Wagner Road Capital Management

A Timelapse of the Tech Sector

Updated on August 4, 2021[1]

Contents

[1] This version has been updated with more sources and source links, more recent data, minor corrections, and more ongoing trends.

Introduction

There are many “snapshots” in time. They usually happen in the moment, looking at where things are right now and speculating about where things are going. What I’m doing here is a series of snapshots intended to make a long-term timelapse. This is the way that I look at markets. It goes back farther than most research analysts would consider necessary, but I find it helpful to examine the strategies and conditions that made businesses successful in the past. It’s also a useful reminder to calm down and look at the long term.

“Tech” is a broad business category, similar to the way that sci-fi is a modifying description for movies. There can be sci-fi dramas and sci-fi comedy films, but not just sci-fi alone. The sci-fi is meaningless without the story. Tech is the same type of descriptor. Within tech, there is manufacturing, consumer goods, consumer services, and others. But there is still a tech flavor, a reliance on silicon, which forms the backbone for the entire sector (as it traditionally existed).

This discussion is a brief review of how the tech sector has changed over time, with a light touch on the major advancements, in both technology and business, which facilitated these changes. We tend to think of tech as today’s hottest developments, but these developments are built on a long period of incremental changes, pushed by a few major advancements. Today’s old news is yesterday’s high tech, but today’s high tech would not be possible without yesterday’s research. Looking to the future requires an understanding of the past.

It’s not possible (or necessary) to detail every computing innovation from the last 100 years in a short report. Entire books have been written about the smallest of changes. But the evolution of the tech sector is a fascinating warning for anyone betting on the next major opportunity. The first mover in the market is not always the winner, and the largest company is not always the most successful. Even the best innovators can be burned by new technology.

Much of the story about the technology is oversimplified and condensed, but that’s because this is not a tech story. This is a business story. And we’re not talking about stock prices. The purpose here is to take a high-level look at the business history of the tech sector in the broadest and most shallow way possible. What it reveals is a pattern that may be useful for future long-term predictions. It can also translate into a general understanding of how markets can become fragmented with every new innovation, mature over time, and consolidate into a small number of major winners.

To keep consistent themes in digestible pieces, I’m splitting this one into multiple parts.

Part 1: Before the Internet (Technology as a Physical Space)

Before the Internet, changes in technology were primarily physical. As time passed, computing devices became smaller, cheaper, and easier to use. A summary of the different computer categories describes this change: from mainframe, to minicomputer, to microcomputer (personal computer), to "pocket computer" (and mobile phone).[2] The company that forced the move to the next market was almost always a startup, but the previous market leaders were not always left behind. Their influence on the research for these new markets helped to set the standard.

It starts with IBM.

The Mainframe Era (1950s to 1980s)

From the early 1900s to the early 1990s, IBM was the premier tech company.[3] It started with paper punch card technology, developed all the way back in the 1880s, which remained the standard for almost 100 years, when magnetic tape finally made it fully obsolete. But these punch card systems were not computers, and they could never become real computers. It was only a preview for something better.

Research supported by the US government through WWII led to the development of the "mainframe" computer. Mainframes were the iconic massive computers that filled an entire room. They still used punch cards to submit programs, but the processing was now done by vacuum tubes. These were later replaced by faster machines that used transistors. During this time, computers were mostly used by trained specialists, and even the programmers would never see the actual machine. It was expensive and slow, but much better than what could be done before.

Only a small number of very large companies could build mainframes, and the research needed to produce them was supported by contracts with the government, primarily for the military. IBM did not build the first mainframe, but it dominated this market as it had dominated the market for punch card systems. Through the 1960s and 1970s, the company held a 70% market share.[4] IBM was unique in its ability to secure government contracts for massive research and development projects, and it was one of the few companies large enough to commit resources into building the type of systems the government needed (other major customers included railroads and insurance businesses).

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[2] The technical changes and challenges that came with new computing standards are well-documented in two great books by Paul Ceruzzi. *A History of Modern Computing* covers them in detail, while *Computing* offers a much shorter summary of these major innovations.
[3] A good description of IBM's early years can be found in the biography of Thomas J. Watson Sr., covered in one chapter of the book, *The Giants of Enterprise*, by Richard Tedlow.
[4] From CNET.

IBM was so influential that it became the target of an antitrust lawsuit that started in 1969 and lasted through the 1970s into the early 1980s. The charge against IBM was that it was using its dominant position in the market for computer hardware (the mainframes) to force customers to buy its computer software (the programs that ran on the mainframes). IBM eventually won the case, but it revealed an industry of layers:

- At the bottom layer is the physical computer hardware. In the mainframe era, these were the mainframes. IBM had control of this market with a 70% market share.
- The top layer is the software programs that make the computer useful. In the mainframe era, this layer could be directed by the companies that made the computers. Controlling the hardware platform allowed IBM to set the standards for the software that ran on its systems.

Other companies with fewer resources did not have the ability to compete with IBM's mainframes, so they didn't try. Instead, they focused on a newer, smaller type of computer: a minicomputer. A startup company called Digital Equipment Corporation (DEC)—a name that intentionally avoided including the word "computer" to stay away from IBM—began developing and selling minicomputers.

The new, smaller computers (still the size of a refrigerator) were introduced at a time when computer terminals became more common. A larger computer could take care of processing while end users interacted with a terminal that behaved a lot like today's personal computers. The main difference was that the large computer did the work and the small one just asked it for the answers. It was on one of these terminals where Bill Gates famously learned how to code.

Connections between these large computers also gradually introduced the concept of the Internet, an idea that had been considered impossible before it was demonstrated and proven in 1969. Computers were becoming better at using the same systems, but they were still vastly different for each generation.

From Mainframe, to Mini, to Micro (1970s)

It was the introduction of the integrated circuit that allowed computers to continue to become smaller and more powerful. Using silicon, engineers could print transistors right on to the circuit board. This was the beginning of Moore's Law, which says that the number of transistors on an integrated circuit will double about every two years. This is also when the tech sector slowly began to burst into thousands of pieces. Another layer became the focus of the industry.

- The bottom layer of computer hardware is the components that go inside a computer. These are the integrated circuits.

- The top layer of computer hardware is the entire physical computers. These were the mainframes and minicomputers produced by IBM and DEC.
- Above the hardware are the software programs that make the computer useful.

Texas Instruments, Motorola, and Fairchild Semiconductor were the leaders in integrated circuits, supplying the internal components for both mainframes and the new minicomputers. As a signal of the region's burgeoning startup culture, the engineering talent within Fairchild Semiconductor drained into Silicon Valley in the form of many new startups. One, Intel, was formed by Gordon Moore (known for Moore's Law), and Robert Noyce (the inventor of the integrated circuit) in 1968.[5] The next year, AMD, which became Intel's primary competitor, was also founded by a group of colleagues that defected from Fairchild Semiconductor.[6]

Intel developed a new memory chip that quickly replaced a major computer component with a much smaller version. Then, with Japanese firms eating up the memory business, Intel shifted to something new. In 1973, the company revealed a new component called a microprocessor. It was essentially an entire computer within one tiny silicon chip.

In hindsight, the microprocessor made personal computers virtually inevitable. With a microprocessor, a minicomputer could become dramatically cheaper, and a computer the size of a modern desktop could be made useful. It was a microcomputer that could become a "personal computer." It may not have been as powerful, but it was cheaper and smaller, and opened up the market for amateur programmers.

These more complex computers required more complex programs to make them run properly. The most important program is called the operating system. An operating system links the individual programs to the computer's hardware, and a modern computer cannot function without one. This is the last layer we need to get the full picture.

- The bottom layer of computer hardware is the components that go inside a computer. The most important are the microprocessors made by Intel and AMD.
- The top layer of computer hardware is the entire physical computers. These were the mainframes and minicomputers produced by IBM and DEC, but now they also included the microcomputer, also known as the personal computer.

[5] Robert Noyce is also profiled in *Giants of Enterprise*.
[6] Fairchild Semiconductor, ironically, was also formed by a group of defectors. They came from a company called Shockley Semiconductor. Gordon Moore and Robert Noyce were also among the "traitorous eight" that left Shockley Semiconductor in 1957 to form Fairchild Semiconductor. Silicon Valley startup culture has never been big on loyalty.

- The bottom layer of computer software (on top of the physical hardware layers) is the operating system that links the physical computer with computer programs.
- The top layer of computer software is the programs that make the computer useful.

Up to this point, the companies building the computers were also generating almost all of the software to make the hardware useful, including the operating systems. Now they were starting to build computers and allow others to do the programming. The more programmers making useful programs for a computer, the more people would buy it.

The Personal Computer Revolution (1970s to 1990s)

The Altair, developed by a mostly-forgotten company named MITS, was the personal computer that broke open the market. It was released in 1975 and sold to "hobbyists" (a.k.a. nerds) by the thousands. But it did not have an operating system. This is where Bill Gates arrived on the scene: with the help of Paul Allen, he founded Microsoft in 1975 and wrote an operating system for the Altair that made it easier for other people to use the computer.[7] Major computer companies of the time saw it as a toy.[8]

Meanwhile, Steve Jobs and Steve Wozniak, the Apple co-founders, began producing their own Apple II computers in 1977.[9] These were designed to be useful to a wider range of people, and quickly became a best-seller after the first reliable spreadsheet program was introduced in 1979. Personal computers found their way into business use.

Apple was quickly overtaken by Commodore, a company that had switched from typewriters and calculators to personal computers. And, for a few years, it looked like the company would overwhelm the market with its affordable computers. Commodore produced a series of famously powerful computers that were also extremely cheap. In 1983, Commodore had about 50% market share in personal computers.

Dozens of other companies began selling their own personal computers, each with a different hardware design, and each with a different set of software. Many of them were vertically integrated, making both the software and the hardware, and they tightly controlled every part of their computer's production. This includes companies that

[7] A good resource on Microsoft's early years is the book *Hard Drive*, a biography about Bill Gates by James Wallace & Jim Erickson. It ends abruptly in 1992, so it does not include some of the more intriguing events that come later, but it's a fascinating profile of (at the time) the world's most eligible bachelor.
[8] Jeremy Reimer's 10-part report for Ars Technica includes a much more detailed summary of how the personal computer market developed. This is the source for most of my personal computer market share data.
[9] *Steve Jobs* by Walter Isaacson provides the definitive story on Apple's rise.

almost no one remembers, such as Wang Laboratories, and names that would seem out of place today, such as Texas Instruments, Xerox, Radio Shack, and Atari. There were also countless tiny computer companies founded by the hobbyists of the 1970s.

All of them were wiped out by IBM's decision to build a personal computer.

In the personal computer market, IBM did something that no other computer company was doing. IBM, realizing that it was late to the party, desperately outsourced almost all of the components for its personal computer. Instead of using its traditional vertically integrated approach, it built the first IBM personal computer almost entirely out of parts that it could buy off the shelf. Microsoft's PC-DOS was licensed to be the operating system for IBM's first PC, with the condition that Microsoft could license its operating systems to other computer manufacturers. (The decision to go with Microsoft, rather than an IBM operating system, may have been influenced by the anti-trust suit against IBM's mainframe business.) An Intel microprocessor was chosen to power the computer.

The outsourcing made an IBM PC cheaper and faster to produce, but it also made the design easy to reverse-engineer for compatible copies. The IBM PC was introduced in 1981. By 1983, the first IBM PC "clone" was already on sale.

Compaq, a company founded by a team of defectors from Texas Instruments, created the first legal IBM PC clone. It was not a direct competitor to the IBM PC. Like DEC in the Mainframe Era (which by now had become a giant of the minicomputer market), Compaq was a startup that chose to sidestep IBM's main influence. The first Compaq PC-compatible computer was much smaller, and it was designed to be carried. At 30 pounds, it was not like a modern laptop, but it was a significant improvement over IBM's desktop models.[10] Compaq's $111 million in sales set a record for the best first year of any American company ever.

Other PC clones quickly followed, including Dell and HP, and almost all of them used the same components as IBM. By 1990, the IBM PC and PC clones had a market share of about 84% in the PC market. The layers of the industry adopted their standards.

- At the bottom layer of computer hardware for personal computers, Intel had about 80% market share for processors in 1990. This rose to about 85% by the year 2000. AMD filled in the rest.
- The top layer of computer hardware for personal computers was dominated by the PC standard. It went from about 84% market share in 1990 to more than 97% by 2000. Apple filled in the rest.

[10] Other companies developed portable computers before Compaq, but Compaq was the first to successfully copy the IBM standards.

- At the bottom layer of computer software, Microsoft matched the PC growth. In 1990, it had an 80% market share for operating systems. By 2000, this had grown to more than 97%.[11]
- The top layer of computer software transformed in ways that are not part of this story. The short version is that Microsoft, with its Microsoft Office products, also came to be a significant player in this part of the industry.

There was a difference between PC market share and IBM's contribution to personal computers. The competing standards for computer hardware were resolved by IBM's decision to enter the PC market. But IBM did not lead the market. Computers became generic boxes that all used Microsoft's operating system (first DOS, then Windows). Microsoft became the platform that linked computer companies with computer users.

In response, the industry consolidated. In 1998, DEC was swallowed by Compaq. Compaq, which found itself in financial trouble, was finally sold to HP in 2002. In 2005, IBM sold its PC division to Lenovo, a Chinese company. Meanwhile, Dell, with a low-cost, direct-to-consumer sales model, steadily rose to the top of the PC market. Today, those three companies, Lenovo, HP, and Dell, make up more than 60% of the PC market (Lenovo, as IBM's legacy, is the largest), with Apple in a distant 4th place, at about 7%. Apple remains the only vertically integrated personal computer manufacturer.

End of Part 1

As the story continues, the same themes will begin to repeat, and the markets of today look very similar in many ways. The layers of the industry still exist, and their interaction over several years is an important piece of evaluating individual investments. It's also useful because these layers show up in every industry. Wal-Mart does not make everything that it sells.

Part 1 really is the story of IBM. Competing with IBM was most effective by avoiding IBM. IBM was examined by antitrust authorities in the same way that many tech companies are now being threatened. IBM had real market power. It chose the standards that all personal computers (other than Apple) still use today. But, after the Internet, the market moved on. That's Part 2.

The PC revolution could have easily become an Apple standard or a Commodore standard instead of an IBM standard. And it took a decade (the 80s) for the IBM standard to be confirmed—a long time to avoid an investment in a new industry with lots of potential. But after that standard was set, the next decade (the 90s) was pretty good too. Not many people who invested in the 90s felt bad about missing the 80s.

[11] Basically all IBM clones used Microsoft's operating system.

Part 2: After the Internet (Technology as a Cyber Space)

After the Internet, changes in technology were primarily digital. While computers kept getting smaller, the main focus became how these computers connect with each other. Technology became more connected, more mobile, and more interactive. The physical components of a computer still had a place in the market, but they were overshadowed by the exponential growth in data. The most valuable technology was used for collecting data, analyzing data, and using data.

The emergence of technology "platforms" defines this new world. At the end of the PC revolution, the IBM PC and its PC clones were the standard for computer hardware, but it was the Microsoft operating systems that became the platform for this standard. Almost every company that made computer programs had to work with Microsoft Windows.

Microsoft was the new IBM.

The Dot-Com Boom (1990s)

In the mid-1990s, when Bill Gates was asked about the biggest threat to Microsoft, he had no doubt. It was the Internet. Microsoft's operating system risked becoming the same type of generic box that had fractured the PC market. Microsoft owned the market for computer operating systems, but a new layer was forming. The Internet had a different set of standards than individual computers. Inside the Internet, a computer could use programs that run through a web browser. Just like the operating system is the link between a computer's hardware and the computer's programs, the web browser is the link between the computer and the Internet. The layers of this market, in a very simplified form, were adjusted for the Internet.[12]

- At the bottom layer of Internet software, Microsoft controlled the market for operating systems.
- The middle layer of Internet software is the web browsers that linked computers to the Internet.
- The top layer of Internet software includes websites and Internet services.

If everything happens online, then the operating system is only useful for making the connection possible. Computer programs would be designed for the web browser, not for the operating system. The type of operating system would no longer have any special value. Internet connection speeds would limit which programs could be used online, but as Internet speeds continued to get faster, maybe Microsoft's operating

[12] There are many other layers involved with Internet connections, but the market for web browsers provides the most instructive story.

system wouldn't be needed at all. Maybe the web browser would completely replace the operating system. It was a real and serious threat.

Netscape Communications' 1995 IPO marked the start of the Dot-Com Boom. When the Internet was opened to consumers in the early 1990s, Netscape Navigator came with it, and it was the first web browser to gain universal acceptance. By 1996, Netscape Navigator had about 80% market share for web browsers.[13] Netscape quickly began developing tools that would displace Microsoft's position in the operating system market.

In response, Microsoft launched its own web browser. The company named it Internet Explorer and packaged it with every copy of the Windows operating system—for free. Internet Explorer was embedded inside Windows and placed in a location that was slightly easier to access than Netscape Navigator. Microsoft also offered favors to other companies that encouraged the use of Internet Explorer.

This caught the attention of market regulators.

In 1998, Microsoft was accused of abusing its operating system monopoly. Just like the mainframe era, where IBM was investigated for using its control of computer hardware to influence computer software, Microsoft was investigated for using its control of the operating system market to influence the web browser market. [14]

Although Microsoft officially lost the case, the final penalty was insignificant, and Microsoft had already won the browser wars. By the late 1990s, Microsoft had achieved more than 90% market share in operating systems (Windows), office software (Excel and Word), and Internet browsers (Internet Explorer). By 2004, Microsoft had a 95% market share in web browsers. Its position was secured.

Meanwhile, the insides of the Internet were following a familiar pattern: thousands of websites came online offering new ways to use the web. All of them promised to change the world. Almost all of them were too ambitious.

The mania surrounding investments during this time period has been well-covered. Our focus here is on the evolution of the technology business. There are many potential markets to explore, but there is only one market that broadly covers the entire Internet: organizing, presenting, and finding the most useful websites. In other words, web portals and search engines.

[13] From The Motley Fool.
[14] CNET has a good summary of the case against Microsoft and how it compares to IBM's antitrust lawsuit. John Borland's article for ZDNet also summarized the browser wars.

In the mid-1990s, there were two primary ways to search through the Internet. One was through what is called a "web portal," a website full of links to other websites that is collected and curated by hand. The other is called a "web crawler," an automated system that attempts to catalogue the entire Internet and sort websites based on relevance.

The first popular web portal was made by AOL in the early 90s. It was the way that AOL customers saw the Internet. The first powerful web crawler, Alta Vista, came out in 1995. It was made by DEC (remember them?), and was only intended to be a way for DEC to show off its powerful computer hardware. It was not aggressively marketed or supported. Yahoo's web portal (as yahoo.com) also came online in 1995.

Market share data for these websites from the 90s is hard to find, but the rankings of the most-visited websites show AOL as the top web portal, with Yahoo a close second, from 1997 through 2000 (Yahoo was widely regarded as the king of web portals). Alta Vista was the king of the web crawlers (now called search engines), throughout the 90s, with close to 20% market share in search by the year 2000. Yahoo's market share for search engines was roughly 35%, but its search engine was also powered by Alta Vista, making Alta Vista's total US market share an incredible 55%. The Microsoft Network (MSN), Microsoft's own attempt at a web portal and search engine, was around 15%. Others, such as WebCrawler, Ask Jeeves, Lycos, and Excite, made up the rest of the market.

And then there was Google.[15]

Google did something different. Officially founded in 1998 by Larry Page and Sergey Brin, two Stanford-trained computer scientists, Google's search engine used a better method and a more Internet-friendly business model. For search, instead of ranking webpages by the number of words that match the search, Google ranked webpages based on how many other webpages were linked to it. For its business model, at a time when every other search engine was attached to a bloated web portal, Google chose to keep it simple. Google did search. It did not do anything else.

The web portal and search engine combinations dismissed Google's entry to the market, because their goal was to keep Internet users on their own websites for as long as possible, while Google's goal was to send users to the most relevant website as fast as possible.[16]

[15] A short history of Google can be found on searchenginehistory.com.
[16] Web portals and search engines both made money by selling advertising space on their pages. The value of that advertising space was roughly determined by how many people visit the page and how many people click on the advertisements. The primary advantage in business strategy is that Google was

Google easily swept through the market. Alta Vista, the only real competitor, was never adequately supported. It went through several owners before it was eventually sold to Yahoo and shut down for good.[17] Yahoo then sold itself to Verizon. AOL merged with Time Warner, collapsed, went independent, and then it, too, was sold to Verizon. Microsoft rebranded its search engine as Bing, but it was never a leader in this market. Google is now, by far, the most popular search engine in the world, with a 92% market share. Its US market share first passed 50% in 2004.

As an endnote to Microsoft's struggle with the world after the Dot-Com Boom, Microsoft did eventually lose the web browser wars—to Google. Google introduced the Chrome web browser, a simple, lightweight, and easy to use product, in 2008. It achieved a 50% market share in 2015, and sits at about 65% worldwide market share today.[18] As Bill Gates once feared, there are now computers that can run entirely through web browsers. But they do not seem to threaten Microsoft's position in the market for operating systems.

Web 2.0 (2000s to Now)

Web 2.0 is a term that refers to websites that rely on user-generated content. It was the next logical step in the evolution of the Internet. Instead of just looking at websites, individual people could also add their own content. This means home pages, blogs, and videos.

In 1998 and 1999, the top two most visited websites were AOL and Yahoo. The third was GeoCities. GeoCities was a web hosting service that allowed anyone to have their own home page. It was a crude way for individual people to mark their place on the Internet. There was not much interaction between users, but it relied on user-generated content to sustain its popularity—a preview to the next generation of the Internet.

In 1999, GeoCities was purchased by Yahoo. But it was shut down in 2009, shortly after social networking became the new standard for web 2.0. Internet users did not just want to mark their place on the Internet. They also wanted to interact with each other. Message boards and chat rooms had been around for years as a feature of web portals such as AOL and Yahoo, and they had even existed since 1980 as a service called Usenet, but they were not the same thing as interactive home pages. Social networking combined home pages with interaction between users.

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better at showing people the advertisements that they wanted to see, just like it was better at showing people the websites that they wanted to find.

[17] A sad summary of AltaVista's potential is covered by Claire Broadley at Digital.com.

[18] A previous version incorrectly stated higher market share numbers. This has version has been corrected with more accurate data.

A few small failures appeared in the late 90s, but it was the early 2000s that exploded with new social networking platforms (now called social media). Friendster and LinkedIn were founded in 2002. MySpace appeared in 2003. Facebook in 2004. Twitter, 2006.[19] They came with dozens of now-forgotten social networking sites. Each individual social media service was designed for a different type of audience:

- Friendster and MySpace for the average teenager.
- LinkedIn for professional networking.
- Facebook for college students.
- Twitter was intended to be a simple text messaging service.

The market share numbers for social media platforms are misleading because each platform serves a different function and many people use multiple platforms. But the number of users represents a good proxy for market share in the age of social media. Friendster peaked at over 100 million users, but it was nearly abandoned by 2004, only two years after its beginning. The website was easily overtaken by MySpace. Friendster limped along for years, and finally shut down in 2019.

MySpace had a more open and adjustable platform, and its webpages loaded much faster. But its position in the market was just as delicate as Friendster. MySpace was purchased by News Corp in 2005, and became the most-visited website in the world the next year. In 2008, MySpace was surpassed by Facebook, just two years after Facebook opened beyond the college demographic. Then the company was sold two more times: to Time Inc. in 2016 and the Meredith Corporation in 2018. It still exists, but it is also nearly abandoned.

Facebook had a more mature way of presenting information than MySpace did. Every Facebook page looked basically the same, and was laid out in a simple, easy-to-understand way. It did not have the painful custom backgrounds and loud music that came with many MySpace pages. Facebook also introduced a new feature called newsfeed, which allowed users to see what their friends were posting without having to stalk their profiles for new information. The combination of these small changes made for a much better experience.

Facebook is now the third most visited website in the world, and has more than 2.8 billion monthly active users. With such a large number of users, it will be very difficult for any other social media service to compete, because a significant part of the value for Facebook's users is that their friends are already using it.

[19] When these social media companies were founded, their peak sizes, and what happened to them is all summarized in an article by Matthew Jones for the History Cooperative.

LinkedIn and Twitter do not directly compete with Facebook. They have carved out their own small pieces of the social media market: Twitter has just more than 350 million monthly active users, while LinkedIn (which was bought by Microsoft in 2016) has about 310 million. There are younger social media websites that have already reached a similar size: Pinterest, which was founded in 2009, has almost 500 million monthly active users, and Snapchat, which was founded in 2011, is near the 300 million user mark.[20] There are also a few massive social media sites based in Asia. But Facebook is the worldwide leader.

Part of Facebook's influence comes from a relentless urgency to acquire potential competitors. A feature of this new web 2.0 world is that successful startups are bought out by larger companies before they can become a real threat.

- YouTube, by far the world's largest video hosting site (and second most-visited website in the world, behind Google), was founded in 2005. It was bought by Google in 2006.
- Instagram (1 billion monthly active users), was founded in 2010 and purchased by Facebook in 2012.
- WhatsApp (more than 2 billion monthly active users), was founded in 2009. It was also bought by Facebook, in 2014.

The social media market is nearing maturity. Facebook is still looking to buy anything that comes close to competing. Any social media service that refuses to be bought can expect to be copied.[21]

The Smart Phone Era (2000s to Now)

As computers continued to become smaller and more connected, the natural extension of this process was that more computer components found their way into mobile phones.

The first smart phone, a computer within a mobile phone, was actually developed by IBM, all the back in 1992. It had most of the features of a modern smart phone, but it was too far ahead of its time. The communication networks required to support a smart phone market were too slow and underdeveloped.

The precursor to modern smart phones was the Personal Digital Assistant (PDA). PDAs were tiny computers with a few limited functions that allowed access to Internet and

[20] Snapchat's active user count is measured in daily active users.
[21] Facebook's defense of its market is remarkably similar to the ambition that drove Microsoft throughout the 90s. This behavior, like Microsoft's, has attracted the attention of antitrust regulators.

email. They were not phones. The most popular PDA was made by Palm (founded in 1992), which had more than 77% market share by 1999.[22]

In PDAs (and later mobile phones), the market layers are the same as personal computers. Simplified:

- The bottom of the market for PDAs (and smart phones) is the hardware layer. This is physical the device.
- The top of the market for PDAs (and smart phones) is the software layer. This is what makes the device useful. For this part, we are only interested in the operating system.

In 2000, Palm's market share had fallen to 72%. In second was Handspring, a PDA device maker founded in 1998 by defectors from Palm. But Handspring was also using the Palm operating system. This meant that Palm's operating system for PDAs had reached 85% market share. A small portion of the remaining market included some familiar names: HP, Compaq, and Microsoft.

Following the expectations of the patterns from the personal computer revolution, Palm had an enviable position in the market for PDA operating systems. It was almost as powerful as the Microsoft platform, but it could not maintain the standard. By 2001, Palm's market share for PDA operating systems dropped to about 65%. At the end of 2001, it was about 50%, and it continued to fall.[23]

Like the beginning of the personal computer revolution from the previous decades, most of the production was vertically integrated. Each smart phone or PDA (or "pocket pc" depending on who you asked) was a computer that came with an operating system, and the phone operating systems were almost entirely made by the same company that designed the phone.

Research In Motion (RIM) was the first to master a smart phone design. The company had been around since 1984 and made personal pagers through the 90s, but did not make a real phone until 2002.[24] The company called it the BlackBerry. Fans called it the "crackberry" because of its addictive design. At the time, the mobile phone market was already dominated by the Symbian operating system (developed by Nokia, used by Nokia, Motorola, Sony, Panasonic, and Samsung), which had an 80% market share. [25]

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[22] The story of Palm is summarized in a Fast Company article by David Lidsky.
[23] These numbers have slight differences depending on the source, but this version has been updated to reflect the best known numbers. The rapid decline in Palm's market share is consistently reported from 2000 to 2010.
[24] A short history of RIM can be found in an article in The Canadian Encyclopedia by Iris Leung.
[25] The Economist wrote a special report on this market back in 2002, speculating that Nokia would most likely be the winner.

The BlackBerry quickly established RIM as a leader in business phones. Within two years, RIM had captured almost 20% of the PDA market.

By 2005, PDAs were fading, and smart phones were the hot new product. The US market for smart phone operating systems was split evenly between four companies, without any clear leader or standard: Symbian, RIM, Palm, and Microsoft (used by Motorola, Palm, and Samsung).

Then Apple surprised the world.

When Steve Jobs introduced Apple's first smart phone in 2007, he described it as three separate products: "an iPod, a phone, and an internet communicator."[26] It was a convergence of technology that no other company had achieved, wrapped in a consumer-friendly package that no other company had considered. And, in a parallel to Apple's choices during the personal computer revolution, it was fully vertically integrated. Apple designed both the phone and the operating system.

Within a year, Apple's iPhone had reached 10% US market share. In two years, it was up to 20%. By then, Symbian and Palm were almost eliminated. RIM's dominance continued to grow, while Microsoft continued to fall behind.

But smart phone buyers were increasingly focused on smart phone features, which RIM was neglecting. RIM viewed smart phones as a purely *business* device, while everyone else believed that smart phones could be useful beyond business. And that's where the market was growing the most.

Behind this big battle for market share, way under the radar, was Google's smart phone operating system, called Android. It was announced in 2007 and released in 2008. And as part of Android's development, Google also led the way in creating the Open Handset Alliance. This was a group of 34 companies involved with every piece of the smart phone market that all agreed to use the same standards—and they would all use the Android operating system. Google had convinced the market to use Android, much like IBM had chosen Microsoft more than 20 years earlier.[27]

With Android, Google was using the same strategy that worked for Microsoft during the personal computer revolution: focus on the software layer and force the smart phone hardware to become generic boxes. If every smart phone app was designed for Android, then smart phone manufacturers would be forced to use it, or they would lose access to those apps. To make their decision easier, Google licensed it for free. The company's plan was to make money through the advertisements that appear on Google's apps inside the phone.

[26] Apple's iPhone announcement is still available to watch on YouTube.
[27] The Open Handset Alliance now has 84 member companies.

Google's Android was quickly adopted as the standard. It became what Symbian had intended to be. By 2012, it had a 50% global market share. It is now at more than 70%, with Apple taking the rest of the market. After Microsoft gave up on the smart phone market in 2017 (with a 0.1% market share), there is no one else left.

The early leaders in the PDA market were eliminated. Palm sold itself to HP in 2010, and the guts of the company were later split up and sold again. RIM renamed itself BlackBerry. It continues to be an independent company, but no longer has any influence on the smart phone industry. RIM now makes Android phones.

The smart phones, other than Apple's iPhone, have become generic phone boxes with Android on top, just like PCs are generic computer boxes with Microsoft Windows on top. Motorola's mobile business was purchased by Google in 2012, broken apart, and resold to Lenovo in 2014. Nokia's mobile business was purchased by Microsoft in 2014, broken apart, and resold through 2016 and 2017. The comparisons to the PC market are uncomfortably similar.

The competition for what goes inside a smart phone—the bottom layer for smart phone hardware—was just as deep, but not as interesting. The short story is that mobile phones don't have Intel inside. They did, but not for very long. Qualcomm, using processors designed by ARM, replaced Intel's standard (ARM only designs processors; it does not manufacture them). Smart phones required a less powerful processor than a full computer, and their design was focused on using less energy (so the battery would last longer). By 2010, ARM had a market share of 95% for mobile phone processors.

The current market is described as a "System on Chip" (SoC), or an entire computer on one small chip, rather than just a processor with other components connected. MediaTek carries a global SoC market share of 37%, while Qualcomm had 31%, with Apple in third at 16%.[28] Many companies in the SoC market rely on ARM-designed processors. The way that this market is measured has changed over time (it can't be compared to the 2010 number), but ARM's influence is certainly fading. ARM has been the market leader in the "design" market since the category was created, but it has declined over time, with a current market share of about 40%.

Intel and Microsoft both failed to transfer their PC market power to mobile phone market power, and ARM is currently targeting the personal computer market. Because of the growth in the smart phone market, Intel's market share in the entire universe of

[28] All Apple SoC are used in Apple phones.

microprocessors (for computers of all sizes) is already down to less than 20%. The competition in microprocessor technology continues to intensify.[29]

The App Revolution (2010s to Now)

In 2009, less than 1% of all web page visits came through a mobile phone. Less than ten years later, that number was already more than 50%, and it continues to stay around 50%.

The trend is even more pronounced within social media networks. In 2013, Facebook already had 68% of the time spent on the network (for US users) coming through a mobile phone. Twitter was even higher, at 86%. And Instagram had an astonishing 98% of its US usage happening on a mobile phone. I could not find more recent data for these individual services, but an updated review of the social media market provides the big picture: 99% of social media users access social media websites from their phone, and 72% of social media users access social media entirely from their phone. Social media has become mobile media.

Smart phones have eliminated the need to say "brb" (that's "be right back" for anyone who missed the Dot-Com Boom). The phone is always there. At the same time, waiting in line has been replaced by phone entertainment time. Reading the newspaper has become a "reading the phone" activity. Almost anything that can be done online can be done on a phone.

The transformation is still ongoing. The app revolution is near the end of the fluid stages, where thousands of new entries cram into the market, each one promising a market disruption. But the most downloaded phone apps of the 2010s decade include some familiar names:

1. Facebook (owned by Facebook)
2. Facebook Messenger (owned by Facebook)
3. WhatsApp Messenger (also owned by Facebook)
4. Instagram (also owned by Facebook!)
5. Snapchat (independent)
6. Skype (owned by Microsoft)
7. TikTok (owned by ByteDance)
8. UC Browser (owned by Alibaba Group)
9. YouTube (owned by Google)
10. Twitter (independent)

[29] An equally intense battle is happening in the market for graphics processors, which are used for more complex operations that are vital for most of our future themes. But those themes are coming later in the next part.

All of the top four apps of the decade are owned by Facebook. One is owned by Google. And one is owned by Microsoft. Web 2.0 has shifted to mobile phones. Social media has a natural attraction to technology that is more mobile and more connected. It was a movement that makes it even easier to be online.

If we include the apps that come with an Android phone, Google has 12 of the top 15 installed apps (on android), while Facebook claims the other three. There are questions about which apps are used the most often, and which apps might rise up in the future, but it is undeniable that the Android operating system has ensured Google's position in the age of the app.

End of Part 2

Part 2 is more complicated than Part 1. It is not just the story of one firm's influence. The standards for each different market were set by the services that managed to gain the widest adoption. At first, this was determined by which ones were the easiest to learn and the most useful. Google's website was as small as possible. Just type in what you want to find. Apple's iPhone was a milestone in simplicity. Anyone could learn how to use it. Facebook's design was easy to navigate. It gave users the information they wanted without the clutter of endless customization. Google's Chrome browser also followed this theme.

Over time, the services that became dominant were the platforms that had already reached a critical point of acceptance. Google's Android phone operating system replicated the success of Microsoft's Windows by starting as the standard platform. If anyone wanted to replace Android, then they would also have to replace all of the apps that were made for Android—and this is not possible.

The market leaders in one age do not always dominate the next. IBM, Intel, and Microsoft all missed the move to mobile phones (this does not mean they became irrelevant, only that they missed the new market). Even Palm and Nokia were unable to translate their early success into what Apple and Android ultimately became. These positions are very hard to defend or expand, and they can disappear in an instant.

But can these major market changes be predicted? That is the question everyone wants to know.

Part 3: The Future of Tech

The future of tech will be driven primarily by two major themes. Both are a continuation of decades-long trends:

- Faster Internet connection speeds will enable more devices to come online and create a more decentralized network.
- Faster, smarter, more efficient components will continue to make computers more powerful and more interactive.

How these trends affect individual markets is nearly impossible to predict, but most of them follow a familiar pattern. Every new technology goes through series of waves. A summary of this process happens in about four or five stages.

1. A new technology becomes viable, introducing hundreds or thousands of startups trying to capture a piece of the new industry.
2. The businesses with the best combination of technology, attractiveness, and strategy become stronger.
3. The weaker businesses start dropping out of the market.
4. Consolidation begins. Stronger businesses buy out what remains.
5. The market matures. In most cases, this leaves only 3-5 businesses that still have the ability to compete.

Predicting stage one is the hardest. At that stage, the best evaluation comes down to who has the best ideas or the best technology. Picking the right one is not much better than choosing the right lottery number—low chances, but extraordinarily high payout.

From there, it gets less rewarding, but easier to see. When the weaker businesses start to fall behind is probably the optimal time to consider investing—there is much more certainty, but still significant upside. By the time the market matures, the remaining companies often begin to pay out healthy dividends, because they don't have anything else to do with their money—their position is already secured.

We can't say for sure which companies will win their market wars, because the one with the best technology is not always the one with the best business. But we can evaluate where everything stands at the moment, consider the historical context, and try to match it to the future.

Ongoing Trends

When we talk about the future of tech, we're only looking at what is just now starting to gain momentum, and we're not making any bold predictions about what might come next. Most of these big ideas are already old news for the people paying close attention—and the biggest names in tech are already making substantial investments in every one of these areas—but their rise to prominence is only within the past five years. I can't predict which one will become the most important, but this is what I perceive to be the most developed markets (I can't tell you what I'm finding, but I can tell you where

I'm looking). They are all enabled and facilitated by the two major themes mentioned above.

Cloud Computing

Mainframes never completely disappeared. They're still around, and they're still mostly made by IBM. These mainframes serve as a secure backbone for mobile apps that require encryption, such as credit card transactions. But software that doesn't need as much security is moving to the "cloud." The cloud is a network of large computers, called servers, which function like mainframes. What this means is that computer programs no longer need to run on your computer—like the mainframes of the past, a big machine can do all of the work while the smaller ones ask for the answers. This has enabled businesses to begin offering software that can be rented for a monthly fee (called "Software as a Service," or SaaS) instead of software that you can buy and own forever with one payment.

The origin of SaaS applications actually goes all the way back to the 1960s, in the form of "time-sharing" on mainframe computers. As we described in Part 1, when computers became smaller and more powerful, they could do more of the work on their own without the help of a larger computer. SaaS fell to the background until the introduction of the Internet created more opportunities. As network speeds increased and more devices came online, SaaS applications have become pervasive, especially in the past five years.

There are thousands of specialized SaaS companies, covering everything from movies and music to accounting and HR, but the cloud computing background (sometimes called Infrastructure as a Service, or IaaS) is dominated by some familiar names. Amazon jumped into the business before most people knew it existed, and remains, by far, the leader in cloud systems, with a 41% market share. Microsoft is a distant second, with 20% market share. Google is even farther behind, with a 6% market share. Even with no market share changes, the tremendous growth of this market will benefit every major player: The worldwide IaaS cloud computing market grew by 40% in 2020.[30] This segment of the market is already well-established, but still fast-growing.

Despite such fast growth, I consider the IaaS part of cloud computing to be the most developed market among these ongoing trends, because it requires immense investment to break into and is already under control by the firms that have the funds to make these massive investments. But there are many other SaaS opportunities.

[30] IaaS market share numbers and industry growth come from Gartner.

The Internet of Things (IoT)

IoT is self-descriptive. It refers to the ability of *any* object to be computerized and connected to the Internet, a direct result of the computer technology that continues to get smaller. The most well-known advancement in this area includes “wearable devices” such as smart watches and “smart home” devices that respond when you talk to them. But it opens up other possibilities as well, such as self-driving cars and high quality medical monitoring devices.

There is not much to say about IoT. In the market for self-driving cars, Google’s Waymo is the industry leader in an industry that does not yet exist. In the market for “smart speaker” home assistants, Amazon (Alexa) is the current market leader in the US, with an installed base of 53%, while Google (Google Home) has 31%. There are no other significant players in that market. Apple is currently the worldwide leader in smartwatches, controlling about half of the market with no serious competitors.

Any assessment of IoT must consider the companies producing the hardware that goes inside Internet devices (who is making the microchips?). While the big players are competing with each other, they often share the same suppliers. The result may be that investing at the hardware level will achieve better returns than looking at the top, but the financial stability for suppliers is generally more uncertain.

Artificial Intelligence (AI)

AI is an attempt to get computers to be good at things that humans are good at. Computers are already very good at analyzing data, especially large sets of data, but they’re not as good at things that require more intuition, such as medical diagnosis and speaking. AI technology is already starting to replace specific jobs done by accountants and lawyers, and has the potential to start affecting the medical field. It also has a promising potential for enabling self-driving vehicles.

AI is a very competitive technology. Almost every software company is making some type of investment in this space, and this includes the big ones: IBM, Google, and Microsoft are all boasting about their AI capabilities. There is very little opportunity for direct investment in this field. It is generally a small piece among many other projects, but companies focused on specific AI applications are worthy of investigation.

Blockchain

For the past ten years, blockchain has been one of the most popular topics among tech enthusiasts. It only became a mainstream phenomenon within the past five years, when investment became easy and financial publications began tracking the price of cryptocurrencies in real time.

The basic idea behind blockchain is called a distributed ledger. The ledger part means exactly what it sounds like—a record of transactions. A distributed ledger is one that keeps a record of transactions in many different places simultaneously (instead of a centralized ledger, like a bank's records). I won't get into the details of how this works. The most important thing to be aware of is that blockchain can do some things well (tracking transactions), and other things not as well (it's slower than centralized ledgers).

There are thousands of cryptocurrencies in the market, each one claiming to solve a different problem, all of them promising to change the world. Most of them cannot do what they claim, and almost all of them will fail. The easy money in this market has already been made—cryptocoins are treated like commodities, and the early traders have already captured most of the big moves.

The future of blockchain is not investing in cryptocurrencies. Like the promise of the Internet, the most valuable part of the blockchain technology will come from how non-tech businesses use the technology. For example, major companies are currently exploring how to use blockchain to track and manage their products. It's not a disruptive threat. It's a business tool.

Quantum Computing

Moore's Law has reached its ceiling. The laws of physics prevent microchips from packing in any more transistors. The next step in the process could be a quantum leap. Just like the switch from vacuum tubes to transistors, and transistors to microchips, the introduction of quantum computing has the potential to replace the previous generation. But right now it's just potential. The cost of producing these systems, the complexity of their operation, and the physical size of their hardware, are all reminders of the mainframe era.

Quantum Computing is a significant area of interest for IBM, Google, Microsoft, and Intel, but Google is currently producing the most powerful quantum computers that are not created by a government entity.

5G

Internet speeds and connections have become more complex and more widely used. This is where 5G comes in, as the next revolution in the process. Mobile phone networks currently use primarily 4G technologies, and 5G is more than 10 times faster, fast enough to rival the speed of home Internet connections. The buildout of this new 5G network is certainly a major investment opportunity, but what it enables (more data transmission) will have an even larger impact. It makes cloud computing more valuable and it makes IoT and AI more capable.

Excellent 5G investments can come from many sources. A few of them to consider could be network security companies, network infrastructure testing and building, device hardware and security, or any of the technologies that are enabled by 5G.

Virtual Reality (VR) and Cybernetics

Computing devices have become easier to use over time as the interaction between the device and the user becomes more intuitive. VR is just an extension of this long-term trend. Right now, VR is limited to creating a more immersive entertainment or educational experience than TV screens. The most common use comes in the form of video games. Whether this technology will become widely adopted is still unclear. It is too early to tell.

Cybernetics is an even bigger extension of this trend. Instead of having a virtual reality device that you wear on your face, cybernetic technologies introduce the idea of creating an entirely new robotic eye (or arm, or leg, or anything). This is when the device becomes part of the person, and this is where technology is going. But it will be a few years before we get there, and "bio" tech is outside the scope of this overview.

Conclusions

Anyone who follows the technology sector knows that I left out some very important features. It's not possible to cover everything, but it's also important to be aware of what I missed.

The rise of the Asian giants is the biggest hole in the story. From Part 2, if we review the top 10 most downloaded apps of the 2010 decade, two of them, TikTok and UC Browser, are owned by Chinese companies. In 2020, the most downloaded app in the world, TikTok, came from China. And while Chinese-owned apps are unlikely to be direct competitors to Western Internet companies, it is a transformation worth watching. Intel's decision to switch from memory chips to microprocessors was also triggered by the advance of Asian memory chip manufacturers. All of these apps are running on Google's Android or Apple's iPhone, but a Chinese competitor, supported by the Chinese government, could still join the market. The Chinese government also boasts the most powerful quantum computer, and Chinese technology firms are formidable global competitors. Most of the worldwide discussion has been about Western firms penetrating the Asian market, but it's worthwhile to consider the opposite possibility. [31]

[31] One issue that I did not have space to address is the substantial investments made by governments that provided the basic research needed for new technologies. A company can plan for research that takes 5 to 10 years to reach the market, but a government has the resources to take on major projects with timelines of 30 years or more. An amazing example is ARPANET. This project, paid for by government contracts, proved that networking was possible and accelerated the introduction of the

There is another general theme that must be addressed: why do some technologies and companies find success, while other flame out? There have been hundreds of books written about this question. For technology, based on the background sources of my review here, there are a few common traits.

- Sleek and simple designs do best. Big and bloated (and confusing) will eventually be eliminated. Apple was the original master of this ideal for hardware. Google's website brought it to the Internet. Facebook's design took it to social media. These are not products that are just better technology, they are also more convenient and easier to use.

- The connection between different layers of the market affects which technologies become the standards. Historically, hardware quickly becomes a group of generic boxes, while the software on top sets the standard. However, sometimes hardware inside the system also becomes a standard. For example, Corning has been the main supplier for the glass on Apple's iPhones since the very beginning. Also, from this report, Intel's computer processors and ARM's phone processors showed a similar dominance as essential pieces of their device's hardware. There is more than one place to look.

- A bad strategy and an arrogant management were universal predictors of a failure to adapt. The pattern for failure is consistent: dismiss a competitor's major announcement, ignore their success, and then follow them into the market (much too late). It is always far better to be proactive rather than reactive. Technology moves too fast to wait for competitors to think of the next best idea. The side note to this observation is that this pattern for failure often started after the founder left the company: From the PC Revolution, Commodore and Compaq both went down after the founder's departure. Apple, Microsoft, and even Dell struggled when the founder left (all three managed to survive and thrive, but briefly lost their touch for innovation). In other words, it's not just about products. It's also about plans.

There were also many dead-end designs that I did not discuss, and some missed opportunities that I left out of the story. It's easy to look at the businesses that still survive and see that their success was obvious. In most cases, it was not obvious. The best product was not always the best seller. It is also true that the companies that fail to become the standard for one market do not necessarily die. They often have other lines of business where their approaches were more successful. The real test is one of purpose. Was the company's new product only made as a response to competitors, or

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Internet. An excellent book about this topic is *Where Wizards Stay Up Late* by Katie Hafner and Matthew Lyon.

is it genuinely providing a better customer experience? The customer-focused firms tend to find more success, while the followers continue to fall behind.

But the move to another market can also be tricky. There is one familiar feature of today's market structure—regulatory risks. As IBM learned in the 70s, and Microsoft re-learned in the 90s, industry regulators do not like it when a company uses its high market share in one market to try and eliminate potential competitors building alternative platforms. The antitrust suits against those two companies were distractions at best, but possibly crippling. Fear of regulation can slow a company's innovation, but the reality of regulation can break it apart.[32] Over the past 2 years (major antitrust investigations seem to have a 20-year cycle), Facebook, Google, and Amazon have all been sued for antitrust law violations. These lawsuits are still in various stages, and we will see how they affect these companies.

Beyond markets, there is one more topic that I consistently avoided—stock prices (and financial returns). The story here emphasizes the creative destruction process without mentioning the prices paid for acquisitions or the stock prices of the public companies. If those were included, it would show that the initial buyers *almost* always paid too much for their growth opportunities, while businesses that kept trading owners were *almost* always dramatically losing their value over time. And the investors in public companies were routinely over-estimating a company's growth. You can be right and still pay the wrong price.

The final conclusion comes from two important questions: Why go so far back in history? And does this give us any special insights for future investment ideas?

The answer to both of these questions is the same. To repeat our description from introduction: *"What it reveals is a pattern that may be useful for future long-term predictions. It can also translate into a general understanding of how markets can become fragmented with every new innovation, mature over time, and consolidate into a small number of major winners."*

As for the future of tech, it's hard to predict who will win this round. If it's a startup, it will be one that competes by avoiding the bigger players, like DEC and Compaq in the past. If it's a larger company, it will be one that persuades the others to use its technology as the standard, like Intel, Microsoft, Google, and ARM. But whoever leads the transition into the next stage of computer technology is not destined to remain the leader forever. In fact, history would advise against betting on the early leader. Then again, history would also advise against waiting too long to make an investment, because the one that

[32] For example, Bill Gates blames the antitrust distraction on Microsoft's failure to move into mobile phones, and IBM considered antitrust issues when it entered the personal computer market.

wins tends to win big, with a market share that can surpass 90%, and investment returns that outperform for decades at a time.

That's why we do the research.

Andrew Wagner
Chief Investment Officer
Wagner Road Capital Management

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