks till the recent deep learning. Beware of these "marketed" terms in recent high-tech products, not "engineering" terms.*

You can see many "smart" robots that can do a lot of incredible tasks which come from **ingenious and comprehensive** *analog circuits, digital systems and embedded microcontroller software functions*, sometimes even mimic learning process. Since '50 real *electronics* emerged from the traditional '10~'40 *radio-electronics* field there are already many ingenious and comprehensive circuits/systems/later software invented, but most are not well-known by the general people even *electronics/computer professionals*. You can find many examples described in professional magazines, books or even so called as their "Encyclopedia".

Regarding to moving robots include drones there are two extra kinds sensors built in beyond early "fixed position" robots, of course they are all installed anti-collision sensors even in the early plain moving robots except current drones. One is everybody familiar "Coordinate or Position" sensor which emerged around 30 years ago for navigation purpose following the previous generation LORAN (**LO**ng **RA**nge **N**avigation) (-C). In the beginning these GPS (**G**lobal **P**ositioning **S**ystem) modules already shrink to match box size and implemented into modern missiles and "smart" precision bombs. The other important moving sensor is the atitude sensor which was originally used in the orientation display/control of airplanes and spaceships. Thanks also from microelectronics contributions currently they are also shrink as match box size like the original GPS sensor. If modern moving robots don't have the help of this atitude sensors and associated controlled actuators, they will easily fall down like early plain moving robots. Of course car-auto driving mechanism doesn't need the atitude sensor but installed with the most advanced anti-collision **Lidar** (**L**aser **l**ight **d**etection **a**nd **r**anging) sensor.