People

CSC218 Computer Organization

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Gordon Bell

—Sloane Bartelme

Gordon Bell is a pioneer in the field of Computer Science. He was one of the original DEC employees and helped invent many of their PDP (Programmed Data Processors).

There is a law of computing named for him. Bell's Law states that every ten years, a new class of computer will be developed, and an entirely new industry will appear to compliment the new technology. So far, he has been right. He went on to become Vice President of Engineering at DEC for eleven years (1972–1983) and oversaw the VAX program. He had many endeavors after this, two most notably his time as researcher emeritus at Microsoft Research (1995–2015) and his venture into LifeLogging. Though his resume is massive, it is his venture into LifeLogging that was most interesting to me. Bell believed, at the height of his interest in LifeLogging, that somewhere in the future, humans would be recording every single moment of their lives on their "lifelog," a small computer worn around the neck. Bell has written two books on the subject, both of which focus on the ways LifeLogging could improve people's lives, socially and in the workplace. However, I see a sinister potential for LifeLogging technology that Bell either does not see or willfully ignores. He has since stopped the practice, or at least become less extreme in his recording methods, so perhaps some of the criticism has reached him.

My problem with LifeLogging is that, in our society, there is no way corporations or the government would not exploit LifeLogging in some way. The NSA would use the memories from people's lifelogs to monitor their every move. Imagine receiving targeted ads that were personalized based on your actual, lived experiences. Honestly, cookies are bad enough. I can't imagine the invasive potential of corporate interference with lifelogs. A society under such invasive surveillance would be extremely restrictive, and not just from government and corporate angles. Such obsessive record keeping would mean we surveil ourselves and each other. It would be like comparing FitBit information is now, except you would be monitoring and comparing literally any or every aspect of your entire life. I don't need to say much further to explain why that might be a negative phenomenon.

In conclusion, Gordon Bell is a brilliant computer scientist, and we have him and the other early employees of DEC to thank for modern computers. However, he's a bit of a nut, and I hope LifeLogging never exists in the way he conceptualized it, for the sake of humanity.

Maurice Wilkes

—Anthony Delgado

Wilkes is arguable one of the most important figures in computing in the UK. Some of his most important contribution were the EDSAC (Electronic Delayed Storage Automatic Calculator), which was the first stored-program computer. I presume stored-program means that it could load and run programs previously stored on the computer. He was a Mathematical Physicist and worked on radar technology during the second world war. His curiosity of computers started from his exposure and fascination with the EINAC (Electronic Numerical Integrator and Computer) used during the war for shell trajectory calculations. He attended lectures during 1946 at the University of Pennsylvania that proved pivotal in his understanding of building computers akin to those proposed by Von Neumann. Now being one of the few people in his time to understand how to build a computer, he got to work on plans for the EDSAC.

His goal was not to produce a robust cutting-edge computer with all the bells and whistles, but instead to take a more practical approach and produce something that would make his and his coworkers lives easier. He sought to reduce the burden of heavy calculations for scientists and engineers he worked with. He also wanted to make the computers easier to work with so that other professionals in different fields could benefit from the technology.

Another notable contribution by Wilkes was the concept of microprogramming, which is a type of control unit that uses stored-programs that controls the logic necessary to execute instructions within a processor. It is often juxtaposed with Hardwired control units which as the name suggest are hardwired into the processor via logic gates. One of the many advantages of microprograming is that it simplified logic control in processors and allowed for larger and more complex instructions to be carried out.

His exposure to work being done in digital telephony by the Switzerland Telecommunication firm of Hasler, allowed him to be early on the scene of networking. This was before the internet was a thing. He wanted to connect computers and started the Cambridge Ring project, which used the idea of Rings from topology, where nodes are connected to two other nodes, and are laid out in a circular fashion. This did not last long because the industry agreed on using ethernet as the standard. After retiring, Wilkes went to work for DEC and said he regrets not working in industry earlier since he really enjoyed it.

Carver Mead

—Noah Carpenter

Mead graduated from Caltech in 1956, where he is now a professor, with a degree in Electrical Engineering. He is most famous for his Very Large Scale Integration (VLSI) work. VLSI has been used in cell phones, as well as microwave dishes for communication. He currently holds over 50 patents for design.

Carver Mead is best known for inventing the high frequency transistor, and pioneered the movement toward programmable logic chips in computers. And then in 1999, carver won an award for half a million dollars from MIT for his all of his innovative work. However, in recent years, he has emerged not as an important computer scientist, but as one of the most important physicists of the twenty first century.

Carvers work in computer science is still incredibly influential in todays world. His work in computer chips is still being used in todays computers. Carver recently said that he believes that computer engineers should look for new forms of computing rather than what they are doing today - similar to what he did when he was younger.

One problem that tends to give computers trouble is overheating. The more chips put in computers, and the more powerful they become, they work harder and thus overheat more. This is where Meads work in computer science began. He sought a way to replace the overheating and less-efficient chips. To accomplish this, he used the brains of living things to use as a start-off point for his work. His work applied to engineering as well, as Neuromorphic Engineering (using humans or animals as a model for engineering) has become an important practice for Engineering, as well as computer science.

Gordon Moore

—John Hoberg

Moore's Law: Monday November 27th Prediction that set pace for the modern digital revolution. Increase in power with a decrease in cost at an exponential rate. Gordon paved this path for Intel to make transistors faster, smaller and more affordable. Economics: Power/ performance and cost are two key elements to tech development. As transistors become smaller, power is increased and energy efficiency becomes greater all at a cheaper cost to the user. This development increased productivity and enhanced existing industries but also created entirely new ones. Tech: Helped to make this industry much more of an affordable necessity instead of a rare and expensive venture. Just about everything about modern computing as we know it (Social Media, Modern data analytics) sprang from this development. Moore's Law has set the pace for 50 years to help allow digitization and personal electronics.

The Road to 14nm (2014):

- 2010 Had Westmere 32nm
- 2011 had sandy bridge 32nm
- 2012 Ivy Bridge 22nm
- 2013 Haswell 22nm

In 2015 Intel stated that the pace of advancement has slowed from 2012 at 22nm continuing to 14nm. Expresses that moores law is closer to 2.5 years and that late 2017 they hope for 10nm transistors. Shoot for 10nm, 7nm and even 5nm and say they have plans for these but that Moore's law may come to a close and significantly slow down by 2025.

Robert Noyce

—Jerome Richards

Robert Noyce was not just a computer guy. He was a renaissance man in the 1900s. He is well known for his work in the computer field, but other than that he was an athlete, pilot, tinkerer, and apparently dabbled in singing. A technologist, he was a co-inventor of the integrated circuit. He also co-founded Fairchild

Semiconductor, as well as the more well known and current industry giant Intel Corporation. By co-inventing the integrated circuit, an argument could be made that he is one of the most important figures in created the age of modern computing that we find ourselves in. Other than his intellectual contributions to the industry, which are many, he helped found the Semiconductor Industry Association, which is technically a trade organization, and it lobbies for and represents the semiconductor and microchip industry in the United states. He served on the Presidents Commission on Industrial Competitiveness, and was the first CEO of SEMATECH, which is a not-for-profit R&D consortium focusing on semiconductors and microchips. Robert Noyce over his lifetime acquired 15 U.S. patents, but his greater legacy can be traced through the omnipresence of integrated circuits in the world today. After reading about Robert Noyce, Intel's website has links to the way microchips are built today. It is a massive industrialized process that takes place in a room "thousands of times cleaner than hospital operating rooms." One of the more interesting processes while making a computer chip is the photolithography used on the chip to map out the circuits and transistors to be put onto the wafer. Ordinary light is not used, as many features on microchips are literally more precise than the wavelength of visible light allows, so shorter wavelength EMW are used to trace the map. Though Noyce took the first steps, the industry is forging on ahead with innovation on each generation of their products.

Federico Faggin

—Jason Wang

This video is about this person called Federico Faggin who is in charge of the development of MCS4 back in 1970s. The MCS4 was a four chipsets that was developed for the physicals. And one of the chips which called 4004 is become the world's first microprocessor. Federico Faggin is hired by Intel at that time and he runs into one problem. He run into was by using silicon gate technology, which is a new technology at that time, is still not enough. He need to build complex circuits in different way than metal gate. And this is a total invention that he have to come up with this by his partner and himself. His partner find out a simpler way of building the chips so that they can combine three chips, which was they plan, into one and also faster at the same time.

Then he talks about how people use the microprocessor nowadays and how it had been developed over years. He state that microprocessor really give the computer the ability of thinking like human brain. And it is show the ability inside the use of internet. Microprocessor has been used in all the pc, smartphones and so on. It connect people with each other with the way that we can just talk with each other just like face to face.And then he talks about the new development of computer science that we should not be scared about the technology development but seeing this as pushing the ability also.

The Future of Microprocessors

—Kunle Olukotun and Lance Hammand

The Future of the Microprocessor Business

—Michael J. Bass and Clayton M. Christensen

- microprocessor is most transformative technology
- likely you have > 100 microprocessors in your household
  - laptop computers, tablet computers, phones
  - entertainment (television, music)
  - appliances
  - toys
  - cameras
  - vehicles (40 or 50 in automobile)
- principal players in industry
  - Intel
  - Motorola
  - Advanced Micro Devices (AMD)
  - IBM
  - Sun Microsystems (now part of Oracle)
  - Hewlett-Packard
- expenditures on development of microprocessors = billions of dollars/year
- 200 millions transistors on 1 square centimeters
- Gordon Moore: co-founder of Intel
- exponential rate of improvement of price/performance ratios

- Moore's Law: double # of transistors on chips every 1.5 years
- Moore's Law: double performance of chips every 1.5 years
- focus on…
  - producing larger wafers
  - producing smaller line widths
  - producing smaller transistors
  - (all to pack more transistors on each chip, maximize performance)
- "this unshakable industry paradigm will change fundamentally"
- **those who strive to keep up with Moore's Law risk losing market share**
- expect Moore's Law to remain valid for at least another 15 years (at least until 2017)
- will physical limits end Moore's Law? — wrong question!
- top chip makers will have not choice but to continue on same path (trying to keep up with Moore's Law)
- many applications will not require highest performance microprocessors
- other factors will be more important than performance…
  - customization
  - rapid development
- microprocessor market: $40B/year
- segments of market
  - top tier—most powerful microprocessors (servers, workstations)
  - PC market—dominated by Intel ($23B in 2001)
  - microcontrollers (for example, to control engines) ($10B)
  - digital signal processors (cell phones, DVD players) ($4B)
- similar patterns seen in developments in many technologies and industries
  - emphasis on improving performance
  - then (when performance exceeds needs of many customers) emphasis is on customization, reliability, ease-of-use, quick delivery)
- customization, upgrades, quick development facilitated by…
  - modularization

  - standard interfaces

- modularization opens opportunities for companies that make just one component

- segment of market that pays the most, wants highest performance will shrink

- largest, oldest firms often miss this kind of shift in markets

- highest performance needed for. . .
  - editing digital video
  - 3D games
  - speech to text

- highest available performance not needed for many more popular applications. . .
  - writing reports, memoranda, correspondence, e-mail
  - calendars, scheduling
  - reading on the Internet, retrieving documents

- history
  - Apple—vertically integrated, proprietary architecture—best performance
  - less expensive machines became "good enough" for doing what most people wanted to do
  - IBM PC—modular, open architecture
  - Compaq and other makers of IBM PC clones entered market
  - customers demand for dependability grew—HP and other companies with strong reputations entered
  - functionality and reliability became "good enough"
  - Dell stepped in to provide highly customized computers and quick delivery

- manufacturers are offering lower performance chips, but not yet modular products

- "design gap"—possible to put more transistors on chip than anyone knows what to do with

- what might modularization look like?
  - SoC—System on a Chip
  - reusable IP (intellectual property) blocks

  - subcircuits (described in software or finished hardware design) that can be dropped into the design of a chip
  - for example, memory controller or serial interface
  - choose amount of instruction-level parallelism, bus widths, cache sizes, specify instruction set
  - design in weeks rather than months

- if product life cycles grow shorter, speed to market will be more important
- predictions...
  - market of PCs shrinking
  - market for DSPs growing
  - use modular designs in many different combinations
  - multiple circuit types/process technologies on a single chip
  - specialized designs to meet needs that cannot be met with general purpose processors
  - designs for small markets
  - designs for short-lived markets

Microprocessors in 2020

—David A. Patterson

- predicts that one computer in 2020 will have computing power equal to combined power of all computers in Silicon Valley in 1995!
- improvement in microprocessors in first 25 years: 25,000×
- silicon chips have led to countless inventions
  - portable computers
  - fax machines
  - intelligence in automobiles
  - intelligence in wristwatches
- predictions often overstate importance of radical, new technologies
- Patterson instead predicted evolutionary changes
- 2 inventions sparked computer revolution

  - stored program concept in late 1940s (basis of every computer since)
    * processor for crunching numbers
    * memory for storing data, programs
    * advantage: same hardware performs variety of tasks (just change program in memory)
  - transistor also invented in late 1940s
    * much smaller than vacuum tubes
    * made possible smaller, faster electronics

- timeline
  - decade between invention of stored program concept and transistor and first pairing of the two technologies
  - first microprocessor in 1971
    * Intel 4004
    * single silicon chip, size of a child's fingernail
    * first processor that could be made inexpensively in bulk

- manufacture of integrated circuits
  - add chemicals to silicon disk
  - place in oven
  - repeat about 20 times
  - in this way, create complex pattern on silicon
  - transistors, conductors, insulators
  - even a little dust or vibration spoils the product!

- key to cheaper, faster chips
  - larger wafers
  - smaller transistors

- number of transistors on a microprocessor
  - Intel 4004 had 2300 transistors in 1971
  - Intel P6 had 5.5 million transistors in mid-1990s

- trade-offs
  - more chips per wafer → lower cost per chip
  - wafers have grown larger but number of transistors per chip has grown → fewer chips per wafer
  - larger chips → faster chips
  - larger chips → more likely to contain defects

- rates of progress
  - 35%/year in mid-1980s
  - 55%/year in mid-1990s
  - actual speed of processors in mid-1990s 3× greater than speed predicted in early 1980s
- keys to progress
  - engineers in industry have borrowed methods from researchers in universities
  - quantitative approach in design
  - careful experiments
  - sensible metrics

Microprocessors

Despite claiming that it is "impossible to foresee what inventions will... go on to revolutionize the computer industry," David Patterson is a wizard who accurately predicted the technology of 2017 ($\tilde{2}$020), from virtual reality and voice recognition to cloud data storage. Essentially, his article describes the rapid shrinking of technology.

The passage talks about how the mass production of microprocessors is becoming easier and simpler nowadays. He gives us the example of making the microprocessors as baking a pizza, but the advantage is, we can produce a big amount of microprocessors at the same time while we only can make one pizza. And writing the logic for each microprocessor is like adding the topping of the pizza, that we can just make the pizza and add different toppings for different pizzas based on what people want.

The author also predicted that the microprocessors will become smaller and smaller in the future and to a certain degree that people cannot use eyes or even use light to detect the chips, we have to use a special way, such as X-rays, to build and produce the microprocessors in the future. And eventually one day, the rapid pace of improvement may well slow down.

- pipelining, superscalar designs based on von Neummann architecture
- pipelining, superscalar approaches no longer providing improvements in performance
- microprocessors became smaller, still overheated, required lot of power
- in 1980s—no heat sink needed

- in 1990s—medium-size heat sink needed
- in 2000s—monstrous heat sinks needed
- water cooling impractical, too expensive
- progress (with conventional methods) stopped because of power constraints
- CMPs—fit multiple processors in same space formerly used for one
- processors on CMP share connections to system, thus reducing power consumption
- CMP can achieve same or better throughput at half the clockspeed of single processors
- CMPs are the future
- CMPs do not rely on von Neumann architecture
- Moore's Law—double # of transistors on IC (w/o increase in cost)
- people will not pay premium for performance they do not need
- design efforts should focus on custom features (chips are stronger than needed)
- facilities can fabricate more transistors/year than design teams can use
- in 1997, fab facilities increasing at 60%
- in 1997, design teams increasing at 20%
- cycle seen in kinds of improvements
  1. focus on performance
  2. focus on reliability
  3. focus on convenience
  4. focus on customization
- improvement cycles seen in...
  - mainframe computers
  - personal computers
  - telecommunications
  - banking
  - hospitals
  - steel

Statistics

- microprocessor market = $40B/year
- 200 million transistors on 1 cm die in 2002

Glossary

Chip Multi-Processors (CMP)

clockspeed

Intel 4004 the very first microprocessor, developed in 1971

latency

microprocessor computer processor which incorporates the functions of a computer's central processing unit on a single integrated circuit, or at most a few integrated circuits

multithreading

pipelining execute instruction #n, decode instruction #(n + 1), and fetch instruction #(n + 2) at the same time

pipelining a method of processing that saves time proportional to the number of stages involved (e.g., one load of laundry is four steps and takes one hour, so 20 loads would take 20 hours. Pipelined laundry would only take 5 hours for 20 loads.)

stored program concept a computer model which prescribes a processor for crunching numbers and a memory for storing both data and programs

superscalar

superscalar and parallel a method that can multi-task at the same time so that we can speed up the whole process. (e.g., same with the laundry example, it will be faster if we can do 3 loads of laundry at the same time for each step, it will be way faster.)

throughput

transistors silicon switches to replace vacuum tubes in circuitry