Richard Sawey Docent Tour Outline Winter 2023 - v5.0 - Godzilla - Where Richard torches the old intro and finally creates a sub 1 hour tour

Tour Goals

Big Idea/Enduring Understanding

Computers are tools, tools of automation, tools of communication and tools of creation, tools created by and for people, people like you (the museum visitor).

This tour will show you some key tools in the history of computing but we'll focus on the stories of the people involved and what drove them to create these tools.

Learning Objectives

- Learn about a few of the wonderful people who have made huge contributions to computing.
- Gain an understanding of some basics of how computers work as well as the history of computing.
- Learn that computers are things you, our visitor, can understand and use.
- This museum is yours, a resource for you whatever your role or your use of computers, not just today but after you leave.

Artifact Stops

1. ENIAC and Univac
2. IBM 360 & AGC
3. Supercomputers
4. PDP 8
5. Moore's Law
6. PC Gallery (Altair, Apple II, IBM PC and Mac)

Introduction

Meeting Spot (3 minutes)

My name is Richard Sawey, I am a volunteer docent here at the Computer History Museum and it's my pleasure to welcome you all both to the museum and this tour of our main exhibit, Revolutions 2000 years in computer. My tour will take about 45 minutes, including time for questions, so please ask them!

Make Big Idea Statement:
I have worked in the software industry for the past 30 odd years and so to me, computers have been the tool of my trade and they may well form a key part of what you do at home or at work.
Computers are tools, tools of automation, tools of communication, tools of oppression, tools of individuality and tools of creativity. On my tour I'll mostly be focusing on the problems and the people, and less on the bits, kilobytes, and gigabytes, if you're into the bit and bytes these are detailed on each exhibit, and I'll answer any questions I can, but my focus will be on stories of success, failure, redemption, paranoia, betrayal, you know, the good stuff. Our stories will involve big problem solving, big egos and we'll watch billions of dollars being made and lost. You should learn from your failures, and boy we have some doozies.

On our way to the first stop of our tour, ask yourself what's the oldest thing a computer history museum might have? 2000 years?
And what is a computer anyway? What was the first computer? We'll discuss these fundamentals in the first couple of stops of our tour.

Please follow me.

ENIAC

Discussion at ENIAC (10 Minutes)

On our way here we walked through the Calculation and Punched Card galleries, for thousands of years we humans have used aids to memory and calculation, from stones and lines in the dirt that later became the Abacus, to knots on strings tied to necklaces that recorded transactions in Mayan culture, to the late 1800s and early 1900s when things like mechanic and electromechanical adding machines, typewriters and punched card based counting machines were created and became common in businesses everywhere. And examples of all of these are in those galleries behind you.

While these tools worked great, they could reliably process numbers read from punched cards or punched in using a keypad, and they were widely adopted and helped drive the industrialization of our society, they were also limited and frustrated many of their users. More was needed, what today we call the computer. But what makes a computer a computer and not just a fancy calculator?

To me the major difference is “programmability” - a calculator can add/subtract, some can multiply and divide, or can do square roots, some even do trigonometry with cosines or basic calculus, but once you build the calculator or the analyzer, the features and capabilities are baked in. There are no blank keys where you can go and wire in your own new feature or function. This requires a machine that can do logic and decision making not imagined by the builder only by the user, someone like you. And this requires a machine that can store not just data, but the instructions for manipulating that data, recalling them at lightning speed without humans slowing things down. Being able to work with text and pictures and things other than numbers is also needed.

But beside here are some cabinets from an early computer, built during WW2, this is the ENIAC, an immense beast, that took up some 1500 sq feet, so about the size of three bedroomed house and that used nearly 18k vacuum tubes, and it was the application of this key, well understood, technology at scale that differentiates this machine from many of the machines in the galleries we just passed through.

Vacuum tubes are a sibling to the old incandescent light bulbs, only they have two circuits instead of the one in a light bulb. The second circuit can be used to turn the first circuit on or off and so we have an all electronic ‘switch’ that can store a 1 or a 0, 1 meaning current is flowing through the first circuit and 0 meaning no current. And all with no moving parts that can run far faster than the older electromechanical ones. And you can wire up multiples of these vacuum tubes to create adders or to create basic logic circuits of the type, ‘if A is on and B is off then the output C is on/off’. And so if you have enough, like 18k, you can build a computer with 20 variables/storage locations/registers, the ability to iterate or loop, to do basic logic and so be programmed to solve a variety of problems. Combine that with a card reader for input, a card punch for output and you have ENIAC. But ENIAC took about three years to build and cost a half million 1945 dollars and was finished in Dec 1945.

And it, kinda, worked, having built the beast they realized the tubes were more unreliable than they’d like, like old light bulbs they can suddenly burn out and now your answers are wrong and you have to find the rack with the burnt out tube and replace it. Also setting the machine up for a new problem could take two

weeks. But I referred to this as an early computer as it has, arguably, the basics, inputs and outputs, memory, though very very limited memory, and programmable, though with great difficulty. ENIAC was one of several attempts at building this next generation general purpose computation machine, The British built their own, Colossus, for code breaking that no one knew about for 30 years and Harvard built one for the Navy by Howard Aitken and with the help of IBM. Theirs was arguably more sophisticated, you could access prebuilt sub routines, reusable math functions, but the Harvard machine still used many electromechanical parts, it had a 55 foot long drive shaft,but their computer could only manage around three calculations a second, ENIAC, when in full flow, could easily do 30 and if it was simple addition or counting, 500 or more per second. Being 'all electronic' meant ENIAC was much faster and this became the standard going forward.

But the creators of ENIAC, John Mauchley and Presper Eckhart, weren't done, if ENIAC was v1, they wanted to build v2, a better computer build for businesses, the Universal Automatic Computer, Univac. They started their own company, signed a couple of deals, and used the funds to start building Univac. To solve the reliability problem they reduced the number of tubes, they added memory by using these liquid mercury acoustic storage devices, one of these can hold about 1000 bytes and a production Univac might have six or more of these, 6kb is enough to load in a program, set of instructions, from punched cards or from the new metal tape drives like the one in the corner. And now you've driven down the setup time for a new calculation from two weeks to minutes or less. Compilers now exist and are used to create the programs, Grace Hopper did a lot of important work on compilers for Univac before later creating COBOL, becoming an Admiral in the US Navy and winning the Presidential Medal of Freedom, a remarkable life.

While intended for business, the first Univac was installed at the US Census Bureau in 1951, the second to the Pentagon and the third went to Univac's newish owners, Mauchley and Eckhart ran out of money and took the first offer they could get which was from Remington, an office supply company famous for their typewriters and adders, but the fourth Univac was sold to General Electric who used it for budgeting and accounting. Business computing was by now definitely a business that lots of people wanted in on.

And so while we've arrived at the birth of commercial computing, we've a lot to cover to get to the machines we all have on our desks, so let's jump forward 10 or so years to our next stop so we can take stock of some important changes.

Summary

Relevant and Essential - what is it that is of value here? Remove everything else!

Five word story: Computers arrive but are awful.

Goals/Strands:
Computation drivers of WW2..
Impact of both Government and Business on post war office automation.
Many problems have to be solved to make computers useful for business.

The story is that while war crystalized computer architecture, issues of funding and patent law are as important as the technical improvements.
The hook is ‘we’ve arrived at the invention of the computer but we’re very far away from computers as you likely know them, long journey ahead.’

1943 ENIAC approved and construction begins
1945 December ENIAC completed
1946 February ENIAC announced/demoed
1951 First UNIVAC installed at U.S. Census

IBM 360

Transition to IBM 360

On that last point, we're starting to see some themes repeat:

- Computer guys don't always make good business decisions - this is a team sport.
- Government continues to dominate as a customer despite attempts to diversify.
- This is an iterative business, you ship something, the next thing you ship fixes the big problems with the last thing you shipped.

So progress, but our next step looks at solving some other big problems, like upgrade compatibility, power draw and size. Please follow me round the corner to our IBM System/360.

This next story is the museum's equivalent of every movie with a casino scene where the underdog pushes all their chips, their car keys, their dog license, into the center of the poker table…

Discussion at IBM 360 & Apollo Guidance Computer (10 minutes)

IBM became very successful in the punched card business in the early 1900s and after the war got into the computer business. By the early Sixties IBM were heading north of $2B/year in sales and they'd created six different but incompatible product lines. Customers hated this, they had to replace everything and IBM management knew they had a tiger by the tail that would eat them no matter how successful they were selling the products. The 360 was going to fix that, it would be a scalable computer that grew as your business grew while continuing to run the same programs and storage you had been using.

But making the 360 happen nearly ended IBM, development costs rose to $5B, the backward compatibility requirements were nightmarish but they stuck with it and it became the huge success they'd hoped for. Released in 1964 IBM ended up selling 100,000 of them, some much, much larger and faster and way more expensive than the one behind me.

The 360 computer is the red unit, note that the label says 'System360', while that's the computer you would also acquire a collection of input and output devices to do useful things. Many businesses used these computers for finance, accounting, payroll, inventory and almost always in 'batch processing' mode. So you might start with a tape of transactions, and a second tape of customer balances and so you read the transactions one at a time and write out new custom balances on a new tape, perhaps printing out some details and summaries so someone can check the programs work.

Disk drives were invented by IBM in 1956, the gallery to your right contains a detailed history of computer storage including the first commercial disk drive, RAMAC, still operating, it stores a whopping 5 megabytes, enough for one photo on your phone. And this ability to directly access a customer's account without having to read through a tape to the right account created entirely new applications for businesses like ATMs and airline reservation systems, databases became a thing with lots of uses.

There are no valves in the 360, it uses transistors instead, the semiconductor functional equivalent of the tube. They're smaller, draw much less power and are solid state and much much more reliable. Also we've moved thankfully away from the liquid mercury storage to magnetic core or rope memory, little donuts of ferrite/iron with wires weaved through them that be energized and magnetize the donut so now it's storing a 1 or a 0. You can de-magnetize and remagnetize as your program moves along storing code and numbers as needed.

We've crammed all this stuff together for the display. In reality a real 360 computer room would be at least twice, often four times the size with room for operators and maintenance people to get at both the fronts and the backs of each device. But still a noisy, unpleasant place to work, and I've spent hundreds of hours working in such rooms.

Apollo Guidance Computer

Over to your left against the wall and right under the Moon hanging from the ceiling is a very different type of computer from the same period, the mid and late Sixties. While the 360 was built for general purpose computing, carried out many different tasks and programs and lived in a dedicated computer room, the computer over under the moon is an Apollo Guidance Computer. It's small and it's got one purpose, to put a man on the moon and return him safely.

There's not much room over there to stand so from here I'll point out the upper panel was mounted on the dashboard of either the Apollo Command Module or the Lunar Module, known as the 'diskey', this was where the astronauts input and received instructions from the computer. The computer itself are those two larger metallic panels underneath. In the spaceship they'd be screwed together and under the seats. You'll find the "diskey" in the middle of the panels in front of the astronauts. Never sold, about 70 were made by MIT's Instrument Lab under contract to NASA and 20 flew, two on each Apollo moon mission, Apollo's 8 through 17.

There are no disk drives, no tape drives, they were too fragile and bulky for space travel, but like the 360, the Apollo computer uses 'rope' memory, wrapped carefully rope memory is very stable and can survive the shaking of take off. But this is also one of the first computers to use integrated circuits to replace some, but not all of the transistors. While ubiquitous today, in the sixties integrated circuits were a big gamble by NASA, but they were desperate to save weight and power while keeping robustness, and the ICs delivered all of this.

Code development was led by Margret Hamilton, there's a picture of her over there next to a print out of the source code that is literally as tall as she is. While a lot of code, no known bugs were ever found and without this code and that computer Apollo would have taken much much longer to get to the moon, if at all.

Again, stepping back for a second, we see the next iterations and innovations in the computer industry, we spend more time talking about integrated circuits, but I want to pull more on this thread of computer diversity where some computers are getting ever bigger and serving the needs of large organizations of thousands of people, while other computers are getting smaller and are focused on a much smaller audience of one.

Summary

Relevant and Essential - what is it that is of value here? Remove everything else!

Five word story: Business scales with transistorized computing.

Goals/Strands:
Story: The mainframe drives business innovation, ATMs, airline reservation systems, networks.

IBM's consolidation leads to domination.
Transistors replace valves and memory and storage improve.
Specialized computers remain important despite the rise of general purpose business computing.
Government has a huge part to play driving the next platform change of integrated circuits.

The hook is 'IBM dominates, competitors struggle. What are competitors to do?'

Supercomputers

On the way to our next stop, the super computer gallery, we will walk right by one of the coolest looking machines in the building, the Cray-1, iconic due to it's semi circular configuration and bench/love seat. I kid you not. Please follow me.

IBM's System/360 was a huge success but outrageous promises for price and performance came along for the ride and the competition, such as RCA and Honeywell, made hay with IBM compatible machines that used integrated circuits that the 360 didn't have. Other competitors decided to go where IBM weren't, arguably the best example is Control Data, they noticed that while the System/360 might be expandible, it didn't expand much at the high end. So they shifted their focus to very high end computing, what today we know of as 'supercomputers'.

While this is called the Supercomputer Gallery, to me it's the Seymore Cray gallery, a computer engineer, revered by those who know their computer engineering history along with Eckhart and Mauchly. Cray, an army veteran who saw service both in Europe and the Philippines, he graduated Uni Of Minnesota in 1951 and quickly showed his work ethic, and crucially his ability to understand and overcome technical problems at a company called ERA who got their start building custom computers for the US Navy. ERA were bought by Remington Rand and folded into the UNIVAC division, William Norris their CEO left and started a new company, Control Data, which hired Seymour Cray away, this was both great and problematic for Control Data. Cray quickly delivered a new fast computer that everyone, including the Navy loved, but marketing at Control Data wanted to do their own IBM System/360, which Cray viewed as an abomination, bloated, slow, a product of groupthink. He wanted to build the world's fastest computer, and that was all he wanted or was willing to do. Wisely Norris let him, while he had others in the company do what marketing wanted, in 1964 Cray and his team delivered the 6600, as he'd promised, was 10 times faster than anything else. This machine held computing speed records for five years until Cray delivered the 7600 which took over the supercomputer title. This computers sold for $8M or more, Los Alamos, Lawrence Livermore, Navy lined up to get the first ones, though big business was keen on them as well, everyone used them for modeling, simulations of real world things, fast enough so that the simulation both replicated real world behaviors, air flow over a wing or water flow over a submarine or the weather or nuclear reactions and reduced the need to build multiple versions of the real thing for testing.

Cray got speed out of his creations not by living on the bleeding edge, he had no time for integrated circuits until the eighties, but by focusing on simplicity and what today we'd call "thinking holistically", focusing on first one bottleneck and when that was addressed, he'd focus on the next bottleneck.

- By simplicity I mean what today we'd call Reduced Instruction Set Computing, keeping the low level commands to the minimum while ensuring they were implemented as efficiently as possible.

- Cray had no time for backward compatibility, which IBM, say, cared a lot about, but Cray knew the right, rich, customers would pay a premium for raw performance.
- He also, and this might seem trite, jammed stuff together as much as possible. That's why the Cray 1 back there is semi-circular, so the boards in the tall units are closed together.
- He sandwiched metal blades between the boards and added refrigeration to draw the heat out to stop them from melting.
- And the whole thing was hand wired, expensive, but again improved performance.
- Uses a vector processor design, so operating on a vector/arrays of numbers in a single action.

Cray worked differently than IBM, Control Data couldn't afford to spend IBM money on any computer and Cray's preference to work with a small team of hand picked engineers suited him and Control Data. While developing the 6600 his reputation had grown so much at Control Data, he told them he wanted his own lab away from HQ and specifically, in his hometown, Chippewa Falls, Wisconsin. He demanded and got, no sales calls, no management meetings, no walk-ins of any kind, not even from the boss, Bill Norris. Having shaken off management distractions he delivered the 6600 with a crew of 34 including the janitor. Once word got out, this fact aggravated IBM's Watson enough to zing a scathing letter to IBM management, "I fail to understand how we have lost our industry leadership position".

But even out in Wisconsin the growth of Control Data, the hand of management was too much and he quit CDC and started Cray Research apparently so people would leave him alone and he could work on what interested him. He was famous enough to easily get funding, and savvy enough to hire professional managers and people like Les Brown dealt with the boring stuff like people management, creating shippable products and scaling up manufacturing. Cray 1 shipped in 1976, was again faster than everything else and again was snapped up by the same deep-pocketed customers that had bought his earlier creations. Cray made a fortune, but money wasn't that interesting to him, he kept building computers, like the Cray 2 behind me, where the boards are actually in a liquid bath of refrigerant, Flourinert, to draw the heat off, the big perspex display behind me is actually a tank that the hot liquid could be seen to bubble through as it cooled using chilled water.

But that was his last hit, Cray stumbles, the Cray 3 never actually worked and they ran out of money, the market for supercomputers shriveled with the end of the Cold War - Cray's first customers were always Los Alamos or Lawrence Livermore, or the weather service or NASA. Cray started another company and was working on a new supercomputer when he was killed in a traffic accident in 1996, his company died with him. Supercomputing had already moved on and aggressively pursued parallel processing using thousands of processors like on the machines to your right.

1957 Bill Norris founds Control Data with many coming from ERA/Univac

1958 Cray joins Control Data,
1960 CDC 160A, “first minicomputer” released
1962 Cray demands his own lab in Chippawa Falls WI with 34 engineers
1964 CDC 6600 released, $8M each, over 100 sold, 10 times faster than competition
1969 CDC 7600 released, four times faster, hold record until 1976
1972 Cray leaves to found Cray Research, CDC invests
1976 Cray 1 released
1984 Connection Machine CM-1 released
1985 Cray 2 released, 12 times faster, $12M and up
1993 Cray 3 prototype installed and taken back.
1996 Cray killed in traffic accident

Summary

Relevant and Essential - what is it that is of value here? Remove everything else!

Five word story: Think differently, succeed where IBM ain’t.

Goals/Strands:
The Story: Control Data succeeding in a space where IBM is weak, calling IBM on their lies and winning, then losing everything anyway.
Supercomputers, again the government now in the Cold War demanding and paying for performance for modeling and simulation.
But creating them required invention, not just of technology but small teams, isolated, focused and different than the accepted big business practices of the time.
Always from the fresh sheet of paper

The story is Control Data avoiding then defeating IBM only to lose anyway.
The hook is ‘how do we get to where we are today with a computer on every desk?’

PDP-8

Transition to the PDP-8

Let's take another quick look at that decision to "go where IBM isn't".

Discussion at PDP-8 (1 minute)

Here we have a PDP-8, a 'minicomputer', introduced in 1965 by Digital Equipment Corporation (DEC). It was one of the first minicomputers, and was very successful, selling over 50,000 units.

Edson de Castro and Gorden Bell were tasked with building a nuclear reactor monitor, instead of building a dedicated device like expected, they built this small general purpose computer and programmed it to do the job.

The PDP-8 was also easy to use with a simple command line interface, compilers for many languages including BASIC and FORTRAN and it was easy to integrate with other devices, making the PDP-8 accessible to a wide range of users. While cheaper it remained reliable, using magnetic core memory like the Apollo Computer. Perhaps tongue in cheek it was promoted as "portable" (point to photo at top of the PDP- on the back seat of a convertible) and later models used integrated circuits.

de Castro wanted DEC to let him build a 16-bit computer, the PDP-8 is 12 bit, but they wouldn't so he quit and started Data General one of many mini-computer manufacturers.

Relatively inexpensive, less than $20k, making this affordable for small businesses and universities, and brought reliable computing into the workplace and away from being the sole preserve of large corporations. And again, going where IBM wasn't, or at least not that interested in and certainly a area they had few successes in. Mini computer makers were often start ups independent of the main frame guys, Dec is probably the most successful, but other ones in addition to Data General, local to this area include Sun Microsystems, Silicon Graphics (whose HQ we are standing in), Pyramid and Apollo,

I mentioned that later PDP-8 models used integrated circuits, let's pull more on that thread in our next stop but as we walk through the gallery you'll notice we've placed big yellow price tags to drive the 'lower cost' point home. But I'd argue the price point isn't the point, the impact, the wider use and adoption of computers because of the lower price point is "the point".

Moore's Law

Transition to Moore's Law

Now we get to the part of the tour with tales of success, paranoia, and "betrayal"?

Discussion at Moore's Law (5 minutes)

We've seen punched cards, vacuum tubes, then transistors and now integrated circuits, and despite these technology shifts, it's still all about zeros and ones, on and off, true or false, just done much much much faster with devices that are much smaller with each shift in the technology used. Vacuum tubes were available starting around 1911, the transistor was released by Bell Labs in 1951 and Brattain - Bardeen - Shockley were the three Bell Labs scientists who invented the transistor, a semiconductor based equivalent of the vacuum tube. As project lead, William Shockley, wrongly demanded all the credit, and he left Bell under a cloud and after a short stint at Cal Tech, returned home to Mom's house, in Palo Alto in 1955. He was a local boy and one who had the juice to get funding and to start his own company, Shockley Semiconductor. He hired a new team of bright young things and worked on manufacturing transistors. But his interpersonal issues continued and a 'traitorous eight' left in 1957 to start Fairchild Semiconductor, whose first headquarters are only a few miles away from here on San Antonio Road, and they scored lucrative contracts with NASA for Apollo. Government procurement drove down the price of chips for everyone. Fairchild intentionally leverages their government sales to scale up production, they relentlessly improved and innovated on production techniques while other manufacturers, Texas Instruments, Westinghouse and RCA got involved. Relentless competition on price and performance isn't a new thing in the computer business, and with integrated circuits prices really began to tumble, performance improved exponentially and the result is shown in the red line of the graph behind me. Gordon Moore famously observed in 1965 that the number of transistors in the same space was doubling every eighteen months and there was no end in sight. And that observation, famously, if inaccurately, became "Moore's Law", not a legal law, more like gravity, a compelling, unrelenting force that acted on everyone all the time.

This is best illustrated by the flip flop display behind you. A flip flop is the term for a computer circuit that can store one bit, a 0 or a 1. <Walk through the different orange rectangles to the orange dot and 30M flip flops>.

This section behind you has much more detail on the original inventors of the integrated circuit and the stories of the people who ran with that invention and who made Moore's observation real. I mentioned how folks left Shockley Semi to go work at Fairchild, that continued, people left Fairchild and started other companies,like Gordon Moore and Noyce leaving to start Intel, initially to make memory chips, their first chip was twice as fast as the competition but then pivoting to make microprocessors after signing a contract with a Japanese calculator company, Busicom. They wanted a calculator chip, Intel gave them a general purpose 4 bit microprocessor chip, 4004 in 1971, that they then programmed to act as a calculator chip. Just as we saw with Dec, Intel ran with this idea of making general purpose chips that then got programmed to do stuff vs. building a specific chip for a specific use case. And since Schockly returned home here, many of these companies were located near here, and this is why the area is called

Silicon Valley though the factories or fabs are long gone, many of the companies or their descendants/spin offs remain.

1951 Bell Labs Transistor
1955 Shockley Semiconductor founded, first mass produced transistor released S-101
1956 Schockly Bardeen and Brattain win Nobel Prize
1957 Traitorous Eight, including Noyce and Gordon Moore, leave and start Fairchild Semiconductor
1968 Intel founded by Moore, Noyce and Andy Grove.
1969 Intel's first memory chip, 3101, released, twice as fast as the competition
1971 Intel releases the first commercially available microprocessor, 4004.
1972 Intel releases first 8 bit CPU chip, 8008.

PC Display

Transition to PC Display

When is plagiarism, that is copying or stealing another's work, actually innovation? And if you make millions does it matter?

Discussion at PC Display (5 minutes):

By the seventies integrated circuits are reliable, cheap, and getting ever more sophisticated meaning a single one of those black rectangles could do more and more, even be a functioning 8-bit, later 16-bit CPU, so a single chip that is an entire computer, though one with limited memory and no input/output devices. These created a hobbyist market where the curious and inclined could build their own computers in their homes and garages from parts for a few hundred dollars. The wall to your left displays some of these computers. While of great interest to the curious, these early micro computers lacked utility, they were hard to use, hard to create, unreliable, and very hard to program.

Note the magazine cover promoting the Altair 8800, "minicomputer", since microcomputers weren't a thing at that point in 1975. That's an Altair below, if you wanted to put a program in you used the switches, if you wanted output you read that row of lights above the switches. You could buy add-ons, the profit was actually in the add-ons, that unit was sold at about cost, BASIC for the Altair could cost you $500 if you didn't buy additional hardware and you needed to, the base model memory was just about useless. So you could buy a computer for less than $500, but you just couldn't do very much with one at that price point. This wall is filled with similar trail blazers in their time, but with various limitations, but there is one special one.

That first computer on the extreme left, the single green board one, is an Apple I, the same Apple, a company whose products are considered the height of fashion and utility, started with a couple of hundred hand made, literally in a bedroom and a garage, Apple 1 computers. The designer, the engineer who made it work was Steve Wozniack, another icon of the computer engineering pantheon of gods, but made with the help of, and influence of the later much more famous Steve Jobs. Jobs understood that computers for the home could be big, but they had to be simple enough to use, and this wall of stuff simply wasn't. While only a board, the Apple I was never sold as a kit, and most were sold through a local retail computer store, The Byte Store. You could plug in any TV, any keyboard and connect a cassette player on which you'd play a cassette tape that had Apple Basic. Once loaded you could write your own BASIC programs.

But Jobs was just getting started, he wanted to build a computer that ordinary people could use, and with the modest success of the Apple I he got funding and he could hire some professional crew and an ad agency, Regis, while Wozniack built the Apple II. First released in 1977, this came in a big cardboard box, you took it out, put a TV or monitor on top and plugged it in. Now BASIC was embedded and you could start programming right away. In 1978 Visicalc, the first spreadsheet, was released, and now you have the ability to do multiple things with your Apple II, budgeting, inventory, accounting, without needing to

program. In 1980 a New York retailer mentioned people started coming into the store and asking for the 'Visicalc machine'. Eventually Apple will sell over a million of these.
Apple had competition, the Commodore PET, the Tandy TRS-80 are all also released in 1977 and they were often half the price of the Apple II. But the Apple II was the long term breakout success, Apple were happy to let anyone develop and sell programs on their computer and they didn't demand a slice of the action in stark contrast to the TRS-80 beside me. The Apple was also more extensible, there are eight expansion slots under that cover, which just pops off, no tools required. And they followed up in 1978 with the Apple Disk II, $500 got you 113 kbytes of storage, and you could expand the memory, 48k memory configuration quickly became popular as that could manage VisiCalc and most other computers easily.

IBM, fearful of missing out on another computer market worth billions, did an un-IBM thing and let a skunk works project in Boca Raton, FL, design and build a 'Personal Computer' in about a year, releasing the IBM PC in 1981. This was the first IBM product you buy in stores, an IBM product that documented everything, absolutely everything, openly in the manuals. It wasn't particularly bleeding edge technology wise, they went with an older Intel 16 bit chip, that was still much more powerful than the Apple II, with 80 character displays, in color if you wanted, and could run a large suite of software products on release day, including Visicalc, though that was rapidly replaced by Lotus 1-2-3.

Both these computers were huge successes upon release, both focused heavily on individuals, but IBM being IBM sold a lot to big business where they could support the individual and act as a terminal to Big Blue. Neither have a mouse, both used arcane command lines, and they were arguably still too hard for many people to use effectively.

But Jobs had heard rumors of interesting things happening a few miles away at Xerox's Palo Alto Research Center, there they had build a computer they called the Xerox Alto, there's one back in the last gallery to the right, and that computer was built from scratch to be a personal computer that augmented the skills of the knowledge or office worker. Now the Alto is the same size at that PDP-8 we saw earlier, it had to go under your desk, it's the size of a two drawer filing cabinet but it had a mouse, and it had a WYSIWYG text editor that supported seven fonts, and that came with Ethernet so you could connect it up to another Xerox invention, the laser printer, all in 1975, so years before our IBM PC here, and you could print genuinely book quality text and graphics. Xerox decided not to get into the personal computer business for a bunch of reasons but when Jobs saw what they'd done, drag and drop, cut and paste, multiple applications in different windows, he knew, and openly admitted he'd seen "the next big thing", computers so easy to use, anyone could use them, no more arcane command line nonsense.

Jobs went back to Apple, and he pushed out the Lisa, his first, unsuccessful iteration of the Alto. At $13,000 in a marketplace used to paying one tenth of that, there were few takers. Not known for quitting once he had an idea in 1984 he released the Apple Macintosh, with a single button mouse, drag and drop, cut and paste, WYSIWYG editing with multiple, extensible, fonts, and the option to connect to a laser printer, a mere 9 years after Xerox managed all that. But he had to leave a lot out to get the price down to $2000, there's no ethernet, but equally he left enough in to have Apple's next hit.

While released afterwards, 1985, but developed concurrently, Microsoft released their iteration, Windows and due to Apple's mismanagement, IBM PC Compatibles and Windows have dominated personal computing ever since. Today it's still around 75% vs Apples 25%. But are they still dominant? Do we

really care that much anymore since the internet and the cloud and web browser? Microsoft and Apple have both pivoted to the cloud meaningfully in terms of making money even if Azure and the Apple Family Plan and iCloud aren't headline grabbers, they sure are hoovering money out of our pockets.

SUMMARY:
1975: Altair 8800 makes front cover of Popular Electronics, Microsoft founded, BASIC for Altair ships
1976: Woz and Jobs creates the Apple I
1977: Apple II, Commodore Pet and Tandy TRS-80 launch the consumer computer revolution
1978: Visicalc invented, Disk II released
1980: Apple III released
1981: IBM Personal Computer released
1983: Apple Lisa released
1984: Apple Macintosh released
1997: Jobs returns to Apple
1998: Apple iMac released
2007: iPhone released

Conclusion

Wrap Up (3 minutes)

And this brings us to the end of our tour, along the way we've met Hollerith, Mauchley, Margaret Hamilton, Gordon Moore, and the two Apple Steves. But I've skipped out on many others. Not because I think these other people are less important, in fact we skipped some of my favorite people, but because I wanted to show you some key transitions in the history of computing. I've intentionally tried to minimize the technical details, but if you are interested please walk back through the exhibit, there's lots and lots of details in each of the displays.

There's another exhibit, 'Make Software' over on the far side of the lobby desk for you to explore and there's more on the internet, mobile computing and gaming in the sections behind me.

I've consistently referred to the computers in our museum as tools, not to trivialize them but to emphasize their real purpose, solving problems. And we've seen the shift from computers as tools for corporations to computers as tools of our personal creativity. Along the way I've hopefully revealed a little about how simple the building blocks of computers are, but like Lego, these building blocks can be put together in very different ways to create tools that solve very different problems.

This museum is a resource for you to learn more, not just here on the floor of Revolutions, but online you'll find content and details on everything here in the museum, as well as lots of recordings where you can hear the stories directly from the people involved. Please check it out. You'll find the museum on all your favorite social media feeds, just look for 'Computer History Museum'.

Along the tour we've seen many successes, but we also looked at some failures, or successes that became failures, everyone involved learning important things, things worth knowing if you want to be one of those successes and avoid the failures. That wall of micro computers built by companies you've never heard off, except for two, Apple and Microsoft. Why did they survive and grow? What made them different? What lessons are there along that wall that we might apply today when we're thinking about what to create next? What company to work for next?

I'll stay here and I'll be happy to answer any additional questions you might have, but please go back through the gallery and delve deeper into the topics of interest to you and come back again, this is a large collection, there's a lot to see. Memberships are available at the front desk or on our website.