SWIPE
TO UNLOCK

The Non-Coder's Guide to Technology and the Business Strategy Behind It

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Swipe to Unlock:
The Non-Coder's Guide to Technology and the Business Strategy Behind It

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To my friends and family, for supporting me no matter how crazy my dreams get — Neel

To my family and friends, thanks for supporting my passion for business and helping me push past my fears to embrace entrepreneurship — Adi

To my friends and family for their never-ending support and Professor Deborah Streeter for believing in my vision which helped make this book possible — Parth

When you grow up, you tend to get told that the world is the way it is and your life is just to live your life inside the world, try not to bash into the walls too much, try to have a nice family, have fun, save a little money. That's a very limited life. Life can be much broader, once you discover one simple fact, and that is that everything around you that you call life was made up by people that were no smarter than you. And you can change it, you can influence it, you can build your own things that other people will use… That's maybe the most important thing. It's to shake off this erroneous notion that life is there and you're just gonna live in it, versus embrace it, change it, improve it, make your mark upon it… Once you learn that, you'll never be the same again.

— **Steve Jobs**
(who, by the way, never wrote any code for Apple)

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Preface

I've always been fascinated by technology. If you ask my parents, they'll tell you how I spent countless hours messing around on my family's Windows 95 PC as a toddler. As I grew older, my excitement for tech only intensified. I would spend hours watching demos and reviews of the latest gadgets. I knew that my dream job would be something in the tech space, but I wasn't really sure what it'd be.

As I walked through the job fair in my freshman year of college, I was captivated by the tech companies surrounding me. As I talked with the recruiters, they asked me if I was a "frontend" or "backend" developer and if I was more skilled with Python or JavaScript. Since I majored in applied economics, I had never learned what any of those terms meant, much less how to respond without sounding stupid.

Fast forward to three years later, when I was a senior: I had job offers from Facebook, Microsoft, and Google as a Product Manager and Product Marketing Manager. I still have yet to take a single computer science (CS) course or have the slightest idea of how to code. The difference between now and when I was wandering around that career fair is this: I taught myself how technology works at a high level and learned the relevant industry jargon so I could converse intelligently with engineers and other technical employees. With this knowledge, I could develop a much stronger understanding of the business strategies that drive decisions at major tech companies. This book is a compilation of all the knowledge I believe you need to get a non-developer role at a technology company.

Does everyone really need to take a computer science class?

I've lost count of the number of times I've been told, "you should take a computer science course in college." I ultimately decided not to. The key reason? I am not passionate about being a developer. Instead, I have always loved coming up with product ideas and developing business strategies that would make the products viable and commercially successful. Don't get me wrong, it would be cool to be able to develop my ideas myself, but I realized early on that the actual coding wasn't what fascinated me. I also know that, personally, I would forget things like code syntax really quickly if I didn't apply the skills regularly.

I asked some of my mentors what they thought the value of taking a computer science class was. They explained that whether or not I ended up remembering how to write functional code, a stronger understanding of the fundamentals of technology and computer science would be very useful in life, regardless of what career I decided to pursue. What these conversations taught me was that coding wasn't the most crucial skill set for business-minded young professionals like myself. Instead, the key skill was being able to think like an engineer and understand technical implications and limitations when making business decisions.

Weighing up the costs and benefits of taking a CS class, I saw a lot of upside but also recognized considerable potential downside. Although I knew the technical perspective would be very valuable, I realized taking a computer science class would require a substantial time commitment given my lack of familiarity in the subject area. It could also potentially hurt my GPA, which could adversely affect my career opportunities. As someone who would be taking a CS course for subject matter insight rather than to develop actual hard coding skills, it didn't seem worth it. Thus, I decided to look for alternative ways to gain a technical perspective.

I want to state that I never intended to write this book — I intended to buy it.

However, after a good half hour of scouring Amazon, I found it didn't exist. The information I sought was scattered across the web, written with various of levels of presumed knowledge. Although there are hundreds of books to teach beginners to code, I found nothing to help me better understand the underlying technology concepts.

That's what led me to team up with my good friends Neel Mehta and Aditya Agashe, both knowledgeable computer scientists and technology experts, to write this book. I hope you enjoy.

— Parth Detroja

Chapter 1: Introduction

Understanding technology is essential in today's world, no matter your career. Doctors are using artificial intelligence to diagnose patients.[1] Finance, payments, and banking have all been moving online.[2] Businesspeople are adapting to a world where, as of 2017, the world's five biggest companies are all tech companies.[3] Even farmers are using drones to grow better crops.[4] Whether you're a doctor, banker, farmer, or most anything else, you need to know how technology works.

If you don't know how to code, you might be a little worried right now.

But here's the thing: you don't need to know how to code to understand technology. We, your authors, believe that all the big ideas of technology — from how the internet works to how apps like Snapchat make money — can be explained in plain, simple English. You'll find explanations for these ideas, and many more, in *Swipe to Unlock*.

In this book, we've distilled everything we've learned from working at companies like Microsoft, Facebook, and Amazon (not to mention hundreds of hours of research). Inside *Swipe to Unlock*, you'll find explanations of the hottest technologies, translations of the most mysterious tech buzzwords, and an analysis of the business strategies that power the tech industry. We think it's everything you need to know about technology and the business strategy behind it, and we think absolutely anyone can learn it.

But enough about us. How about you?

Who this book is for

The goal of *Swipe to Unlock* isn't to teach you how to code. It's to teach you how to think like a technologist. Whenever you come across a technology topic at work or on the news, you'll be able to think through how the technology works, why it was made that way, how it makes money, and how it might help or harm people. While technology is always evolving, the concepts you pick up here should be useful to you for a long time to come.

If you want a non-technical job at a tech company, *Swipe to Unlock* will teach you how to think like a software engineer. You'll learn how software is made, where the tech industry is going, and what buzzwords like "big data," "machine learning," and "APIs" mean. (Don't worry if you've never heard of these terms — we'll break them down throughout the book!)

If you're already a software developer but want to move more toward product management roles, we'll teach you the business strategy and bigger-picture thinking you need to know. We'll pose a variety of real-world business questions and work through the answers. *Why does Amazon offer free shipping with Prime if it loses them money? Why did Facebook acquire Instagram? How do software companies make money when most apps are free?*

If you work outside the tech industry, you'll learn about the digital tools and techniques you'll need to stay ahead of the curve. We'll teach you what jargon like "predictive analytics" and "the cloud" means, and we'll introduce you to companies that have been using these technologies to boost sales, cut costs, and improve efficiency.

Even if you don't need to know any technology for your career, you still use it every day — you probably have a very advanced piece of technology in your pocket (or your hand) right now. *Swipe to Unlock* will make you a better-educated consumer by answering some of the questions you might have had while following the news or using your favorite apps. *How does Facebook decide what shows up in my news feed? What is this "net*

neutrality" debate that everyone's talking about? What does it mean for my privacy when companies have so much data about me? We'll talk about these questions and many others.

No matter why you're reading this book, we think you'll find plenty of valuable insights and ideas, and you'll learn how to think — and speak! — like a technologist. Before we start, let's dive a bit deeper into the topics you'll learn about.

What's inside

We'll kick off *Swipe to Unlock* by looking under the hood of the technology you use every day, from your phone's operating system (like Android or iOS) to your favorite apps. In the middle chapters, we'll break down important concepts like "the cloud," "big data," and hacking. Then we'll zoom out and look at some of the business, legal, and political implications of technology. We'll finish up with a look at emerging trends in technology and some predictions for the future.

All three of us hate reading textbooks, so we didn't write *Swipe to Unlock* like a textbook. Instead, every single section is in the form of a question, where we step through real-world examples. *How does Spotify recommend songs to you? How do self-driving cars work? How could a hacker hold your computer for "ransom"?* We'll look at these cases and many more like them.

Along the way, you'll read about some surprising, and maybe even funny, stories. *How did Target figure out that a teenager was pregnant before her own father did? How did a single typo take down 20% of the internet?* We'll even meet some interesting characters, like a Wall Street trader who blasted right through the Allegheny Mountains in his quest to make a perfectly straight internet cable.

A final note: we couldn't possibly cover everything in full detail in *Swipe to Unlock*, so we'll give you dozens — and, in some cases, hundreds — of citations per chapter. You can use these links to dive deeper into any topic that interests you.

For job hunters

If you're looking for a non-developer role at a tech company, we're glad you're reading *Swipe to Unlock* — we think it'll be useful! A big reason we wrote this book was because there just weren't any good resources for non-developers to learn about technology.

Swipe to Unlock aims to teach you the technology and business concepts you'll need to know, and it'll help you understand the jargon that tech companies love using. Bear in mind, though, that *Swipe to Unlock* isn't designed to give you resume or networking advice, and it won't teach you how to code or prepare for interviews. For that kind of information, check out the Resources section of our website at swipetounlock.com/resources, where we'll share links to some useful books and articles.

The questions you'll see in *Swipe to Unlock* aren't designed to resemble actual interview questions; instead, they'll give you the technical and business insight to craft answers that'll set you apart from the pack. Let us explain with a couple of examples.

One example: we'll talk about how Google's algorithm decides which ads to show to users. Google probably wouldn't ask you to explain this algorithm at an interview, but they could ask you how you would increase ad revenue from a particular group of users. Knowing how the targeting algorithm works is crucial to creating a good answer.

A second example from the world of business: we'll discuss why Microsoft acquired LinkedIn. Microsoft interviewers probably wouldn't ask you to explain the reasons for the purchase, but perhaps they'd ask you how you'd improve the email client Outlook. In your answer, you could draw on our discussion of the acquisition, where we talk about how Microsoft and LinkedIn data could work together. For instance, you could talk about one interesting idea we'll cover: Outlook could use LinkedIn data to give salespeople insights about potential clients before going to a meeting with them. We think answers like these will help you stand apart from the crowd.

Third, we'll give you some great anecdotes to take to the interview. For instance, we'll introduce you to Robinhood, an app that lets you trade stocks without paying brokers any commission. Robinhood has a clever way of making money: it earns interest on the unspent money sitting in users' accounts. At an interview, what if someone asks you to come up with a new money-making strategy for Venmo, an app that lets you send money to friends for free? Well, you could pull out the Robinhood story and propose that Venmo earn interest on money sitting in Venmo users' accounts. We think our stories will help you find many creative ideas like this.

In short, *Swipe to Unlock* is an essential complement to books full of sample interview questions. Sample questions alone won't help you understand the tech industry, think strategically about software products, or become fluent in technology jargon, but we believe *Swipe to Unlock* will. Best of luck!

Who we are

Before we jump into the main content of *Swipe to Unlock*, let us introduce ourselves. The three of us met while working at Microsoft in summer 2016. Through our conversations, we quickly realized we were passionate about making the world of technology accessible to everyone. We genuinely believe that everyone can — and should! — understand the fundamentals of technology, and we want to help make that happen. That's why we've written this book.

Here's a bit more about us.

Neel Mehta studies Computer Science at Harvard University, where is a John Harvard Scholar (top 5% of class). He's done the "tech triple crown": he worked at a .com (Microsoft, as a Program Manager Intern), .org (Khan Academy, as a software engineer), and .gov (the US Census Bureau, where he founded the first fully-funded tech internship program in the federal government). At Harvard, Neel founded the Harvard Open Data Project, a student-faculty group that uses tech to push for government transparency, and was a teaching assistant for CS50, Harvard's introductory computer science course.

Aditya Agashe studied Computer Science and Business at Cornell University. He graduated Cum Laude as a Rawlings Presidential Research Scholar (top 1.5% of class). At Cornell, he founded Belle Applications (belleapps.me), a company that builds and optimizes software platforms for businesses. He has grown the annual revenue to $50,000+ and is negotiating an acquisition offer from a small-business conglomerate. Adi is currently a Program Manager at Microsoft.

Parth Detroja studied Applied Economics and Management at Cornell University. He graduated Summa Cum Laude as a Merrill Presidential Scholar (top 1% of class). During his time at Cornell, he cofounded the Cornell International Business Association (CIBA) and served as the lead undergraduate teaching assistant for AEM 3249: Entrepreneurial Marketing

and Strategy. He has previously worked at Microsoft, Amazon, and IBM. He is currently a Product Manager at Facebook.

Thank you and good luck!

Whatever your personal or career goals, we hope *Swipe to Unlock* helps you. If you'd like more tips along the way, learn more and join our mailing list at swipetounlock.com. We regularly release new interviews, articles, and posts to help non-developers understand the world of technology.

Thank you again for reading *Swipe to Unlock*, and all the best!

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Chapter 2: Operating Systems

Android or iOS? Mac or Windows (or, if you're especially hardcore, Linux)? Everyone has their preferences of operating systems. These preferences are important, since operating systems (OSes) are at the heart of every computing device, from phones to supercomputers. The operating system sits between the device and apps; pretty much no device and no app can run without an operating system.

So, before we discuss anything else, let's look at operating systems. We'll start off by learning how operating systems differ and why that matters. Then we'll investigate mobile operating systems, including Android and iOS, and see how their creators can get filthy rich — or go broke. We'll finish up with a look at desktop operating systems like Mac and Windows.

We'll talk about each of these topics through a case study, where we'll pose a real-world question and then break it down. Let's jump in!

How are smartphone apps like Toyota cars?

Before we talk apps, let's talk cars. For whatever reason, people in countries like the United States, China, and Brazil drive on the right side of the road, while people in countries like the United Kingdom, India, and Japan drive on the left.[5] Cars that drive on the right usually have their steering wheels on the left side ("left-hand drive"), while cars that drive on the left have their steering wheels on the right ("right-hand drive.")[6] This is more than just a quirk: it means that cars built for the United States won't work in the United Kingdom and vice versa.

Incompatibility is an issue for carmakers like Toyota, which sells cars in over 80 countries.[7] Toyota could just build cars with steering wheels on the left, but then they couldn't sell in markets like the UK, India, and Japan. If they only built cars with steering wheels on the right, Toyota couldn't sell in the US or China. So, to maximize the size of their market, Toyota has to make two versions of the same car: a left-hand drive version and a right-hand drive version. Most of the car design, from the engine to the audio, is the same between the two versions, but changing a car to the other version requires re-engineering the entire instrument panel.[8]

So what does this have to do with apps? Well, much like Americans and Brits have incompatible road layouts, smartphone users have two kinds of incompatible operating systems. Some users use Androids while others use iPhones. Apps built for one platform won't work for the other: for instance, Snapchat for Android won't run on iPhones, while Snapchat for iOS (the operating system that iPhones use) won't run on Androids.

As such, app makers need to choose which platforms they want to target. There are heated debates over whether startups should build an iOS or Android app first.[9] But most major apps, from Venmo to Snapchat, run on both major mobile platforms for the same reason Toyota makes both left-hand and right-hand drive cars: doing so ensures they can reach the largest possible market.[10]

Like cars, apps built for different operating systems have a lot in common, but they look and feel a little different.[11] For instance, most of Facebook Messenger looks the same on Android and iOS, but a few pieces of the app are subtly different.

Facebook Messenger on iOS vs. Android. Notice that the core messaging area looks almost the same, whereas the top and bottom bars look different.

While they look different, both versions of the Messenger app talk to the same Facebook database that stores your friends and conversations.

So how exactly are smartphone apps like Toyota cars? Both cater to multiple markets that use mutually incompatible platforms. This means both app developers and Toyota tend to make slightly different versions of their product for each market.

A final note: while there are only two major versions of smartphone apps (iOS and Android), apps that work on other types of devices can have even more versions. For instance, there are five versions of the super-versatile Microsoft Office apps: Windows, Mac, iOS, Android, and web apps.[12]

Why did Google make Android free to phone manufacturers?

Google's Android mobile operating system is free for both consumers and phone manufacturers. The likes of Samsung and HTC can slap Android on their phones without paying Google anything.[13] But, in 2016, lawyers revealed that Android was earning Google $31 billion a year in revenue.[14] How on earth could a free product earn Google so much money?

Google's strategy begins with getting as many people as possible using Android.[15] Clearly, making Android free is working: in the last quarter of 2016, over 80% of newly-sold phones ran Android.[16]

Now that Google has such a high market share, they can start converting it to cash in a variety of ways.

First off, Google forces any phone manufacturer that uses Android to install all the core Google apps, like YouTube and Google Maps, by default. In the US, Google even forces phone manufacturers to put the Google search bar no more than one swipe away from the home screen.[17] By getting more people on its apps, Google can get more data, show more ads, and thus make more money.[18]

A second source of income — which is smaller but still considerable — is app purchases.[19] In most countries, Google insists that phone manufacturers prominently feature Google Play, Android's app store, on the home screen of any Android phone.[20] This is designed to drive more users to download apps from the Google Play marketplace. And whenever someone buys an app or makes an in-app purchase, Google takes a 30% cut.[21] More Google Play users leads to more downloads, which leads to more commission revenue.

Third, making Android more prevalent could help Google keep more ad revenue for itself.[22] Whenever an iOS user clicks on ads in Google Search, Apple keeps a sizable chunk of the ad revenue that would otherwise go to

Google.[23] Plus, Google pays Apple an estimated $3 billion per year just to make Google Search the default search engine on iOS.[24] So you can see why Google would prefer if people ran Google searches on Androids instead of iPhones.

More Android users equals more money for Google, so it's no surprise Google is giving away Android for free.

Why open-source?

Android isn't just free — it's also open-source,[25] meaning that anyone can make and distribute their own spin-offs of Android.[26] There's a vibrant community of developers making custom "flavors" of Android, like the popular LineageOS (formerly known as CyanogenMod).[27] You can replace your phone's Android operating system with LineageOS to get improved speed, security, and features.[28]

Android is literally open-source to the core; it's built around the "kernel" of the open-source operating system Linux, which is also used in some of the world's biggest supercomputers.[29] The kernel is a bit of software that lets software talk to the device's hardware, like by reading and writing files, connecting to the keyboard and Wi-Fi, and so on.[30] A kernel is like a car's engine: the computer literally wouldn't run without a kernel. Using this pre-built, open-source kernel saves Android developers a lot of work,[31] since the Linux developers have been constantly improving their kernel since 1991.[32] And Linux works on an incredible range of devices, from supercomputers to video game consoles,[33] so by adopting Linux, Android automatically became able to run on a vast variety of hardware.

Anyway, why did Google make Android open-source? For one, because Android is open source, phone manufacturers get to customize the interface, which helps their phones stand out.[34] That's a good incentive for phone makers to pick Android over another operating system.

Second, making Android open-source brings more people into the Android and Google ecosystem.[35] Since Android is open-source, people who want to

massively customize their phones are much more likely to use a spin-off of Android than iOS (which isn't open source and hence can't be customized as easily). The spin-offs are fine by Google. Even if someone uses an Android spin-off rather than the standard version of Android, they're probably still doing Google searches and using Google apps. Since more users equals more money, promoting open-source actually helps Google's bottom line.[36]

To summarize, why did Google make Android free to phone manufacturers? While it might not directly make Google any money, this move helps Android get more users, more app purchases, and more searches on Android — all of which helps Google rake in the cash.

Why do Android phones come pre-installed with so many junk apps?

Ever bought an Android phone? When you unwrap it, you realize pretty quickly that it's crammed with all kinds of useless apps you never asked for: NFL Mobile, Candy Crush, Samsung Pay, Verizon Navigator (a knockoff of Google Maps that costs $5 a month), you name it.[37] Smartphone makers like Samsung, mobile carriers like Verizon, and phone sellers euphemistically call these "pre-installed apps" and claim that they showcase the functionality and performance of the phone.[38] But most of us just call it "bloatware," and we aren't fans.[39]
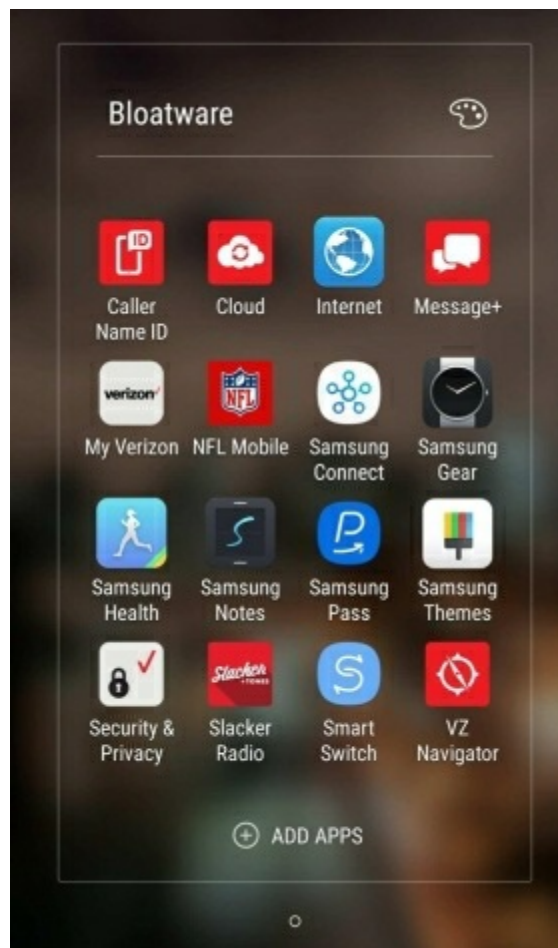
A Samsung Galaxy S8 full of bloatware. It appears that the bloatware apps

were so annoying that the phone's owner put the apps into their own folder just to get them out of the way!

Most pre-installed apps can't be uninstalled and, by default, run constantly in the background, which eats up battery, makes your phone run slower, and wastes storage space.[40] One reviewer found that his new Samsung Galaxy S8 had 37 bloatware apps that ate up 12GB of his 64GB of storage as soon as he peeled off the plastic.[41] Sometimes things get truly absurd, like when Verizon pre-installed a bloatware app on Galaxy S7s that would download *other* bloatware apps without the user knowing.[42]

It's not that easy to fight back, either. While you can disable some bloatware apps and prevent them from running in the background and wasting your battery, they'll still take up storage on your phone.[43]

Simply put, bloatware is aggravating.

The business of bloat

So why does your phone come with so much junk? Mobile carriers and smartphone manufacturers aren't just trying to be mean. It turns out that bloatware is at the center of a pretty lucrative business model.

The bloatware business model arose when smartphone manufacturers like HTC and mobile carriers like AT&T realized that the American market for smartphones and data plans is pretty much saturated. That is, almost everyone who wants a phone and data plan already has them, so manufacturers and carriers can't grow their revenue much by just selling phones and data plans. Instead, they've turned to new ways of making money — which leads them straight to bloatware.[44] There are two big ways carriers and phone makers make money off bloatware.

First, app makers can pay carriers and phone makers to pre-install their apps. For instance, Verizon once offered to pre-install big companies' apps for $1 to $2 per installation.[45] In other words, if your Verizon phone has 10 bloatware apps, Verizon could have made an easy $20 off you. It's free

money for carriers and phone makers, and it helps app makers get their apps in front of people — which is very important, since the majority of Americans download exactly zero apps a month.[46] The only loser, of course, is the consumer.

Second, carriers and phone makers also pre-install their own apps, which are often expensive knockoffs of popular free apps. For instance, Samsung pre-installs its own Android app store, and AT&T pre-installs Navigator, a $10-a-month clone of Google Maps.[47] Verizon's Message+ is like Facebook Messenger but charges you for texts you send over Wi-Fi.[48]

Why do carriers and phone makers pre-install these apps? Again, it's easy money: Samsung earns a commission from paid apps and themes from its app store,[49] and carriers and phone makers make money from the pricey knockoff apps. These companies hope that users won't notice that there are free alternatives to the bloatware apps and just use (and pay for!) the default pre-installed apps. Defaults are powerful: Apple made Apple Maps the default navigation app on iPhones, and even though most customers preferred Google Maps, Apple Maps became more popular than Google Maps on iPhones by 2015 — thanks to Apple Maps's position as the default.[50]

However, many users seem to be rebelling against bloatware. For one, many don't use this useless software. Even though Samsung's bloatware chat app, ChatOn, has 100 million users, they only use it for an average of 6 seconds a month, compared to 11 hours for Facebook.[51] And second, customers have started giving many bloatware apps low reviews in app stores.[52] The danger of all this? Frustrated users could just abandon the bloated phones altogether, which would make the bloatware strategy backfire.[53] But are there non-bloated alternative phones?

Non-bloated Androids

Remember how both mobile carriers and phone makers can load bloatware on Android phones. How could you start reducing bloatware? Consider this case: in 2016, Google launched its own flagship phone, the Pixel.[54] Since Google manufactures the Pixel phone, there's no bloatware from the

manufacturing side.[55] However, carriers still injected their own bloatware, although Google tried to restrict this.[56] Pixels didn't manage to entirely eliminate bloatware, but they're a step in the right direction.

Bloated iPhones?

If you have an iPhone, here's a reason to smile: iPhones don't have bloatware.[57] Why?

Think first about how Apple makes money: most of their revenue comes from selling hardware.[58] In 2017, over 60% of Apple's income came from iPhone sales alone.[59] Plus, Apple's brand, driven by how "pleasant" it is to use their products, is one of Apple's core strengths.[60] So bloatware wouldn't align with Apple's money-making strategy, and it would also weaken their treasured user experience.

Why can't carriers just slide in their own bloatware? For starters, Apple outright forbids carriers like Sprint or Comcast from putting bloatware on iPhones.[61] That might seem to make Android more attractive for carriers. But because so many customers demand iPhones, it would be foolish for carriers to refuse to support iPhones — and so they're forced to go along with Apple's bloatware ban.[62]

But how about those Apple-branded apps that come pre-installed on iPhones, like Safari, iCloud, and Apple Maps? Some users don't like them: when Apple rolled out Apple Maps in 2012, customers said it "sucked" and was "the phone's biggest drawback."[63] We wouldn't call these apps bloatware, though, because (as of iOS 10) you can delete almost all of Apple's pre-installed apps. The few that you can't uninstall, like Messages and Camera, are core to the operating system,[64] so it's understandable why you can't get rid of them.

Bloatware on laptops

There's one final chapter to the bloatware saga, and it's laptops. PCs running Windows have had bloatware for ages,[65] like an eBay app[66] or a trial of the McAfee antivirus software.[67] One particularly infamous case was when PCs

made by Lenovo around 2015 came with the Superfish bloatware, which injected ads into every webpage you visited and left your computer vulnerable to hackers.[68]

Why does Windows have bloatware? Similar to Google with Android, Microsoft licenses out Windows to laptop manufacturers (known as OEMs or Original Equipment Manufacturers), and these companies are free to install bloatware.[69] Since Microsoft makes OEMs pay for Windows (unlike Android, which is free),[70] OEMs might be even more motivated to install bloatware, since they need to recoup some of the costs of Windows. There seems to be a happy ending, though, thanks to Microsoft. A new feature in Windows 10 lets you reset your computer to a permanently bloatware-free state.[71]

How about Macs? They don't have bloatware for the same reasons that iPhones don't.[72]

That brings us back to the original question: why do Android phones come with so much bloatware? Bloatware is, unfortunately, the center of a lucrative business model. But the silver lining is that Apple products — and, it appears, Windows — are starting to fight back against the bloat.

Why did BlackBerry fail?

In 2000, BlackBerry launched the world's first smartphone.[73] The phone rose to fame because it let users access the internet and email anywhere, which was great for the always-on world of business.[74] Its QWERTY keyboard made typing far faster than before.[75] People were hopelessly addicted to their so-called "CrackBerries."[76]

By 2009, BlackBerry was a dominant player in the mobile phone space, with 20% market share, more than iOS (14%) and Android (4%) combined.[77] It was so popular that President Obama chose the BlackBerry as his smartphone when he took office in 2009.[78]

But fast forward to the last quarter of 2016, when BlackBerry's market share hit 0.05%, with the company shipping just over 200,000 units.[79] Meanwhile, during the same quarter, Android shipped over 350 million units, and iOS shipped 77 million.[80]

Where did BlackBerry go wrong? Let's take a look.

Resting on their laurels

When Steve Jobs launched the iPhone in 2007,[81] BlackBerry executives didn't take it seriously. They saw it as a flashy toy aimed at young people[82] and not something that competed for BlackBerry's market, which was overwhelmingly comprised of business users.[83]

What BlackBerry failed to realize, though, is that people really enjoyed using their iPhones, with their bright colors and touchscreens.[84] And instead of selling phones to corporate IT managers, as BlackBerry did, Apple sold iPhones directly to consumers.[85]

The result? With greater access to iPhones, people started carrying two phones: BlackBerries for work, but iPhones for personal use.[86] Soon, businesses realized they could save money and keep employees happier by

just letting employees use their personal phones for work purposes.[87] Slowly but surely, iPhones started creeping into BlackBerry's treasured enterprise market — a perfect example of the trend known as "consumerization of the enterprise."[88] In short, BlackBerry realized too late that everyday users, not businesspeople, called the shots.[89]

By the time BlackBerry realized it had to reach consumers directly, it had already fallen behind.[90] To compete with the iPhone, BlackBerry designed a touchscreen phone called the Storm in 2008. But, in their hurry, BlackBerry released the phone before it was ready, and consumers gave it phone negative reviews.[91] Even the BlackBerry CEO admitted it was a flop.[92]

The other main trend that BlackBerry missed was the rise of the "app economy." BlackBerry didn't realize that consumers wanted to do more than just send emails on their phones: they wanted apps, games, and instant messaging.[93] BlackBerry didn't do enough to encourage developers to build apps for their platform. Instead, Apple's App Store grew to have far more apps than BlackBerry's store, which sent customers stampeding toward iPhones.[94]

In short, BlackBerry got complacent, focusing too much on their current users without thinking about growing their new user base.[95] They didn't notice the emerging trends in the software industry. BlackBerry continued to see its phones as business productivity tools, whereas Apple (and Google) rethought phones as versatile "entertainment hubs" for everyday people.[96] Apple read consumers correctly, and they won.[97]

A failed comeback

By 2012, BlackBerry's market share had tumbled from 20% in 2007 to just 7%.[98] That year, BlackBerry appointed a new CEO to try to turn things around.[99] They even launched a new series of high-end phones, the Q10 and Z10, in what a New York Times critic called "BlackBerry's Hail Mary pass."[100]

Did it work? Not really.

As BlackBerry sank into third place behind iPhone and Android, it got stuck in a vicious cycle called the "chicken-and-egg problem."[101] Developers wouldn't build apps for the BlackBerry platform if it didn't have any users, and users wouldn't buy BlackBerries unless there were enough apps.[102] Imagine if no one would walk into a party unless there were already enough people there — it makes you wonder how you'd ever get anyone to come in. [103] BlackBerry tried hard to entice developers to their platform, even offering $10,000 to anyone who made a BlackBerry app in 2012.[104] But it still didn't work.

BlackBerry continued its downward spiral — and the rest, as they say, is history.

Can Macs get viruses?

For years, one of the biggest selling points of Macs was that they "don't get viruses."[105] In 2006, as part of Apple's famous "Get a Mac" advertising campaign, Apple even made an ad that showed the healthy "Mac" character giving a tissue to the sickly "PC" character.[106]

But are Macs really immune?

First things first: Macs can't get Windows viruses.[107] That's just because any app made for Windows, whether a Google Chrome installer or the nastiest virus out there, won't run on a Mac. Think back to our analogy with cars: the platforms are just incompatible.

Though Windows viruses won't affect Macs, viruses built specifically for Macs can definitely infect them.[108] But many people are adamant that Macs don't get viruses.[109] How could that be?

Testing the claims

People who say that Macs are invincible have two main lines of argument. One argument is that Macs are so uncommon that hackers don't bother targeting them, and another is that Macs are so secure that a virus wouldn't be able to infect them anyway.[110]

Let's look at the first argument. It's true that Macs are uncommon: as of 2017, just one in 16 computers is a Mac, while most of the rest are Windows PCs.[111] And since hackers usually just want to make money, the theory is that they'd focus on Windows, which gives them more targets.[112] That's not a bad argument, but there's a small catch: hacking a Mac might earn a hacker more money than hacking a PC. Macs are more common in wealthier countries, often clocking in at 20-30% of the computer market share in western nations, and Mac owners tend to be much wealthier than their Windows-toting friends.[113] That might give hackers more of a reason to target Mac owners, since Mac-owning victims would be more likely to fork

over more money. So the argument that "Macs are too uncommon" is legitimate, though flawed.
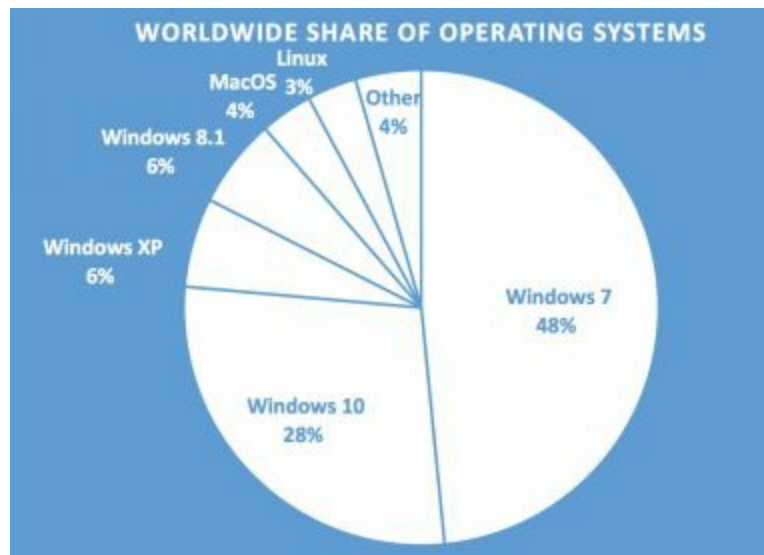
The worldwide market share of desktop operating systems as of 2017. Notice that Macs are just 4% of all computers, while Windows PCs are over 88%! Source: NetMarketShare[114]

How about the claim that Macs are more secure than PCs? Macs do have some built-in security features that make them harder to hack. By default, Mac users can't run potentially-risky software or change certain setting unless they enter their password, while Windows is less strict.[115] That means that, on a Mac, rogue software can't do as many damaging things without the user noticing. Macs also have a feature called "sandboxing," where a virus in one part of the computer can't easily spread to others.[116] It's like if you locked the door to every room in a house individually: even if a burglar broke into one room, they couldn't get to other rooms without extra effort. And finally, macOS also has built-in malware scanners, and it blocks apps whose authors weren't approved by Apple.[117] Put these together, and hacking a Mac looks more challenging than hacking a PC.

Mac vulnerabilities

But despite Macs' security features, they can — and do — get viruses. For instance, in 2012, over 600,000 Macs were infected by a virus called Flashback, the biggest Mac epidemic to date.[118] Apple had always boasted

about Macs' invincibility,[119] but now they were forced the publicly admit that this wasn't entirely true. Apple's website used to brag that "Macs don't get PC viruses," but shortly after this incident, Apple replaced it with the more generic tagline "it's built to be safe."[120] Over the next few years, several more Mac viruses, including ones called Rootpipe and KitM.A, started appearing.[121]

Clearly, Macs aren't immune to viruses. In fact, one 2017 analysis found that macOS actually had more security flaws than Windows 10.[122] So if you have a Mac, it's worth checking out free Mac antivirus apps.[123]

One last thing: anyone, no matter how secure their operating system, can fall prey to "social engineering" attacks like phishing, which trick you into giving away personal information that hackers can use to defraud you.[124]

So if anyone ever smugly tells you that their Mac can't get viruses, tell them to look beyond the marketing. The fact is that no operating system is perfect — any OS can get a virus.

Chapter 3: Software Development

Every piece of software, from the original Pac-Man game to the latest version of Snapchat, is made of instructions, or code, that people wrote down and that computers follow. While the code behind apps like Spotify or Yelp might seem like magical spells, many of the core ideas are simple. We won't get into the nitty-gritty of the code, but here we'll look into three big building blocks of apps and websites.

First, software is built around algorithms, or well-defined procedures that computers use to solve a problem. For instance, the algorithm to find the area of a triangle is to multiply the base and the height, then cut the result in half. There are algorithms to predict the weather, recommend movies to watch, process credit card payments, and more. We'll take a look under the hood of some famous apps and websites to reveal the algorithms that make them tick.

Then we'll turn to a second building block: APIs, or application programming interfaces, which let apps borrow algorithms and data from other apps. We'll explore how APIs work and why developers use them, and we'll learn how to analyze an app to figure out what APIs it uses.

Algorithms and APIs help developers build out software, but to perfect it, developers turn to a third tool: A/B tests. In an A/B test, you show different versions of a feature to different groups of users: for instance, half the users get a red button while the other half get a blue button. Then you look at certain metrics to see which variation performed better, and you push the winning version to all users. We'll finish up this chapter with a look at how some apps and websites use this powerful, scientific technique to improve their software.

Once you understand these three building blocks, you can start peering under the hood of any app or website to learn how it works.

How does Google search work?

Whenever you search on Google, the search engine finds thousands — if not millions — of results for you in just half a second, on average.[125] And the results are sorted pretty well: 92% of searchers go to a link on the first page of results.[126] How on earth does Google do it?

Google doesn't actually search the entire internet every time you ask it something. It actually has huge databases (tables of information, like in Excel) and algorithms that read over those databases to figure out what to show you. Let's dive into how these work.

First, Google needs to build up a list of every webpage on the internet; it's a tall order because there are over 30 trillion pages out there.[127] Google uses programs called spiders to "crawl" over webpages until it's found all of them (or at least, what Google thinks is all of them). The spiders start on a few webpages and add those to Google's list of pages, called the "index." Then the spiders follow all the outgoing links on those pages and find a new set of pages, which they add to the index. Next, they follow all the links on *those* pages, and so on, until Google can't find anything else. This process is always ongoing, and Google is always adding new pages to its index or updating pages when they change. And the index is huge, weighing in at over 100 million gigabytes.[128] If you tried to fit all that on one-terabyte external hard drives, you'd need 100,000 — which, if you stacked them up, would be around a mile high.[129]

When you search Google, it grabs your query (the text you typed into the search bar) and looks through its index to find the webpages that are most relevant to your query. How might Google do this? The simplest way would be to just look for occurrences of a particular keyword, kind of like hitting Ctrl+F or Cmd+F to search a giant Word document. Indeed, this is how search engines in the 90's used to work: they'd search for your query in their index and show the pages that had the most matches,[130] an attribute called keyword density.[131] This turned out to be pretty easy to game. If you searched for the candy bar Snickers, you'd imagine that snickers.com would

be the first hit. But if a search engine just counted the number of times the word "snickers" appeared, anyone could make a random webpage that just said "snickers snickers snickers snickers" (and so on) and jump to the top of the search results. Clearly, that's not very useful.

PageRank

Instead of keyword density, Google's core innovation is an algorithm called PageRank, which its founders Larry Page and Sergey Brin created for their PhD thesis in 1998.[132] Page and Brin noticed that you can estimate a webpage's importance by looking at which other important pages link to them.[133] It's like how, at a social event, you know someone is popular when they're surrounded by *other* popular people. PageRank gives each webpage a score, which is based on the PageRank scores of every other page that links to that page.[134] (The scores of *those* pages depend on the pages that link to them, and so on… don't worry, this doesn't go on forever, thanks to some clever math.[135])

For instance, if we made a brand-new webpage about Abraham Lincoln, it would initially have very low PageRank. If some obscure blog added a link to our page, our page would get a small boost to its PageRank. PageRank cares more about the quality of incoming links rather than the quantity,[136] so even if dozens of obscure blogs linked to our page, we wouldn't gain much. But if a New York Times article (which would probably have a high PageRank) linked to our page, our page would get a huge PageRank boost.

So once Google finds all the pages in its index that are relevant to your search query, it ranks them using a variety of criteria.[137] PageRank is the major one, but Google has several other criteria: Google considers how recently a webpage was updated, ignores websites that look spammy (like the "snickers snickers snickers snickers" site we mentioned earlier), considers your location (it could return the NFL if you search for "football" in the US, but the English Premier League if you search for "football" in England), and more.[138] One particularly interesting technique is called query rewriting, where Google looks for words with similar meanings to the word you searched for. For instance, if you searched for "sofa", Google could also

return webpages that include terms like "couch," "chair," "seat," or "furniture."[139]

Gaming Google?

There are pitfalls to PageRank, however. Much like spammers abused keyword density (as with "snickers snickers snickers snickers"), spammers have now created "link farms", or webpages that contain tons of unrelated links. Website owners can pay link farms to include a link to their webpages, which would artificially boost their PageRank.[140] However, Google has gotten pretty good at catching and ignoring link farms.[141]

There are some more mainstream ways to game Google, though. An entire industry, called search engine optimization (SEO), has sprung up to help website owners crack Google's search algorithm and make sure their webpages are at the top of Google searches.[142] SEO starts with getting more pages to link to your page. SEO has plenty more techniques, such as putting the right keywords in your page's title and headings or making all of your site's pages link to each other.[143]

Google is always innovating on its search engine. The company made 1600 changes to its search algorithm in 2016 alone,[144] and in recent years it's added features like driving directions and "infoboxes," or cards that show quick information about your search term from Wikipedia.

Infoboxes are a new feature of Google's search results; they grab relevant information about your search from sources like Wikipedia. Source: Google search

How does Spotify recommend songs to you?

Every Monday morning, Spotify sends its listeners a playlist of 30 songs that are, almost magically, perfectly tuned to their tastes. This playlist, called Discover Weekly, has been a hit: within six months of launching in June 2015, it was streamed over 1.7 billion times.[145] But how does Spotify get to know its 75 million users so intimately?

Spotify does employ music experts who hand-curate public playlists,[146] but there's no way they could do that for all 75 million Spotify users. Instead, Spotify has turned to a computer algorithm they run every week.[147]
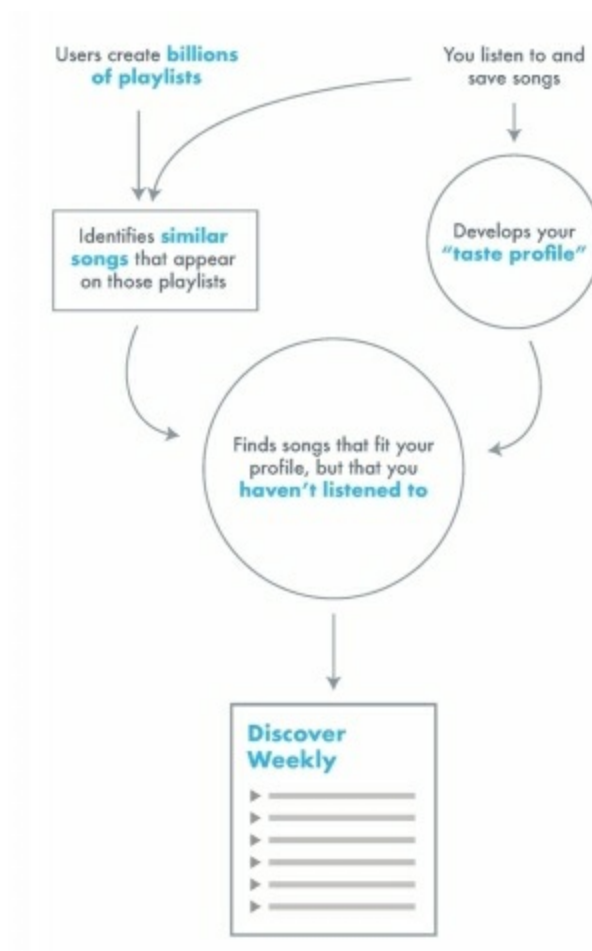
Spotify's algorithm for automatically recommending songs for you. Source: Quartz[148]

The Discover Weekly algorithm starts by looking at two basic pieces of information. First, it looks at all the songs you've listened to and liked enough to add to your library or playlists. It's even smart enough to know that if you skipped a song within the first 30 seconds, you probably didn't like it! Second, it looks at all the playlists that other people have made, with the assumption that every playlist has some thematic connection; for instance, you could have a "running" playlist or a "Beatles jam" playlist.[149]

Once it has this data, Spotify uses two methods to find songs you might like. The first method involves comparing the two datasets to figure out which new songs are related to the ones you like. For instance, suppose someone made a playlist with eight songs on it, and seven of those are in your library. You probably like that type of song, so Discover Weekly might recommend the one song that isn't in your library.[150] This technique is called collaborative filtering, and it's the same technique that Amazon uses to suggest items you might like based on your purchase history and the purchases of millions of other users.[151]

The second method that Spotify uses to make your playlist is your "taste profile." Based on just the songs you've listened to and liked, Spotify will determine which genres (e.g. indie rock or R&B) and micro-genres (from chamber pop to New Americana) you like and recommend songs from those genres. It's just a different form of their strategy for recommending songs based on past listening patterns.[152]

Recommendation systems are getting more and more popular across the app landscape: besides Spotify, Netflix suggests movies, YouTube suggests videos, Amazon suggests products, Facebook suggests friends, and so on. Once you understand how Spotify runs its recommendation system, the others all become easier to understand, because they largely use the same methods, like collaborative filtering.[153]

How does Facebook decide what shows up in your news feed?

Over a billion people look at their Facebook news feed every day, and Americans spend almost as much time on Facebook as they do interacting face-to-face with other people.[154] Because it draws so many eyeballs, the news feed has tremendous power. The news feed can influence our mood, put us in an ideological echo chambers,[155] or even influence who we're going to vote for.[156] In short, what appears in your news feed matters. So how does Facebook design what to show in your news feed?
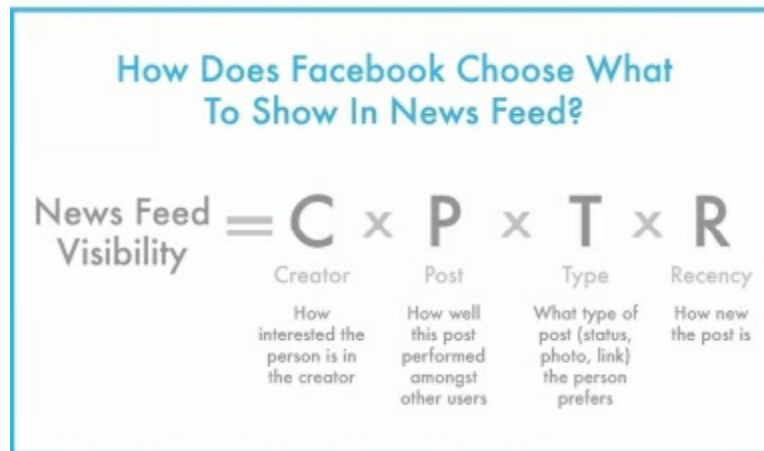
A simplified explanation of Facebook's news feed algorithm. Source: TechCrunch[157]

More specifically, how does Facebook take the hundreds (or thousands) of updates you get every day and sort them for you? Like Google, it uses an algorithm to figure out what's most important. There are about 100,000 personalized factors, but we'll focus on four key ones.[158]

The first factor is who posted it. Facebook will show you more posts from people you've interacted with more (e.g. people you've messaged more or tagged more), assuming that you're more likely to engage with their future posts.

Second is the post's quality. The more people have engaged (e.g. liked or

commented) with a post, the more interesting Facebook thinks it is, so the more likely it is to appear at the top of your news feed.

Third, the type of post. Facebook figures out what kinds of posts (videos, articles, photos, etc.) you interact with a lot and shows you more of those.

The last factor is "recency": newer stories get higher priority.[159]

There are plenty more factors, though. TIME found a few:

> Use a phone with a slow mobile connection and you may see less video. Writing 'congratulations' in a comment signals the post is probably about a big life event, so it will get a boost. Liking an article after you clicked it is a stronger positive signal than liking before, since it means you probably read the piece and enjoyed it. [160]

As you can tell, Facebook really tries to maximize the probability that you're going to like or comment on the posts in your news feed. After all, the more you like your news feed, the more you're going to scroll down, and the more you scroll down, the more ads you'll see. Ads, of course, are how Facebook makes most of its money.[161]

Score 1.4	Score 1.3	Score 0.8
Photo	Video	Link
Friend	Family	Publisher
100 likes	20 likes	5 likes
8 comments	2 comments	0 comments

An example of how Facebook ranks posts and determines what appears on your newsfeed. Source: TechCrunch[162]

Fighting fake news

Algorithms like Facebook's news feed algorithm are incredibly powerful, but the danger is that they're still easy for crafty hackers to game. With no human oversight, the algorithms could be turned against us. A famous example is the fake news epidemic that swept Facebook during the 2016 American presidential election. Notice that the news feed algorithm we mentioned above doesn't consider how true or reputable a post is; it only cares about maximizing engagement. Fake news-mongers took advantage of this to attack politicians they didn't like, posting outrageous and demonstrably false news articles around Facebook. These articles naturally drew many clicks and comments, so Facebook's news feed algorithm propelled them to the top of many people's news feeds.[163]

How do you fix weaknesses like this in the news feed algorithm? You might need to bring back a human touch to the algorithm — which is a bit ironic because algorithms are designed to reduce the amount of work humans have to do in the first place. For instance, Facebook and Google have introduced features that let people flag fake news posts, which their updated algorithms can then hide.[164]

Even outside the battle against fake news, Facebook has been bringing in humans to improve the news feed algorithm, because counting likes can only tell you so much about how people feel about posts. In 2015, Facebook started hiring focus groups that scroll through their news feeds and give feedback to the people behind Facebook's news feed algorithm.[165] (Yes, that's right, you *can* be a professional Facebook tester, but we recommend staying in school regardless.)

Algorithms aren't magic spells that run the world. They're just sets of rules (although complex ones) that other people wrote to make computers do a particular task. And, as Facebook shows, sometimes machines and people need to work together.

What technologies do Uber, Yelp, and Pokémon Go all have in common?

Ever tried making a digital map? It's pretty hard. You need to keep track of every road, building, city, and shoreline on the planet. Maybe you'll need a fleet of cars to drive around the world and take pictures and measurements, as Google has done for Google Maps.[166] Oh, you'll also need to make a nice interface with features like panning and zooming. (Don't get us started on making an algorithm to find driving directions between two points.)

In short, making a digital map is really hard. But apps like Uber, Pokémon Go, and Yelp need to include a map to show where available cars are, help the user find wild Pokémon, or display nearby restaurants. Do these apps need to spend thousands of person-hours making their own maps?

Fortunately for them, the answer is no. And if you've ever used these apps, you can probably figure out what they do instead: they embed a Google Map in their app. Searching up restaurants? Yelp drops pins on a Google Map centered on your location. Want to Uber downtown? The app draws the route you'll take on a Google Map and calculates the approximate time it'll take to get there.[167]
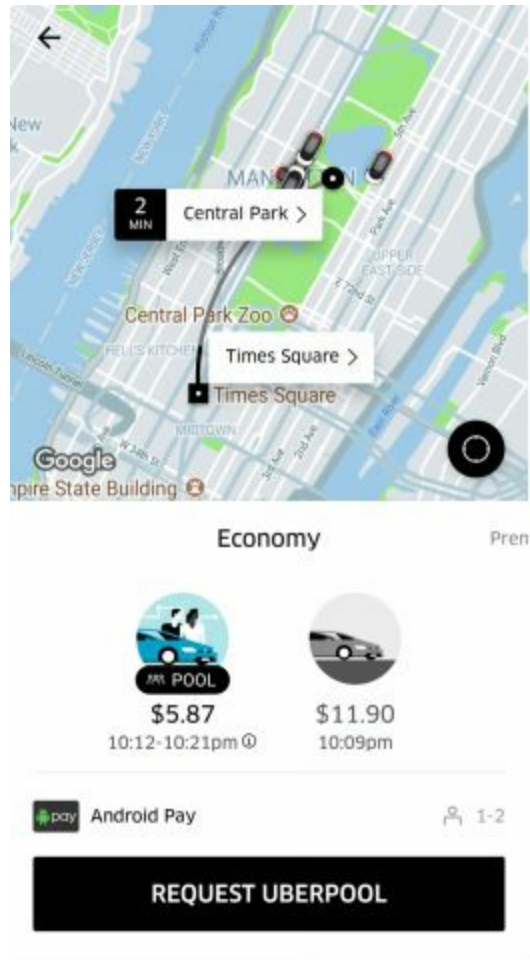
Uber uses the Google Maps API to draw a map of your area and predict your car's travel time. Source: Uber on Android

Google lets you include a small snippet of code in your app to draw a Google Map, and it provides other snippets of code to let you draw on the maps, calculate driving directions between points on the map, and even find out the speed limit for a particular road. All of these tools are cheap or even free.[168] These tools are big win for developers; they can use the technology that has taken Google years to perfect with just a small amount of code. There's no need to reinvent the wheel!

These snippets of code that let you borrow another app's functionality or data are called APIs, or application programming interfaces. In short, APIs let apps talk to each other. There are three main kinds of APIs.

The first kind of API lets one app ask another specialized app to solve a

particular problem, like calculating driving directions, sending text messages, or translating sentences. It's like how you could call a plumber or carpenter to fix problems around your house instead of trying to do it yourself. Here's an example: processing credit card payments is pretty difficult, so apps that charge you (like Uber[169]) can use PayPal's Braintree API, which lets anyone use PayPal's algorithm for processing credit card payments with just a few lines of code.[170] It's a pain to write code yourself that sends emails or text messages — so when apps like Venmo need to send you confirmation emails or texts, they can just use a specialized API.[171] And any app that lets you log in via Facebook or Google uses those websites' APIs for verifying someone's identity.[172]

The second type of API lets one app ask another app to hand over some interesting information, such as sports scores, recent Tweets, or today's weather. It's like calling the front desk at a hotel to learn which museums and restaurants they recommend. ESPN offers an API that lets you get rosters for every major-league sports team and scores for every game.[173] New York's subway system lets you track where trains are and predict when the next train will arrive at a station.[174] The US government offers APIs that let you access all kinds of data about American healthcare, energy, agriculture, and more. [175] And don't worry, there's even an API to get random images of cats.[176]

The final kind of APIs lets developers access features of the device itself. Snapchat taps into your phone's Camera API to zoom, focus, and snap photos. Google Maps itself uses your phone's Geolocation API to figure out where in the world you are. Your phone even has sensors called accelerometers and gyroscopes, which fitness apps (and Pokémon Go) use to determine which direction you're walking and how fast you're moving.[177]

It's worth noting that APIs aren't perfect. Using an API makes app developers' lives easier, but it also makes their apps dependent on the API. [178] If PayPal's Braintree payment API somehow stopped working, Uber would be unable to process payments — not great for their business. Still, a specialized company's API will likely be more reliable than any similar feature that a non-specialist company could make themselves.

All this brings us back to the question: what technologies do Uber, Yelp, and Pokémon Go have in common? They all use APIs, especially the Google Maps API, to avoid reinventing the wheel. Indeed, APIs are a core part of pretty much every app out there.

Why does Tinder make you log in with Facebook?

Swipe Right to anonymously
like someone or Swipe Left to
pass

LIKE

LOG IN WITH FACEBOOK

We don't post anything to Facebook. ∨
By signing in, you agree with our Terms of Service and
Privacy Policy
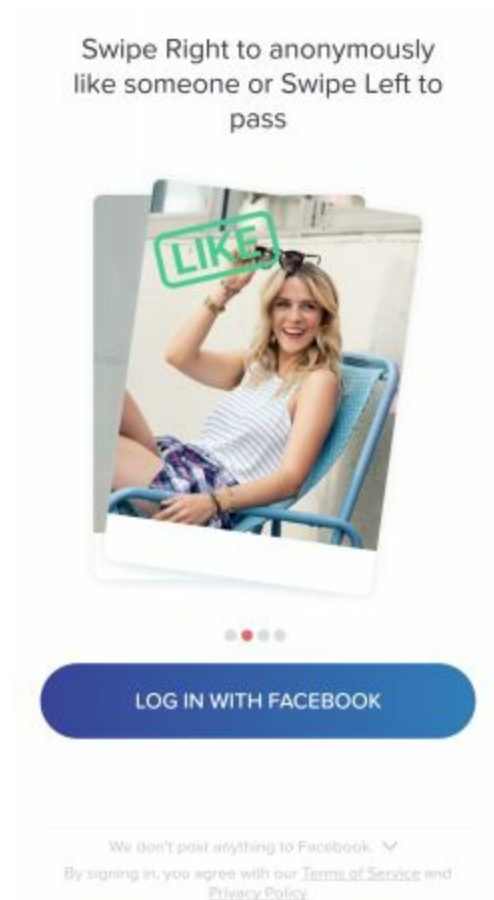
Tinder on Android. Note that the only way to sign in is with Facebook.

If you've ever used the dating app Tinder, you'll notice that they make you log in with your Facebook account before you can set up a profile. Once you connect your Facebook profile, Tinder imports information like your profile picture, your age, your list of friends, and the Facebook pages you like.[179] As you might have guessed, this is an API that Facebook offers. With this API, any app can let users create accounts by linking their Facebook profiles. [180]

Why does Tinder use this API? For one, it ensures that there are no empty profiles (which no one would want to swipe on) since some basic information

always gets imported from Facebook.[181] Second, requiring Facebook login helps them stop bots, since bots are less likely to have Facebook accounts.[182] Third, this helps Tinder make better matches: by gathering your friend list, Tinder can show you how many mutual friends you have with each potential match, and that sense of connection probably encourages people to swipe more. Finally, by getting the Facebook profiles of all their users, Tinder can get some deep insights into their user base, such as how old they are, where they live, or what they're interested in.[183] That's great data for their product designers to use.

Signing up with Facebook is also helpful for users. Making your profile with Tinder becomes much faster when most of your basic information and pictures are already imported from Facebook.[184] Seeing more completed profiles and fewer bots improves your experience, as well.[185] And signing up with Facebook means you don't have to remember yet another username and password.[186]

Why would Facebook publish the API that lets people sign in to other websites using their Facebook credentials? Well, when you use Facebook's sign-in API (often called "single sign-on," or SSO) to register for Tinder, Facebook realizes that you're a Tinder user. Facebook gets similar data points when you use Facebook to log into other websites. Facebook can then use this data to target ads at you more effectively, for instance by showing more dating-related ads to Tinder users.[187]

As this example shows, publishing APIs is a great way for companies to gather data and usage, and using APIs helps apps save time and offer better features. The ultimate winner is you, the user.

Why does Uber let other apps use Ubers to deliver their products?

In 2015, Uber published an API called UberRUSH that lets other app developers ship items short distances using Ubers.[188] For instance, a local florist could use the UberRUSH API to deliver flowers using Ubers instead of hiring their own fleet of drivers.[189] In other words, the API lets other companies pay to use Uber's huge driver network and logistics infrastructure.[190] Why did Uber bother going through the hassle of making and publishing this API?

An example of a website that uses the UberRUSH API to deliver items using Ubers. Source: Uber[191]

The most obvious reason is money. Uber can charge a bit for companies to use UberRUSH.[192] There are some more interesting reasons, though.

The second reason is to help Uber expand its market. Uber is already a leader in transporting people on demand,[193] but before UberRUSH, Uber wasn't competing in the market of transporting *objects* on demand. Uber wanted to be sure they won that market before someone else, like the fast food-delivery service Postmates, beat them to it.[194] In fact, UberRUSH might even let Uber start competing with traditional shipping companies like FedEx and UPS in the same-day shipping space.[195] It's a savvy business move.

The third reason is users and data. By expanding into the "ship things short

distances on demand" market, Uber can attract new customers and drivers and run more trips. Uber's key strength (or "core competency," as businesspeople call it[196]) is its huge driver network,[197] so attracting new drivers is a big win. More trips also means more ride data, which can help Uber improve its services — for instance, by helping Uber figure out where to place cars to minimize riders' wait times.[198]

So why does Uber publish an API that lets other app developers deliver stuff with Ubers? It's not just to be nice. The API lets Uber make money, expand into new markets, and gather more customers, drivers, and data. Meanwhile, the companies that use UberRUSH to ship things avoid the cost and headache of operating their own driver network.[199] It's a win-win.

How does your weather app work?

Pull out your phone and open the weather app. Let's use it as an example to show how you can understand almost any app by analyzing which APIs and algorithms it uses.

Your weather app will probably look something like this:

The Weather Underground app on Android.

Let's dive into the screenshot to figure out how the app works.

First, consider the APIs it uses. As you can tell from the map, the Weather Underground app embeds a Google Map (just like Uber, Yelp, and so many other apps) and then uses the Google Maps API to draw temperatures and

weather patterns (green blobs for rain, white blobs for snow, etc.) on top.[200] Second, whenever you plug in a zip code, the app uses a zip code API to figure out which city you mean.[201] For instance, entering 60601 shows you the weather for scenic Chicago, Illinois. Third, if you hit the button that looks like a target in the top right, the app will use your phone's Geolocation API to figure out your GPS location and show you the weather for that place. And finally, Weather Underground gets its weather data, such as the current temperature and probability of rain, from the National Weather Service, which offers all the weather data that the American government collects through a free API.[202]

Current weather information is great, but weather app users really want to know what future weather will be. So the National Weather Service, Weather Underground, and other companies use algorithms to predict future weather based on current weather conditions, recent weather trends, and other factors. The National Weather Service, for instance, uses the Weather Forecasting Model, an algorithm that simulates the physics of the atmosphere to make weather predictions.[203]

These APIs and algorithms are the heart of the weather app, and they might just be enough to build a weather app yourself. If you use this same lens to look at your favorite apps — from Pokémon Go to Snapchat to your to-do list app — you can start making sense of how these apps really work.

Why does every Washington Post article have two versions of the headline?

Take a look at the following two screenshots of the same Washington Post piece. Notice anything different?

Notice a difference? The Washington Post shows people different versions of the same headline. It's part of an experiment to figure out which one gets more clicks. Source: The Washington Post[204]

That's right, the headlines are different! In 2016, the Washington Post rolled out a feature that lets article writers specify two different headlines for every article.[205] But why?

It's actually an experiment that the newspaper runs to maximize the number of clicks on its articles.[206] This experiment automatically shows one version of the headline to one group of visitors; let's say one-half of them, randomly chosen. It shows the other version to the remaining visitors. After letting the experiment run for a while, developers look at particular statistics, or metrics, like the number of clicks on the headline. Developers decide which version is better and show the winning version to everyone. This is a simple but powerful way to improve an app's metrics. For instance, the first version of the above headline was clicked 3.3% of the time, while the bottom version was clicked 3.9%[207] — that's an 18% jump, just by changing a few words!

This technique is called A/B testing, which you might remember from the start of the chapter. A/B testing is a powerful, data-driven way to improve online products.[208] It's called "A/B" because you compare at least two

versions of a feature, A and B.
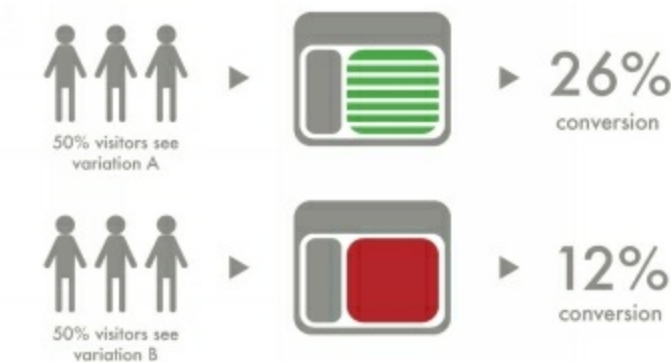
A/B testing shows at least two variations of the same feature (A and B) and compares relevant metrics to decide which variation to push to all users. In this case, everyone would start seeing variation A, which had better metrics. Source: VWO[209]

Not sure which marketing catchphrase will get people to buy? Instead of endless debating, just run an A/B test! Not sure if a red or green "sign up" button will get more people to click? Run a test! (If you're curious, the red button got 34% more clicks in one experiment.[210]) Not sure which Tinder profile picture will get you the most swipes? Guess what: Tinder automatically runs A/B tests to decide which of your photos, when shown as your main profile picture, gets you the most right swipes.[211]

That brings us back to the question: why does every Washington Post article have two versions of the same headline? It's part of the Washington Post's A/B testing framework, called Bandito. Bandito tries out different versions of the headline to see which one people click on more, and then shows the winning headline more often.[212] (Technically, it's a little more sophisticated than an A/B test — it's a so-called "multi-armed bandit" algorithm[213] — but the core idea is the same.)

A/B testing is very popular among news outlets. BuzzFeed uses A/B tests to find the most clickbaity headlines as well.[214] A BuzzFeed competitor called Upworthy actually tries up to 25 versions of the same headline in its quest to find the perfect one.[215] A/B testing is very important: according to Upworthy, the difference between a decent headline and a perfected one is

1,000 vs. 1,000,000 views.[216]

Many more apps and websites use A/B testing. Facebook, for instance, is always rolling out new features to "limited test audiences."[217] Snapchat lets advertisers A/B test their ads to pick the ones that get tapped the most.[218] Even brick-and-mortar stores can do A/B testing: one startup, for instance, lets stores vary the background music they play to maximize shoppers' spending.[219] A/B testing really is everywhere.

Validity testing

There's one important caveat to keep in mind whenever you're doing statistical tests: you need to check whether your observed findings happened because of something meaningful or were just due to chance. For instance, if you flip a coin six times and get five heads, you can't be confident that the coin is unfairly weighted toward heads — it could just be dumb luck. But if you flipped the coin six hundred times and got five hundred heads, you might be on to something.

When companies perform A/B tests, experimenters report how one version changed a particular metric compared to the other version. They also report a statistic called a *p*-value, which shows the probability that the difference they observed was due to chance.[220] Usually, if $p < 0.05$ (i.e. there's a less than 5% chance that the difference was just random), they can assume the change was meaningful, or "statistically significant."[221] Otherwise, they can't be sure that their results weren't just dumb luck.

For example, say Amazon made the "Add to Cart" buttons a bit bigger for half their users and found a 5% increase in sales, with $p = 0.15$. While the bigger button seems like a great move, there's a 15% chance that the sales boost was caused by dumb luck, not the button. That 0.15 is greater than 0.05, so Amazon's testers won't roll out the bigger button. (A cutoff of 0.05 might seem too strict, but statisticians are very careful people.[222])

So if you ever get clickbaited by a headline like "18 Food Arguments So Strong That They End Friendships,"[223] don't feel too bad — you're up

against a powerful blend of social science, software development, and statistics. Like it or not, A/B testing is extremely effective.

Chapter 4: App Economics

Back in 2010, Apple trademarked the catchphrase "there's an app for that."[224] And, indeed, it seems as if apps are taking over the world. Billion-dollar companies like Uber (founded 2008[225]), Airbnb (also 2008[226]), and Snapchat (2011[227]) are based on little more than an app. This entire "app economy" was valued at over $50 billion in 2016, and it was projected to double in just four years.[228]

So how do those little tiles on your phone screen lead to billions of dollars in economic activity? The rules for this "app economy" are very different than the rules of the "traditional" economy, where people just walk into stores and buy items off the shelf. In this chapter, we'll explore this strange new world of apps. We'll meet a wide range of totally free-to-download apps that, somehow, make millions — or even billions — of dollars. We'll dive into these apps' business models and why they work.

So let's unlock how this new world of apps helps people get rich — or go broke.

Why is almost every app free to download?

A medium pizza might cost you $9.99. A car wash will set you back $15. You'll need to fork over about $45 a month for a data plan.

But almost every app you have on your phone is free. Instagram, Snapchat, Dropbox, Candy Crush, Google Maps — all free. In fact, of all the highest-grossing apps on Android and iOS, only one paid app cracks the top 100, and it's Minecraft.[229] And we haven't even talked about websites, which are almost always free to read.

And yet, many companies that produce these free-to-download apps are raking in millions. For instance, the Snapchat app is totally free, yet Snapchat's parent company (Snap, Inc.) was valued at $33 billion when it went public in 2017.[230] It shows just how different the app economy is from the "normal" economy: if Pizza Hut said they were going to make money while giving away pizzas for free, you'd think they were crazy.

So how do app makers make money without selling software? They've come up with some pretty clever business models, also known as "monetization" strategies. Let's take a look at one of the most popular ones, called "freemium."

Freemium: more features, at a price

If you've ever played Candy Crush, you'll notice that the app is free, but once you start playing, you're bombarded with offers to use real money to buy extra lives or to unlock new levels.[231] Similarly, Tinder lets you "swipe" on potential romantic partners — but only a few dozen a day. If you want to get more "swipes," you'll need to pay for Tinder Plus, a monthly subscription.[232]

This business model is called "freemium,"[233] and it's pretty simple. Give away your app for free, so people will download it, then make them pay for extra "premium" features (hence the name "freemium").[234] Freemium is

everywhere: it's how many mobile games like Candy Crush and Pokémon Go make money,[235] and it's extremely popular among popular apps like Tinder,[236] Spotify,[237] and Dropbox.[238]

Freemium apps usually use one of two strategies to make money: in-app purchases or paid subscriptions. Let's dive into both.

In-app purchases
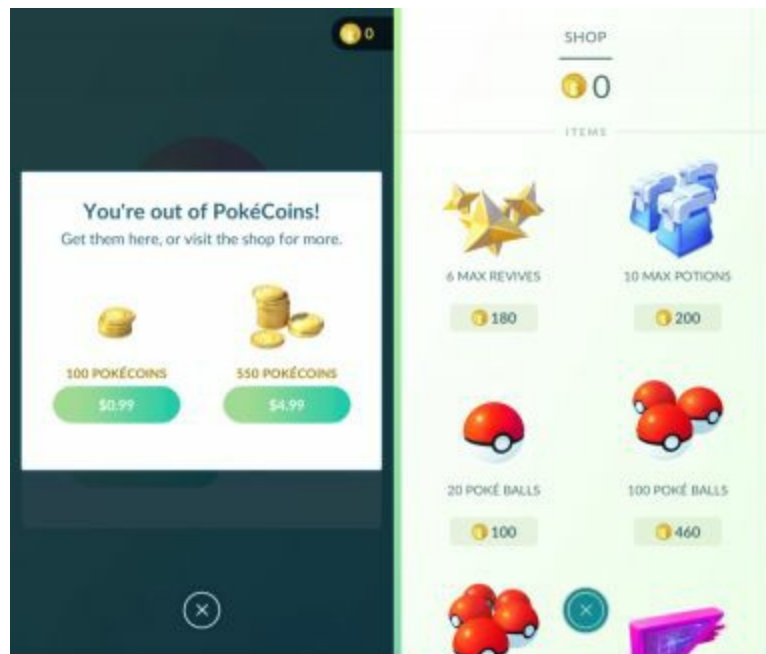
Pokémon Go is free to play, but you can use real money to buy coins, which can be swapped for in-game goodies. (Yes, we have zero coins; we admit we're not Pokémon experts.) Source: Pokémon Go on Android

In-app purchases usually refer to extra features or goodies in the app that you can pay real money for.[239] In-app purchases are mobile games' bread and butter. Candy Crush, as we mentioned, peddles extra lives. Pokémon Go lets you buy coins, which can be redeemed for extra Poké Balls or Potions that'll let you beef up your pet monsters.[240] Paid upgrades are nothing new for games, though. Even decades-old PC games like *World of Warcraft*[241] or *SimCity*[242] have long offered paid "expansion packs."

Other apps besides games also use in-app purchases, though not quite as

frequently. There are still several examples. Snapchat, for instance, lets you buy your own customized geofilters for special events.[243] And many Android/iOS apps that normally show ads will let you buy an upgrade to remove them.[244]

Paid subscriptions

Besides in-app purchases, the other major "freemium" business model is paid subscriptions, similar to your monthly phone bill. Usually, subscriptions let you unlock useful new features in exchange for a monthly payment. Paid subscriptions are easy to spot; just look for "Plus," "Premium," or "Gold."

Subscriptions are more the territory of non-game apps, and they are everywhere. We mentioned Tinder Plus, which lets you pay a small monthly fee to get unlimited swipes and extra features.[245] LinkedIn requires a monthly payment for LinkedIn Premium, which lets you email people you aren't connected to.[246] You can stream music for free with Spotify, but to remove ads and store music offline, you'll have to pay for the Premium subscription.[247] Even Microsoft, which has for years made money selling Office and Windows, new offers some Office apps for free but encourages users to buy annual subscriptions to Office 365.[248]
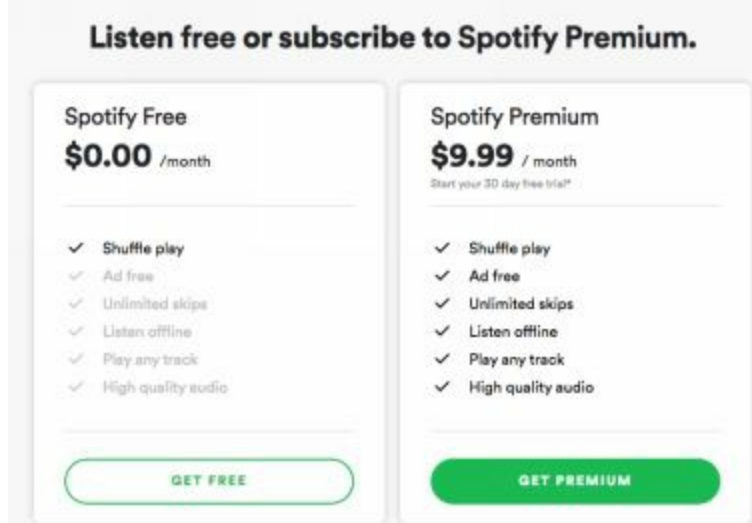
Spotify Premium is a classic example of a paid subscription: pay a small monthly fee to get extra features. Source: Spotify[249]

Some websites and apps have also started using subscriptions: the New York Times, for instance, lets you read a few articles a month for free but makes you pay monthly to get unlimited access.[250]

Whale hunting

Most people are willing to pay exactly zero dollars for software; one study found that only 6% of all iOS app downloads were for paid apps.[251] Yes, even $1 is too much for most people. But while most people won't pay anything, the small fraction of people who use the app the most are often willing to pay a lot of money. Economists call this the 80-20 principle or the Pareto principle: 20% of your customers will generate 80% of your revenue, and 80% of your customers will provide the other 20%.[252]

The key for app developers is to find the small fraction of people who want to pay money (called "whales" in the industry, probably because they're rare but huge) and squeeze as much cash as possible out of them.[253] These whales are big: the average paying user of a mobile game spends $86.50 on in-app purchases every year.[254] Some whales are of positively Moby Dickian proportions: in 2015, the title *Game of War: Fire Age* earned almost $550 per paying user.[255]

Because the heaviest users of an app are the most likely to pay, most in-app purchases or subscriptions are aimed at the most dedicated users. For instance, remember how Tinder lets you pay for unlimited swipes. Most users will never swipe enough to run out of the few dozen free swipes you get per day, but the most enthusiastic Tinderers will quickly run out. And because these users are so committed to Tinder, they won't mind paying a few dollars to get more use out of it — whereas most casual users would balk at even a small fee.[256]

So, why are most apps free to download? The freemium business model is one big reason. In the rest of this chapter, we'll explore other ways that apps can make money without selling you anything.

How does Facebook make billions without charging users a penny?

Freemium can be highly profitable. But think about Google and Facebook. You've probably been using their apps — from Maps and Docs to Instagram and the Facebook app — for years, yet you've likely never paid them a single cent.[257] So if they don't use freemium, how do they make money?

The simple answer: targeted ads. Let's break down what both of these words mean.

Ad auctions

As you've probably seen, apps and websites have long used ads to make money. They'll charge advertisers a small fee to show their ads on the app or website. But how exactly do apps and websites how much to charge for ads? There are two main approaches.

First, apps and websites can charge advertisers a small fee every time someone views an ad, a strategy called Pay-Per-Impression (PPI).[258] Since so many people view ads, apps and websites usually charge in increments of 1000 views; that is, the pricing for an ad campaign could be $5 for 1000 "impressions." Because advertisers often pay for every 1000 views, Pay-Per-Impression is also called CPM, or Cost-Per-Mille.[259] (*Mille* comes from the prefix *milli*, as in *millimeter*.)

Alternatively, apps and websites can charge advertisers whenever someone actually clicks an ad, which is called Pay-Per-Click (PPC).[260]

Google[261] and Facebook[262] offer both Pay-Per-Impression (PPI or CPM) and Pay-Per-Click (PPC) advertising to earn money from ads. An advertiser who wants to place an ad on Google or Facebook services, like Google Search or Facebook's news feed, specifies their "bid," or how much they'd be willing to pay per click or view. Every time a visitor loads a page, all the advertisers face off in an instant "auction," and the winner's ad gets shown.

[263] Having a higher bid makes your ad more likely to show up, but the highest bidder doesn't necessarily win; Google and Facebook consider a few other criteria, like how relevant the ad is, to decide which app to show. Why? More relevant ads will probably get clicked more, so they might make more money than a less relevant ad with a higher bid. Think about it: if you were Google, would you rather show a $5 ad that gets clicked 5 times or a $1 ad that gets clicked 100 times?[264]

Ads are how Google and Facebook make money, but the reason they make *so much* money is because of a technique called targeting.[265]

Targeting ads

Would you ever click on an ad for sofas unless you were actively shopping for furniture? Probably not. That's one of the pitfalls of ads: blasting your message to everyone can be wasteful when only a small audience would be interested.[266] But what if advertisers strategically showed you sofa ads when you were moving into a dorm room or new house and needed new furniture? That would probably be more effective.

This "ad targeting" strategy is how Google and Facebook really set themselves apart. Because you do so much on Google's and Facebook's apps and websites, these companies know a lot about what you like. They then use this data to target ads to you, which lets them rake in advertising dollars while giving you the service for free.[267]

For example, if Google notices that you search for "guide for choosing a watch" or "how much does a cheap watch cost," Google could infer that you're shopping for a wristwatch. Then they could show you ads for watches when you're doing future searches. Since these hyper-targeted ads are more relevant to you, you're more likely to click on them than non-targeted ads.[268] More clicks leads to more purchases, so targeted ads help advertisers make more money.

In other words, targeting ads improves the "click-through rate," which gets advertisers more bang for their buck. Since they have more data on users than

anyone else, Google and Facebook can target ads extremely well, and so they can charge advertisers top dollar.[269] The business of targeting ads based on user data is lucrative: Google and Facebook rely on ads for almost all of their revenue.[270] Facebook, for instance, made over $7 billion in ad revenue in the third quarter of 2016.[271]

So, are targeted ads good or evil? Privacy advocates are worried about how these big companies can track your every click[272] and know vast amounts about your interests, habits, and activities.[273] But maybe that's just the cost of doing business: there's no such thing as a free lunch, and instead of paying for Google and Facebook products with money, you're paying with personal data.[274] This debate is summed up in the Silicon Valley proverb: "If you aren't paying for the product, you *are* the product."[275]

Some caveats

It's important to know that Google and Facebook don't sell your data to advertisers. Advertisers submit ads to Google and Facebook, and the two companies use user data to decide what ads to show you. Your data is used extensively on Google and Facebook computers, but it never leaves them.[276] In fact, selling your data to advertisers would actually *hurt* Google and Facebook, because then advertisers would stop buying their ad-targeting services, which would lose Google and Facebook money in the long run.[277]

Also, don't forget that the targeted ads approach is less common than you think. Google and Facebook have a near chokehold on advertising, together accounting for about half of the entire mobile ad market.[278] It's much harder for smaller app makers to start selling user data because advertisers would rather just buy from Google and Facebook, who have far more data on users.[279]

Still, some companies are making a dent; the key is to master a market that Google and Facebook know little about.[280] For instance, Snapchat drew praise in 2016 for being extremely popular among teenagers, a market where Facebook had historically been weak.[281] As such, advertisers who cater to teenagers started choosing Snapchat.[282] This helped Snapchat get a foothold

in the advertising market: Snapchat earned $180 million in revenue in the second quarter of 2017.[283]

For all the nuance, don't lose sight of the big picture: even if a company doesn't charge you anything, it can still bring in billions of dollars. That's the incredible part of the app economy.

Why do online news platforms have so much "sponsored content?"

When you think of ads, you might think of banner ads: those flashy, animated rectangles that show up on webpages or at the bottom of apps. They remain popular on websites, although fewer and fewer major apps have banner ads nowadays, probably because ads are annoying and take up valuable space.[284] Plus, people rarely click on banner ads anymore, so they aren't very profitable. In fact, people only intentionally click on banner ads 0.17% of the time[285] — that's roughly 1 out of every 600 ads you see.

But now, there's a new kind of ad on the block, and it's less intrusive and harder to ignore.[286] When you scroll through your Instagram feed, you might notice some posts that aren't from your friends but rather from companies trying to sell you something.[287] Snapchat lets advertisers make filters that all users see,[288] and Twitter even lets advertisers buy hashtags that start "trending."[289]

The word you see attached to all of these? "Sponsored."[290] Sponsored content, also called "native advertising," means ads that blend in with normal content, making viewers more likely to take the ads seriously instead of ignoring them.[291]

Sponsored content is growing especially quickly in the world of journalism. [292] Advertisers can pay to include legitimate-looking articles (which are really just ads) amidst normal material on websites like the New York Times, CNN, NBC, and the Wall Street Journal.[293] Newer media companies like BuzzFeed also love native advertising.[294] An example: the New York Times once ran a story about why the traditional jail system doesn't work for female inmates. It was a well-researched and engaging story, but it was all an advertisement for the Netflix series *Orange is the New Black.*[295]

Sponsored content is highly effective for advertisers: native ads are clicked on over twice as much as banner ads.[296] And it's become a powerful revenue

stream for news publications. For instance, in 2016, the Atlantic expected to earn three-quarters of its digital ad revenue from native ads.[297]

Native advertising is powerful, but it's dangerous all the same because it makes it harder for people to distinguish facts from marketing.[298] In fact, Reuters found that 43% of American readers felt "disappointed or deceived" by native advertising.[299] And, more fundamentally, native advertising breaks down the walls that news publications have traditionally placed between journalists and businesspeople.[300] In other words, if the same people who report the news are now writing advertisements, journalistic integrity could be compromised.[301]

Is there a silver lining to native advertising? Maybe. One study found that 22% of consumers thought native advertising was educational, versus just 4% who thought the same of banner ads.[302]

How does Airbnb make money?

Amazon, Uber, and Airbnb are all free to download, never bill you for using the app, and show you few, if any, ads. So how do they make money?

"Marketplace" or "platform" apps like these, which connect buyers to sellers (or riders to drivers, etc.), earn commission by sneaking some fees into the purchases you make.[303] It's like how the government makes money using sales tax, or how a real estate agent charges commission whenever they help you buy or sell a house.

For example, Airbnb includes a "services fee" whenever you make a booking. Hosts pay 3%, and guests pay another 6-12%.[304] These fees provide most of Airbnb's revenue.[305]

Airbnb makes money by charging you a small "service fee" on top of any reservation you make. Source: Airbnb[306]

Other marketplace apps also take commissions. Uber grabs 20-25% of the

money that drivers earn.[307] Amazon also takes a cut when third-party sellers list and sell their items on the platform.[308]

So that's how most marketplace apps make money. Can any buying-and-selling apps make money without charging commission? Read on.

How does the app Robinhood let you trade stocks with zero commission?

Buying and selling stocks is a great way to invest your earnings and make extra money, but with every trade you have to pay some commission to a broker. Or do you? The stock-trading app Robinhood lets you make trades for free.[309] That's right, zero commission.

So how do they stay in business? There are two main ways Robinhood makes money.[310]

First, they employ the classic freemium model to help "power" users get more functionality. Robinhood Gold lets you trade after hours (i.e. for a few hours before and after the normal trading day, which is 9:30am to 4pm EST), and it lets you borrow money from Robinhood to make additional purchases beyond what you can currently afford.[311]

The second way is pretty clever. Robinhood earns interest from unused money sitting in users' accounts in much the same way that you earn interest by stashing your unused money in a bank.[312]

As you can see, apps are getting crafty with their business models. Let's finish the chapter with a look at some even more creative approaches.

How can apps make money without ads or charging users?

Every app we've talked about so far makes money by showing ads or charging users (if not up front, then through subscriptions, in-app purchases, or commissions). Is there another way for app businesses to stay afloat? Can apps get money from anyone besides users or advertisers?

As it turns out, the answer is yes. Let's finish up the chapter by looking at some of these clever business models.

First, you could charge people besides the users. The travel-booking service Wanderu, for instance, helps you find the best bus tickets and refers you to the websites of bus lines like Greyhound and Megabus to purchase them. Wanderu doesn't charge shoppers anything, but it takes a small commission from the bus lines for the privilege of sending customers their way.[313]

Or, apps could try to survive without making any revenue at all. It sounds impossible, but in the world of tech, it can happen — temporarily, at least.

Some apps just live on borrowed time (and venture capitalist money), providing free service until they get large enough that they can start earning — in other words, "grow first, monetize later."[314] For instance, Venmo makes no money from your payments to friends. It charges nothing if you transfer money between bank accounts, and if you're transferring money from your credit card, it only charges you the same fee (3%) that it's required to pay to the payment processing company.[315] But, once it gets enough market share, Venmo plans to make money by letting customers pay in stores with Venmo (similarly to Apple Pay), from which Venmo can take a small cut.[316]

Other apps just hope to be bought before their money runs out. For instance, a free email app called Mailbox hit the market in 2013, and soon it was delivering 60 million messages a day.[317] Then, within a month of launch,

Dropbox bought the app and the team behind it[318] for $100 million.[319] There's a slightly tragic ending, though: Dropbox killed the app in 2015 and shuffled the employees to different teams.[320] Call it cynical, but Mailbox's ability to grow explosively and get to an attractive "exit" was because it offered its service for free.[321]

In short, app makers have had to become ever more crafty now that users demand free-to-download apps. The remarkable part is that they never seem to run out of clever ways to monetize. What's the next big monetization strategy? Now that you've read this chapter, maybe you'll be able to figure it out.

Chapter 5: Cloud Computing

When technologists rave about "the cloud", they haven't become meteorologists. They're just referring to a trend of storing files and running apps over the internet instead of on your own phone or computer. You can store your files online with Dropbox instead of keeping them in the physical hard drive of your own laptop, or you can edit documents online with Google Docs instead of desktop apps like Microsoft Word.

This seemingly-simple shift has upended the software industry, consumer tech, and the way developers build apps. So how does it work? In this chapter, we'll start by exploring what the cloud is. Then we'll look at how the cloud can explain several major shifts in consumer tech, like why Adobe made it impossible for you to own Photoshop anymore and why Microsoft released a "subscription-based" version of Office. Third, we'll turn to the enterprise space to learn how big companies like Netflix are using the cloud to massively improve their business, but also how relying on the cloud could cause millions of sites to crash at once. Let's jump in.

How is Google Drive like Uber?

Before we dive into "the cloud", let's talk about cars. Owning a car gets expensive; between fuel, insurance, repairs, taxes, and other costs, you'll have to fork over $8000 a year.[322] But you need a car to get around, unless you only spend time in big cities with public transit. (And even then, you need a car when public transit closes.)

Or do you?

"Ridesharing" apps like Uber, Lyft, and Zipcar, and even taxis and car rental companies, aim to solve this problem by letting people get rides on demand. No need to own a car; just rent one when you need it. (We'll choose Uber as an example, but any of the other companies would work too.) Uber's cost and convenience can be really useful. If you drive less than 9,500 miles a year, Uber is cheaper than owning a car[323]. Uber also lets you get around anytime, anywhere, no matter where your car is; you also don't have to worry about repairs, gas, or car theft, since you don't own the cars you're riding in.[324]

What does this have to do with computers? Well, the world of technology has been undergoing a change pretty similar to the car-to-Uber shift. Traditionally, you'd run apps like Microsoft Word on your computer, and you'd store all your photos, documents, and other files on your hard drive. But in 2006, Google launched Google Docs,[325] and in 2012 they rolled out Google Drive.[326] With these services, you're no longer bound to your laptop. Files you keep in Google Drive can be used anywhere, on any internet-connected device; you can run Google Docs on any browser or phone. This trend, where apps and files live online, is called *cloud computing* or *the cloud*.[327]

With Google Drive, you don't have to worry about owning and repairing a hard drive. Even if your hard drive breaks, you're fine. If you're in New York but left your laptop in California, no big deal — you can log in to Google anywhere to get your stuff. And you only pay for as much as you need: you get 15GB free storage, and you can pay a few extra bucks for more space.[328]

You can start to see how this is similar to Uber. With Uber, you don't have to worry about owning a car. Even if your car breaks down, or if you're on the other side of the continent from your car, you can still call an Uber as long as you have an internet connection. And, instead of paying that $8,000 a year for a car, you only pay for as much travel as you need to do.

In short, cloud computing, like Google Drive, is like Uber for computers.[329] Instead of owning your own car or computer, you can get your files or transportation on-demand from anywhere with an internet connection.

When you look harder, cloud computing is everywhere. Gmail is a classic example: you access your emails from a website.[330] Spotify lets you listen to music over the internet instead of downloading and owning songs. Your iPhone stores your texts and other files on Apple's iCloud so that they all come back even when you switch to a new phone. And so on.

Where do things in "the cloud" live?

When you visit Google Drive in your browser, your files show up as if by magic. You can tap a button on Spotify and music will start playing. But all computer files — from spreadsheets to songs — must exist as 0's and 1's on a computer somewhere. But if these files aren't on your computer, where are they?

Technologists will tell you that this information lives "in the cloud", but that's not that helpful.[331] Obviously, there are no giant floating computers that store your data. What does this weird buzzword mean?

The world of servers

Simply put: "the cloud" is just someone else's computer. When you make a Google Doc on Google Drive, all your text and photos are stored on Google's computers instead of your own. Whenever you run Gmail, the email processing is also done on Google's computers instead of your own.

Now, when we say "Google's computers," we don't mean that the files live on some Google employee's laptop. Instead, Google Docs lives on Google "servers," which are powerful computers that specialize in storing data and running apps and websites. Since servers are only used for their computational might, they usually lack keyboards, mice, screens, and user apps like iTunes or Chrome. Since apps need to be running 24/7, servers are always on (or at least they try to be).[332]

Servers are often stored in huge buildings called "data centers," which feature racks and racks of stacked servers. Data centers can't be any old building, though. Data centers need to have powerful cooling systems, since servers get really hot; data centers also need backup electrical generators in case the power goes out.[333]

A view inside a data center, with many servers — computers that run websites and apps — in the foreground. Source: Torkild Retvedt[334]

So what do these servers do? Whenever you log into Google Docs to view your document, Google retrieves your data from its servers and shows it to you. Similarly, when you play music off Spotify, those music files live on Google servers that Spotify has rented out.[335] Videos you watch on Netflix aren't on your hard drive but rather on giant servers that Netflix has rented from Amazon through a platform called Amazon Web Services.[336] Whenever you want to play a song on Spotify, your web browser sends a message to the Spotify servers asking for the song, Spotify sends back the song file, and your web browser plays it.[337] Your Spotify app or browser tab is called the "frontend," and Spotify's servers are called the "backend."[338]

Something similar happens with web apps. In most apps on your phone or computer, like your camera app or Microsoft PowerPoint, the code just runs on your device.[339] However, web apps — apps that you visit with your browser, like Gmail or Facebook — run a large chunk of their code on distant servers. For instance, all of the Gmail code to send, receive, and search through emails runs on Google's servers; the buttons you click in your web browser just tell the servers what to do.[340]

In short, when your data and apps move "to the cloud," they aren't disappearing — they're just moving to another company's servers.

The best and worst of the cloud

Think about a cloud storage service like Dropbox, which lets you sync your files between devices and back them up in the cloud. It's tremendously convenient: there's no more emailing files to yourself, and you have the peace of mind that your files will be safe even if your laptop gets mauled by a gorilla.[341]

But what are the risks?

One is security: the moment you put your files on someone else's computer, you're trusting them to keep your stuff safe. This doesn't always work. In 2014, hackers broke into user accounts on iCloud, Apple's online backup service (similar to Dropbox), and leaked nude photos of several Hollywood actors.[342] But Apple worked hard to improve its security,[343] and most cloud providers today have incredibly tough security. For instance, when a hard drive at a Google data center gets decommissioned, employees ruthlessly crush and shred it so no one can get the information on it. Google's data centers also have "custom-designed electronic access cards, alarms, vehicle access barriers, perimeter fencing, metal detectors, and biometrics" to prevent intruders from breaking into their server warehouses. Their data center floors even have "laser beam intrusion detection,"[344] the kind of thing you'd expect to see in a James Bond movie. Simply put, cloud companies do a lot to keep your information secure, and your information is probably safer in the cloud than on your own computer.[345]

A second troubling concern is around privacy: if you store your stuff on someone else's computer, you can only hope that they don't let anyone read it.[346] There are legitimate fears. American courts have tried several times to force Google and Microsoft to hand over emails stored on their servers.[347] To their credit, Microsoft[348] and Google[349] have repeatedly pushed back against these demands.

And the third issue is around internet access. If all your favorite apps — like Twitter and Google Maps — are web apps, then you can't be very productive if you aren't connected to the internet (say, when you're on a plane with

exorbitantly expensive Wi-Fi).[350] However, many apps have been making progress on working offline. Google Docs and Gmail have started offering limited functionality offline,[351] and several games and productivity apps have made offline-capable versions through Google Chrome.[352]

So, while there are some risks, the convenience and security of cloud storage make it an overall strong choice.

Why can't you own Photoshop anymore?

In 1990, Adobe launched the first version of its famous photo-editing tool Photoshop; you could buy the floppy disk containing the software from a computer or hobbyist store.[353] Eventually, Adobe upgraded to CDs, and later you could download the software directly.[354] But no matter how you installed the app, you would pay for a "perpetual license" to use the software — meaning that the app was all yours, to keep and use forever.[355] Photoshop CS6, released in 2012, was $700.[356]
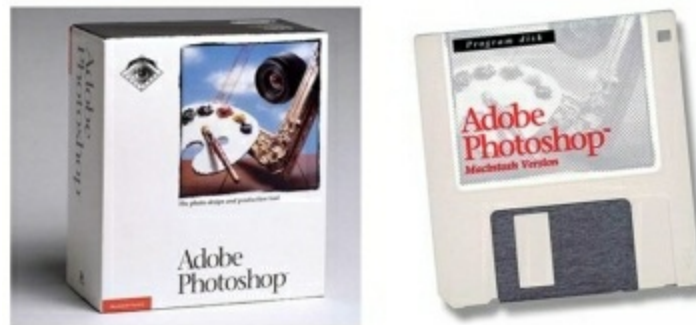
The box that the first version of Adobe Photoshop, released in 1990, came in, as well as the floppy disk the software lived on. Source: ComputerHistory[357]

But in 2013, Adobe announced a massive shift: you would no longer be able to own any of its "Creative Suite" apps, including Photoshop! Instead, you could download Photoshop for free, but you'd have to subscribe to their new Creative Cloud service, which cost about $20 a month, to keep using it.[358] This new model of "renting" Photoshop is called software-as-a-service, or SaaS (pronounced like *sass*).[359] It's like leasing a car instead of renting it.

Once you've downloaded the app, you need to enter a license key. Then Photoshop will connect to Adobe's servers to check that your license key is valid, and it'll do this every month to ensure that you've been paying.[360] Note that Photoshop still runs entirely on your computer; only checking your subscription uses the cloud.[361] But if your subscription expires, sorry — Photoshop will refuse to work!

What was in it for Adobe

Moving to a subscription model for Photoshop (also known as a software-as-a-service model) proved to be a smart business move for Adobe. For one, they could earn more consistent revenue, since they started getting subscription fees every month instead of having to wait for a huge new release, which only happens once every few years.[362] It also helped Adobe fight piracy, since the monthly license check means that Adobe gets to decide who can and can't use the software.[363] And third, since Photoshop now regularly connects to the internet, Adobe can constantly push updates and bug fixes instead of having to wait until the next big version is ready. This keeps customers happy and helps squash security issues faster.[364] (This development model is called "agile development.")

This move wasn't without controversy, though…

Customer complaints

Customers weren't happy at the time. Many were angry that Adobe was forcing users to upgrade, and they felt Adobe was trying to milk them for money by making them keep paying for Photoshop forever.[365] A prominent blogger called the move "the biggest money grab in the history of software"[366], and consumer advocates called it "predatory."[367]

But it turns out that consumers quickly got over their anger, adopting cloud Photoshop in droves[368]: Adobe's revenue jumped 70% within a year[369]. Why? For one, a subscription lets you get continuous updates for no extra cost.[370] Second, it makes Photoshop more accessible for new users; you now get a month-long free trial, and the first year costs $240, compared to $700 to buy the last boxed version.[371] Third, Creative Cloud lets you store your Photoshop files in the cloud for no extra cost, making it easy to edit on any of your devices.[372]

So despite the original controversy, moving to a subscription service was huge for Adobe: the website Quartz says it helped Adobe "save Photoshop" from becoming irrelevant.[373]

Slow adoption

You might be wondering why, if offering Photoshop as a subscription service (or software-as-a-service) is so great, it took Adobe 22 years (from 1990 to 2012) to discover it.

First, it's important to note that the software-as-a-service model relies entirely on the internet. That means that people will only buy subscriptions if they have internet access, and it took a while for the internet to become common enough for the business model to work. In 1997, only 18% of Americans had internet access at home, but that number had quadrupled to 72% by 2011,[374] which made it much more feasible to start selling software exclusively over the internet.
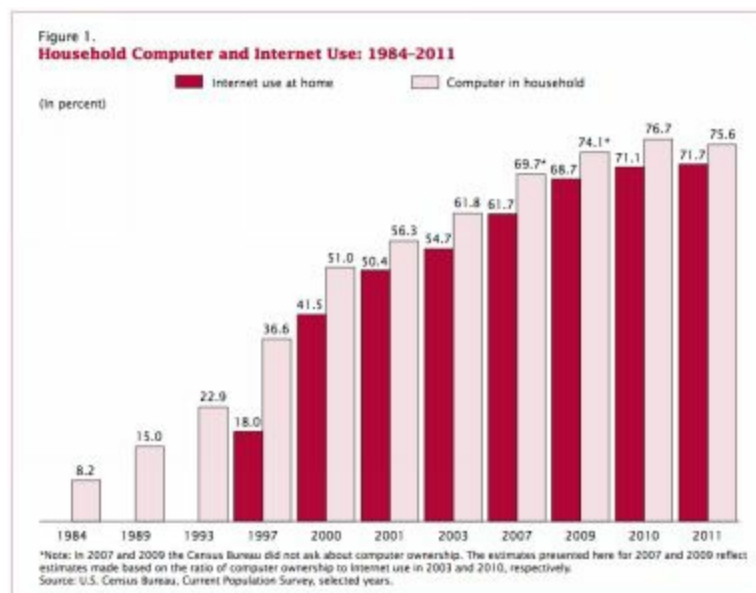
Internet use became mainstream in America throughout the 2000s. Source: US Census Bureau[375]

The second reason it took so long is that Adobe's cloud platform, Creative Cloud, took several years to prepare. Creative Cloud wasn't announced until 2011,[376] and it's likely that this set the stage for Photoshop's big move to a subscription service.

Other examples of SaaS

We've talked a lot about the Photoshop example, but it's important to note that this business model is widespread. Remember that SaaS stands for software-as-a-service, which is a business model where customers buy subscriptions for software to be delivered over the internet.[377] Many times SaaS apps run online, but not always — recall that, even with the subscription model, the Photoshop app still runs on your own machine.[378]

There are plenty of other examples of SaaS. Dropbox lets you rent out 1TB of storage on their servers for $10 a month.[379] Spotify lets you play unlimited music for a monthly price.[380] Gmail is free for individuals, but companies can pay to get unlimited web-based email through G Suite.[381] Google Sheets, the SaaS version of Microsoft Excel, is also free, but you can pay a few bucks a month to get extra file storage on Google Drive.[382]

What do all these examples of SaaS apps have in common? You can access all these apps through a web browser, and all your data is stored on other companies' servers. In other words, SaaS is just another name for apps that run in the cloud.[383]

That brings us back to the question we asked at the start: why can't you own Photoshop anymore? Photoshop has evolved into a SaaS app, and as such you can only rent it. Start thinking about the apps you use every day, and you'll start seeing more and more examples of SaaS.

Why does Microsoft offer both buy-once and subscription-based versions of Office?

In 2015, Microsoft announced Office 2016, a new iteration of its productivity suite.[384] It followed the traditional "buy-once" model, where users would pay up front for a perpetual license.[385] But in 2010, Microsoft had announced Office 365,[386] which lets you access the same Office apps as the "buy-once" versions, except through a monthly subscription.[387] In other words, Office 365 was a cloud, or software-as-a-service, version of Office 2016. Shouldn't the SaaS version have replaced the old-school version, like in the case of Photoshop? Why would Microsoft offer both Office 365 and Office 2016?

First, let's weigh the pros and cons of Office 2016 (and any future "buy-once" versions of Office) and Office 365.

Office 365 has some notable advantages. For one, Office 365 will download a steady stream of updates like extra PowerPoint templates, whereas 2016 will only get minor security updates. When the next big version of Office, like Office 2020, comes out, Office 365 users will get a free upgrade.[388] Second, Office 365 also gives you free cloud storage through Microsoft's OneDrive, which 2016 won't. And third, Office 365 lets you use Office apps on multiple phones and computers, whereas 2016 only gives you a license for a single device.[389] Corporate IT administrators also say that Office 365 makes their lives much easier, for what that's worth.[390]

Office 2016's main advantage is that it can be cheaper in the long run if you're happy with the current version of the software. The cheapest version of Office 365 was $69 a year as of 2015, but the cheapest version of Office 2016 was $149.[391] So if you don't want to upgrade, Office 2016 will become cheaper than Office 365 after a bit over two years, since the cost of 365 keeps mounting while 2016 costs nothing after you first buy it.

Office 365 has proven to be lucrative for Microsoft,[392] so it's no surprise

that they're trying to push people toward Office 365 and phase out "buy-once" versions like Office 2016.[393] A Microsoft help center article comparing Office 365 and 2016 seems to urge people to pick Office 365, for instance by listing one useful feature of 2016 but six features for 365, as if to show how much better 365 is.[394]

So why does Microsoft still offer Office 2016? Maybe they notice that some users are still resistant to subscription-based software[395] and want to phase out buy-once software only gradually. By continuing to offer Office 2016 for a short time, they could avoid the customer fallout that would ensue if they suddenly forced users to switch to a subscription-based model — which, you'll recall, is exactly the problem that Adobe faced when it pushed Creative Cloud on its Photoshop users.

How does Amazon Web Services work?

We've talked a lot about software-as-a-service, or SaaS, which is an increasingly popular model for consumer software like Google Docs or Spotify. But that's just part of the story. Big businesses and tech companies have tons of data and users, and they're also turning to the cloud.

If you're running a big website or app, you'll need a mega-computer, or server, to handle all the data and computation. But unlike consumer-focused laptops and phones, servers aren't always the cheapest or easiest to set up and maintain. To set up your own server, you have to buy machines, mess around with IP addresses, install complex server software like the popular Apache, keep the computers cool (this is a harder problem than you think[396]), and keep everything updated and running.[397] Sometimes you even need to hire dedicated specialists to keep your servers working.[398] Simply put, it's a pain.

Instead, what if you just rented out a server and avoided all those hassles? (It's like getting around with Uber instead of trying to buy and maintain a car yourself.) It turns out you can through tools called cloud computing services.

The most famous of these cloud computing services is Amazon Web Services, or AWS, which lets you rent out Amazon's servers instead of buying your own.[399] Amazon Web Services is actually a family of applications, but the most famous ones are the Elastic Compute Cloud (EC2) and Simple Storage Service (S3).[400] In a nutshell, EC2 lets you run your app's code on Amazon servers,[401] while S3 lets you store all your app's data.[402]

Benefits of the cloud

As we hinted at earlier, renting servers with Amazon Web Services far easier than running your own servers, since Amazon will take care of upgrades, security, and other maintenance issues. Amazon owns millions of servers, which their customers share; each customer gets (and pays for) only as many servers as they need. This is great because you only need to pay for what you use. Plus, since Amazon has so many servers, they have achieved great

economics of scale, which drives the cost of a server down.[403] The cost savings really can be massive: one health research startup would have paid $1 million for their own servers, but instead chose AWS and only has to pay $25,000 a month.[404]

A second big reason is security. Sony, Target, and Home Depot all avoided the security features of Amazon Web Services, instead choosing to run their own servers — but all three companies were victims of data breaches, where hackers broke into their servers and stole customer data.[405] (Think about it: would Amazon or the Home Depot have more online security experts on staff?)

A third reason is reliability. Businesses can't make money if their websites or apps are down, and fortunately cloud computing providers like AWS are excellent at keeping their servers running. AWS keeps multiple copies of apps and data on several independent data centers around the world, so your app will be fine even if a natural disaster strikes one data center or a few servers break down.[406] Meanwhile, if you ran your own servers, you'd just have to hope that your one data center is safe. As Investopedia puts it, "Imagine if Netflix were to have all of their personnel files, their content and their backed-up data centralized on-site on the eve of a hurricane. It would be madness."[407] Using cloud platforms like AWS helps Netflix keep its chill.

There are a few even more interesting and more complex reasons to use cloud computing services like AWS — but we'll get to those in the next chapter.

Services upon services

AWS isn't the only game in town, though it does control more of the market than anyone else, with 40% market share in the cloud computing services space as of 2017.[408] Microsoft has a similar product called Azure, and Google has Google Cloud Platform.[409] All these platforms let app developers use the same technology that the companies' own apps use; for instance, YouTube runs on the Google Cloud Platform, and so can anyone else's app.[410]

Remember how SaaS describes rentable web apps? Technologists have acronyms for these cloud computing providers as well. AWS, Azure, and Google Cloud Platform are all infrastructure-as-a-service (IaaS; we have no idea how to pronounce it), which lets app makers borrow servers to run their apps on.[411]

There's a third kind of cloud service that falls somewhere between IaaS and SaaS: platform-as-a-service (PaaS, pronounced like *pass*).[412] These platforms often include extra useful features like databases, advanced analytics, and entire operating systems.[413] Basically, PaaS makes it even easier for developers to build websites in the cloud. PaaS examples aren't as famous, but one is Heroku, a service that lets you just send in your app's code and then automatically sets up the website, with minimal setup required.[414] (AWS, which is IaaS, also makes it easy to set up a website, but PaaS makes it even easier.)

What's the difference between SaaS, IaaS, and PaaS? Let's use an analogy: food. SaaS is like a restaurant: you just tell the waiter what food you want, and they'll bring it to you. IaaS is like renting a kitchen: you have the space, but you have to bring your own ingredients and utensils, and you'll have to cook the food yourself. PaaS is in between SaaS and IaaS: you give someone your ingredients and recipe, and they'll prepare the food for you.

To summarize, what's Amazon Web Services? In a word, it's IaaS. But, in plain English, it's a tool that lets you rent space on Amazon's servers, making it much faster, cheaper, and easier to launch an app than if you had to set up your own servers.

How does Netflix handle sudden spikes in viewership when a new show launches?

One Sunday in March 2015, Netflix aired the premiere of the 3rd season of the wildly-popular show *House of Cards*, and people flocked to see it: Netflix's traffic that day was 30% higher than on a normal Sunday.[415] This 30% jump is huge, especially when you consider that, in 2015, Netflix accounted for 37% of all internet traffic.[416] (This wasn't an isolated incident, either: HBO saw a 300% spike in traffic when the fifth season of *Game of Thrones* launched in April 2015.[417]) How did Netflix's website handle such a huge influx of visitors?

First, let's look at how Netflix runs its website. In 2008, Netflix owned its own servers, but over the next seven years, it started moving more and more of its website to Amazon Web Services, finishing the job in 2016.[418] The cloud offers Netflix many benefits over owning their own servers; we'll get into the full explanation in a bit, but let's start with one feature called *elasticity*.

When Netflix owned its own servers, it had to own enough servers to handle peak usage. The problem was that, most of the time, usage wasn't at its peak, so most of the servers would be sitting around unused — which meant wasted money.[419] But cloud hosting services like Amazon Web Services will instantly grow or shrink the computing power given to your app as your app's usage goes up or down, so you only pay for as much usage as you need.[420] This feature is called elasticity.

As an analogy, imagine you owned a restaurant that had a huge lunch rush but only had a trickle of customers at every other time. If all your employees had to work the same hours, you'd need to hire enough to handle the lunch rush — but then, for the rest of the day, you'd have way too many people doing nothing but eating up your payroll. But if you could flexibly adjust your employees' shifts, you could bring in more employees during the busy times and send home the extra employees during quiet times. That way you'd

only pay for as much as you need. It's an easy way to save money.

Elasticity also helps save money on a daily basis, because web traffic will vary throughout the day. Think about it: you probably won't watch Netflix from 9-5 (or at least you shouldn't), but it hits a peak in viewership at around 10pm every night.[421] Thanks to elasticity, Amazon Web Services can automatically give Netflix more or less computing power throughout the day, instead of having the same amount all day.[422]

Besides elasticity, why else would Netflix move to the cloud? One big reason is "scalability": Amazon Web Services helps you grow, or scale, your application quickly as you get more users (this is growth on the scale of months and years, not sudden spikes).[423] This is quite important for Netflix because the amount of video viewed on Netflix has grown over 1000-fold from 2007 to 2015.[424] Without the cloud, Netflix would have had to physically install new servers all the time, but Amazon Web Services automatically gives them more computing power as they grow, with no work needed on Netflix's end.[425]

The last big reason why Netflix chose the cloud was because Amazon Web Services was more reliable than owning their own data centers, or buildings full of servers.[426] This is primarily because the cloud builds in lots of "redundancy," or multiple copies of the same information or code, so that even if a few computers fail, there will be plenty of others to pick up the slack.[427] (It's like how we humans only need one kidney but have two, so that even if one fails — or we donate one! — we're fine.[428])

The cloud gives Netflix some huge advantages, but it wasn't a simple change. It took Netflix seven years to completely migrate from their own servers to Amazon Web Services — and, along the way, they basically had to rebuild all their infrastructure and databases from scratch.[429] It was a lot of work, but it will probably be worth it in the end.

So the next time you're binge watching Netflix, thank the engineers who decided to move to the cloud. (Your friends who haven't read this book might be confused by your sudden fascination with living in the sky, but tell

them not to worry and just enjoy the show.)

How did a single typo take down 20% of the internet?

It was February 28, 2017.[430] An Amazon engineer typed in a standard command to disable a few servers to fix a billing issue. But the engineer made a typo that accidentally took down a huge set of servers, which forced Amazon Web Services to restart S3,[431] its service that lets developers store photos, videos, and other files in the cloud (think of it like a massive Dropbox for apps).[432] For the next four hours,[433] nearly 20% of the internet was down, including popular sites like Medium, Quora,[434] Netflix, Spotify, and Pinterest.[435] The damage was extensive: S&P 500 companies lost over $150 million.[436]

How did this happen? How could so many companies be entirely dependent on one system?

The answer: the affected sites all run on Amazon Web Services.[437] Their code runs on Amazon servers and their files live on Amazon servers (specifically, S3). So when Amazon Web Services' servers go down, all the sites go down as well.

This highlights one of the biggest pitfalls of cloud computing: if you run your app in the cloud, you're in trouble whenever your provider has an "outage."[438] Even the best cloud providers won't have 100% "uptime;"[439] for instance, Amazon Web Services was down for a total of two and a half hours in 2015, which means it was up about 99.97% of the time.[440] Getting from 99.97% to 100% might not seem like much, but it would actually be far too expensive to be worth it.[441]

So what can app makers do about the inevitable downtime of cloud hosting providers? Well, they could buy their own servers and run their apps on those servers, a model known as "on-premises."[442] While this would let companies put matters into their own hands, the numbers suggest that it might backfire. For instance, Microsoft offers two ways for companies to get enterprise

email: in the cloud with Office 365, or on-premises with Exchange. One study found that Exchange was down almost 3.5 times as much as Office 365, which equals an extra nine hours of downtime every year.[443]

So what are app makers supposed to do then? Their best choice might just be to use the cloud but accept that occasional failure is inevitable. Cloud service providers like Amazon Web Services and Microsoft Azure, for their part, should tell customers immediately when their servers go down, work fast to fix the problem, and do their best to ensure it doesn't happen again.[444]

As an example of how (and how not) to deal with outages, let's quickly go back to the story of the Amazon Web Services typo. AWS was criticized because, during the outage, its dashboard showed that everything was fine — ironically because the dashboard ran on AWS itself and went down as well. [445] But to their credit, Amazon has put in security checks to limit the damage that these kind of typos can do, and did extensive safety checks throughout the system.[446]

That brings us back to our original question: how did a single typo take down 20% of the internet? Well, that 20% of the internet runs on Amazon Web Services, and when AWS had to restart because of that fateful typo, the websites that ran on AWS went down as well. But, for all its flaws, the cloud is a great tool to save money, improve website reliability, and scale sites up more quickly. Don't forget about how much more convenient the cloud makes your life as a consumer, as well. So yes, this time it's OK to have your head in the clouds.

Chapter 6: The Internet

In 2006, Alaska Senator Ted Stevens, tasked with creating internet regulations, made an infamous speech in which he tried to explain the internet:

> Ten movies streaming across that, that Internet, and what happens to your own personal Internet? I just the other day got… an Internet was sent by my staff at 10 o'clock in the morning on Friday. I got it yesterday. Why? Because it got tangled up with all these things going on the Internet commercially... They want to deliver vast amounts of information over the Internet. And again, the Internet is not something that you just dump something on. It's not a big truck. It's a series of tubes.[447]

Clearly, he didn't understand the internet. But do we?

The internet can seem like magic at times. Our emails, Facebook messages, and Netflix shows can go from New York to Australia and back in a fraction of a second.[448] When we turn on Wi-Fi, we can access every website known to humankind without even plugging in a cable. And yet, somehow, all of this happens without any one person or company coordinating it; the internet isn't owned by anyone.[449]

But the internet isn't magic. In this chapter, we'll start pulling it apart to see how it works. We'll start with a high-level look at how computers talk over the internet. Then we'll dive a bit deeper and learn about the core technologies used to send bits of information back and forth. We'll finish up by looking at the cables that the internet runs on, and we'll meet some interesting characters who are obsessed with perfectly straight cables. Let's jump in.

What happens when you type "google.com" and hit enter?

You probably pull up a web browser and punch "google.com" into the address bar several times a day. But what really happens between when you hit enter and when the familiar homepage shows up on your screen?

Website addresses

Before we talk about websites, let's talk about building addresses. Every building has an address so that people can find it easily and consistently. If we told fifty people to go to "1600 Pennsylvania Avenue Northwest, Washington, DC 20500," they'd all end up in the exact same place. Even if someone had never been in the US before, they'd be able to figure out how to get to this building: go to the District of Columbia, get onto Pennsylvania Avenue, and walk to the 1600 block.

Every webpage has its own address, just like a building. In this case, it's like "https://www.nytimes.com/section/sports". And just like with buildings, webpage addresses make it easy for different people to get to the same page. For instance, if you sent "https://www.nytimes.com/section/sports" to fifty friends, they'd all end up at the exact same webpage. This webpage address is called the Uniform Resource Locator, or URL.

In our example, you typed in "google.com." But in the address bar, it says the URL is "https://www.google.com"! What's all the extra stuff?

When you type in "google.com", the address bar says "https://www.google.com." Source: Google Chrome on Android

To go back to our building analogy, notice that you can abbreviate addresses and people will still know what you mean. For instance, instead of "1600 Pennsylvania Avenue Northwest, Washington, DC 20500," you could just say "1600 Pennsylvania Avenue NW, Washington, DC," leaving out the zip code and using "NW" instead of "northwest." You could even just say "1600 Penn Ave NW DC" and people would still get what you mean. (Try entering all of these addresses into Google Maps — they'll all send you to the White House!)

Similarly, "google.com" is just an abbreviation of the real URL, which is "https://www.google.com", but your browser knows what you mean and just fills in the rest of the URL.[450] But what does the rest of the URL mean?

Address decoding

When your browser sees the full URL, it breaks the URL into parts to figure out where to go. It's like how you'd break a building's address into its number, street, city, state, and zip code. Let's break down the URL like your browser would.

First is the "https://". That's called the "protocol," and it defines how your browser should connect to the website. As an analogy, if you're trying to Uber to the White House, you have a few options for how to get there: UberPOOL, UberX, or UberBLACK (a way to ride in luxury cars).[451] Similarly, when you're trying to get around the internet, you have a choice of two main ways of getting around, or "protocols." The default protocol is HTTP, the HyperText Transfer Protocol, which shows up as "http://" in URLs. The more secure, encrypted version of HTTP is HTTPS, the HyperText Transfer Protocol Secure, which shows up as "https://" in URLs. [452] They're pretty much the same, except HTTPS indicates that your browser should encrypt your information, which keeps it safe from hackers. If you're ever filling in a password or giving your credit card number, the website should be using HTTPS.[453] In this case, your browser knows to use HTTPS instead of HTTP — it's like telling your friend to call an UberBLACK instead of an UberX.

The second part of the URL is the "www". It's optional for most websites, but your browser will often show it anyway for the sake of completeness.[454] It's like how, if you're giving an American phone number to another American, you don't need to give the +1 country code (as in +1-617-555-5555), but you can if you want to.

After that, your browser looks at "google.com", which is called the "domain name." Each website has its own domain name. These should be pretty familiar: google.com, wikipedia.org, whitehouse.gov, and so on.

IP addresses

The catch is that computers don't think in terms of domain names; they think in terms of numerical codes called IP addresses.[455] Every website has at least one IP address, much like most people have a cell phone number. Your computer can only go to websites if it knows their IP addresses. It's like how you can't just type "Bill Gates" into your phone and expect to get on the line with him — you'd have to look up his phone number.

To convert a domain name to an IP address, your browser uses a Domain Name Service (DNS),[456] which is kind of like a giant contacts list on your phone. Your computer keeps a list of recent domain name-IP pairs on your hard drive. If your computer can't figure out what IP address a domain name corresponds to, it'll usually ask your internet service provider (ISP), like Comcast or Verizon.[457] It's like how you might keep your family members' phone numbers in your phone's contacts app — if you don't know a particular aunt's number, just ask another relative.

Your computer looks up "google.com" using the DNS. Google has many IP addresses,[458] one of which is 216.58.219.206.[459]

So now your browser knows to access google.com's IP address, which could be 216.58.219.206, through secure HTTP. The rest of the URL beyond the domain name, or the "path," stays the same, so "google.com/maps" would become "216.58.219.206/maps".[460] (Try typing "216.58.219.206/maps" into

your address bar and amaze your friends!)

Hold on! you might say. *We didn't specify a path; we just wanted "google.com"!* Good catch. Well, if you don't specify a path, your browser gives it the placeholder value "/", which represents the homepage. That is, "https://www.google.com" and "https://www.google.com/" are the exact same, and both point at Google's famous homepage.

Asking Google

So, to summarize, your browser now knows to use HTTPS to grab the homepage of 216.58.219.206 — an IP address that humans fondly call "google.com". Your browser packages up this "request" and sends it to the huge computers that run Google's website, called "servers."[461] We'll explain how exactly the information travels in the next few sections.

Eventually, the servers that run google.com get the request and notice that you want the homepage.[462] The servers do some computation to prepare the webpage you want. For instance, they check if there's a Google Doodle for today, in which case they'll replace the standard Google logo with the Doodle. Then, the servers gather the code to draw the homepage; this code is written in languages called HTML, CSS, and JavaScript.[463]

Back to the browser

Google's servers send all this code back to your browser as a "response." Then your browser uses this code to draw the proper elements on your screen, make them look nice, and make them interactive.[464]

As soon as you click on a link or hit the search button, you go to a new URL, like "https://encrypted.google.com/search?hl=en&q=llama". And thus, the cycle starts all over again.

How does information travel between computers over the internet?

So now we know how your computer connects to websites using the internet. But webpages don't just magically teleport from Google's computers to yours. In this section, let's dig into how exactly a particular piece of information — whether a webpage, YouTube video, or Facebook message — gets from point A to point B.

To explain this, let's start with an analogy.

An analogy: shipping hot sauce

Say you live in Los Angeles and really like hot sauce, so you buy 50 huge bottles of hot sauce from Cholula, a company whose American branch is based right outside New York.[465]

One employee at Cholula in New York notices your order. She can't fit all those bottles in one box, so she separates them into ten boxes of five bottles each. To ensure you'll know if you've gotten all ten boxes, she writes "Box 1 of 10", "Box 2 of 10", etc. on the boxes. She doesn't know your address, so she just writes your name on the box.

A second employee gets your boxes from her. He notices that you have an account on Cholula's website, so he looks up your address in the database. Then he writes your address on the boxes and gives them to the post office.

The post office employee can't send your hot sauce straight from NYC to LA; that's too far a trip. Instead, the post office employee notices that there are trucks bound for Philadelphia and Chicago in the loading dock. Both of those cities are closer to LA than NYC is, so sending boxes there would be a step in the right direction. The employee can only fit 6 boxes in the Philadelphia truck, so he puts the other 4 in the Chicago truck. It doesn't matter if the boxes take different routes to you — whatever the route they take, they'll all reach your house.

When the boxes reach the next city, the post office employee forwards the boxes to any city that's a little closer to Los Angeles — from Chicago, maybe the boxes will go to Denver or Phoenix. This continues until the boxes reach a post office that's near Los Angeles, at which point the post office just sends the boxes to LA and ultimately to your house.

The boxes take different routes to reach you, so they arrive in random order. Box 3, then Box 5, then 1, 10, 8, 4, 7, 6, and 2. But wait, where's Box 9? Maybe it got lost in the mail. Thankfully, since the boxes were labeled with "Box # of 10", you're able to figure out what's missing. You ask Cholula for another box, which they send you, and soon you have all the hot sauce you could ever want.

TCP and IP

What on earth does hot sauce have to do with the internet? As it turns out, the hot sauce shipping process we just mentioned is very similar to how information travels across the internet.

A pair of protocols, called TCP (Transmission Control Protocol) and IP (Internet Protocol), work together to send information between computers. [466] They work very similarly to the Cholula employees we just met.

Because webpages are usually too big to send all at once, TCP splits them into many little "packets" and attaches labels to each (like "1 of 10.")[467] This is what the first Cholula employee did when she packaged all your hot sauce bottles into several smaller boxes.

Then, once it's time to send the information back to you over the internet, the servers use the Domain Name Service, or DNS, to figure out your IP address. [468] This is like how the second Cholula employee looked up your shipping address from the customer database.

Next, the information gets sent to you through the Internet Protocol. IP sends

each packet across the world in several short trips, or "hops", but no matter what route the packets take, they'll reach their destination eventually.[469] That's just like how the post office sent different boxes to different intermediate points, like Philadelphia and Chicago, but the boxes eventually reached you.

Once the packets reach you, TCP reassembles them in the proper order and notices if any of them got lost, in which case it'll ask the website to send the missing packets again.[470] That's like how you used the labels on your boxes to notice that a box of hot sauce was missing.

So, in a nutshell, that's how information travels on the internet. Whether you're buying hot sauce or reading google.com, stuff is broken into smaller chunks (via TCP), sent to you through several intermediate shipments (via IP), and then reassembled into the original content (again via TCP).

You might be wondering where HTTP and HTTPS, the protocols for fetching webpages, fit into this. HTTP and HTTPS are actually built right on top of TCP and IP.[471] HTTP and HTTPS say, "get me this webpage," and TCP and IP team up to actually deliver it. In the hot example, HTTP and HTTPS are like you placing the order for Cholula hot sauce. TCP is like the employee splitting up and packaging your items, and IP is like the postal service.

So while these protocols might sound obscure, they're fundamental to how you do pretty much anything online.

What path does information take to get from one computer to another?

Remember that, with TCP and IP, information is broken into tiny packets and sent through various intermediate computers until it reaches its destination. Each packet takes its own path from a website's servers to your computer or phone. But what do these paths look like?

To test it out, we used a Mac/Linux tool called *traceroute*, which shows the path that a sample "packet" of information took to get from your computer to a specified website.[472] We were in Washington, DC and looked up the path to ucla.edu, the website of the University of California in Los Angeles. UCLA's servers are in Los Angeles, so doing this test lets us ask: what path does information take to get from DC to LA over the internet?

You'll see the route below. Each intermediate point was a computer that relayed the "packet" of information along to the next one; each trip between computers is called a "hop." It's very similar to how packages sent in the mail often stop at intermediate post offices, or how you sometimes have connecting flights.

The path that a packet of information took to travel from Washington, DC to UCLA in Los Angeles. From DC, it stopped in Ashburn, VA (B); Chicago (C); Abilene, KS (D); Denver (E); Salt Lake City (F); and Las Vegas (G) before it went to UCLA. Source: traceroute and Bing Maps[473]

Notice how the packet didn't magically fly across the country. It had to travel across physical wires (which we'll talk about in the last section), so it had to actually travel from state to state. It's interesting to note that, if you mailed a package from DC to UCLA, it might take a similar route to this packet!

It's worth noting that every packet might take a different route. Sometimes packets will bounce around the world, go backward, travel to a different country, or take all kinds of crazy detours before getting to the destination. [474]

Want to try this for yourself? Use the online *traceroute* tool[475] to look up how a packet would travel from southern California (where that tool's website is based) to a website of your choice. You just need to provide an IP address; you can look up your own IP address[476] or try sample ones like 23.4.112.131 (mit.edu, based in Massachusetts) or 216.58.219.206 (google.com, based in northern California).

So we talked about how information travels from computer to computer over the internet. But how does information physically get from point A to point B? Read on.

Why did a Wall Street trader drill through the Allegheny Mountains to build a straight fiber-optic cable?

In 2008, a Wall Street trader named Daniel Spivey built a nearly straight, 825-mile long fiber-optic cable between Chicago's South Loop, home to Chicago's stock exchanges, and northern New Jersey, right outside New York City and home to Nasdaq's servers. Spivey was serious about making a straight line: work crews drilled straight through the massive Allegheny Mountains of Pennsylvania, avoiding some much easier (but slightly roundabout) routes. The price tag? $300 million.[477]

But why would anyone be so obsessed with building a straight cable?

Internet cables

Why do cables matter? Whenever information is sent across the internet through IP, it travels through long underground cables.[478] (The internet isn't a series of tubes, like Ted Stevens said, but it sure is a series of cables!)

A popular type of cable is a fiber-optic cable, which you might recognize from Verizon's popular FiOS service.[479] Fiber-optic cables are made of pure glass and no thicker than a human hair.[480] Fiber optic cables are so clear that, if you stood on top of an ocean made of miles of solid fiber-optic glass, you'd be able to see the bottom clearly.[481]

Recall that computers store all information as 1's and 0's, just like we store text using the 26 letters of the alphabet. When your computer wants to send information to another computer (using TCP, IP, and HTTP/HTTPS!), it needs to move those 1's and 0's over the cables. Your computer converts the 1's and 0's into tiny flashes of light; 1's might mean to keep the light on for a fraction of a second, while 0's might mean to keep the light off for the same amount of time. These flashes of light then travel through the fiber-optic cable. Since the fiber-optic cable is made of clear glass, information can

travel ridiculously fast:[482] about ⅔ the speed of light.[483]

So while information might seem to travel around the internet by magic, it actually travels through long underground cables. Since the shortest distance between two points is a straight line, the person with the straightest cables gets the fastest internet access. We all like fast internet, but who's so obsessed that they'd blast through the Alleghenies? Let's meet them.

High-frequency trading

Many so-called "high-frequency traders", or HFTs, use software to make rapid trades between America's two major stock market centers, New York and Chicago.[484] We aren't finance experts, but basically, HFTs exploit tiny differences in stock prices between exchanges in both cities — like buying a stock for $1.000 in New York and selling it for $1.001 in Chicago — to make tiny amounts of profit thousands or millions of times a day.[485] This process is called "arbitrage," and arbitrage opportunities disappear quickly. To get there first, you need a lightning-fast internet connection. It's so competitive that traders fight for edges of a few microseconds (one-millionth of a second) or even nanoseconds (one-billionth).[486]

So these high-frequency traders need the fastest-possible internet connection so they can beat their competitors to the lucrative trades. Since information travels across the internet in giant cables, traders need the straightest possible cables.[487]

That brings us back to the question: why did the trader Daniel Spivey spend so much money building an incredibly straight cable? It's to maximize the internet speed between the two stock exchange capitals, which would help HFTs get an edge. The cable was far straighter than the previous record holder: Spivey's cable sends information between the two cities in just 13 milliseconds, a full 3 milliseconds faster than the previous record.[488] HFTs were willing to spend top dollar for this slight speed advantage: the first 200 HFTs to sign up to use this cable spent a combined $2.8 billion.[489]

Remember how fiber-optic cables let information travel at ⅔ the speed of

light? That's still too slow for some traders. In 2014, one company started experimenting with giant laser guns that would beam information through the air between NYC and Chicago. Since light travels faster through air than glass, information would travel far faster — and it would probably be near-impossible to beat.[490]

But for now, at least, cables are the way to go. And as long as we'll have cables, we'll have mildly obsessive Wall Street traders like Daniel Spivey. So if you happen to meet a trader sometime, thank them for how their cables have helped you stream your Netflix shows faster.

Chapter 7: Big Data

We humans generate a mind-boggling amount of data. As Google cofounder Eric Schmidt put it in 2010, "every two days now we create as much information as we did from the dawn of civilization up until 2003."[491] That's five exabytes, or five trillion GB, every two days.[492] You could give every person on Earth a 512GB iPhone and still not have five trillion GB worth of storage.[493]

Simply put, this is an enormous amount of data. Or, as technologists call it, "big."

But how can you use these vast amounts of data? In this chapter, we'll explore some examples of how companies have used big data to find profitable — and sometimes shocking — insights about their customers. We'll also dig into some of the tools and techniques that technologists use to make sense of the data in the first place. And we'll finish up by looking at some of the unintended consequences of having so much data on people, and we'll ask: is big data good or bad for society? Let's take a look.

How did Target know that a teenager was pregnant before her own father did?

In 2012, a father in Minnesota was surprised to find coupons for maternity goods from Target in the mail — and he was furious to see that they were addressed to his teenage daughter. He stormed into the nearest Target and confronted a confused Target manager, demanding to know if the manager was trying to encourage his impressionable young daughter to get pregnant. Naturally, the manager apologized. He even followed up on the phone a few days later to apologize again.[494]

On the phone, though, the father sounded embarrassed. "I had a talk with my daughter," he said. "It turns out there's been some activities in my house I haven't been completely aware of. She's due in August. I owe you an apology."[495]

Target had figured out that this teenager was pregnant before her own father did![496] But how? The answer: big data.

Retailers know that major life events like going to college or starting a new job tend to lead to new buying habits, which they are eager to take advantage of.[497] For instance, Gillette sends teenage boys free razors on their 18th birthdays.[498] Similarly, pregnancy is a pivotal moment for retailers, because new mothers suddenly start needing things like baby clothes and formula, spending hundreds of dollars along the way.[499] But because birth records are usually public, new parents get overwhelmed with offers from retailers trying to get their business. To stand out, retailers like Target need to preempt birth and start reaching expecting mothers as early as the second trimester, when they start needing things like maternity clothes and prenatal vitamins.[500]

Thus, retailers need to predict pregnancy or other situations that cause new buying habits. To do this, they try to find patterns in the data they gather about customers.[501] For instance, suppose you notice that customers with 18-year-old children tend to buy a lot of dorm room furniture in the fall,

probably because their kids are moving into college. Then, over the summer, you could target these customers with coupons for furniture and school supplies. That's more likely to lead to a sale than sending random people these coupons.

Getting to know you

But how do stores collect all this data? Many use free "loyalty cards" or "savings cards", which they scan when you check out. By tracking your buying habits this way, they can create targeted offers for you.[502] However, two of the biggest retailers, Walmart and Target, have no such card. Instead, Target[503] and Walmart[504] assign each credit card a unique code, which they can track to understand a customer's purchase history and start targeting coupons. Internally, Target calls their code the "Guest ID number."[505]

It's not just purchases, though. Target can link a lot more information to your Guest ID:

> "If you use a credit card or a coupon, or fill out a survey, or mail in a refund, or call the customer help line, or open an e-mail we've sent you or visit our Web site, we'll record it and link it to your Guest ID," said Andrew Pole, Target's Director of Guest Data.[506]

Demographic information like your age, ethnicity, and address are also tied to your Guest ID. Target could also try to guess your salary, perhaps by finding the estimated price of your home, and they could use public records to learn when your kids were born, when you got married, and even if you got divorced.[507]

Predicting pregnancy

As you can imagine, Target compiles huge amounts of information on each Guest ID. Using this data, Target can start finding patterns and making predictions about customer behavior. For instance, Target found that women who suddenly bought large amounts of unscented lotion were likely around the beginning of their second trimester, because these purchases tended to correlate with births a few months later. Pregnant women were also likely to

buy supplements like zinc, calcium, and magnesium.[508]

Eventually, Target identified a group of roughly 25 buying habits that, when analyzed together, would let the company assign each shopper a "pregnancy prediction" score. With this "predictive analytics" solution, Target can predict pregnancy with 87% confidence — and sometimes, they can even predict the approximate date of delivery.[509] As the example from Minnesota shows, that might be an even higher prediction confidence than fathers have with their own daughters!

Techniques like this helped Target's "Mom & Baby" section grow quickly and boosted Target's overall revenue.[510] But the challenge for retailers like Target is capitalizing on these customer insights without coming across as "creepy." As you might expect, many couples were startled when Target sent them targeted pregnancy coupons shortly after they realized they were expecting. Some were so startled, in fact, that they stopped visiting Target altogether. Thus, Target started getting subtler with its promotions. The company would still send prenatal vitamin coupons, but they would be nestled between, say, a charcoal coupon and a lawnmower ad to make these targeted ads appear "random."[511]

Retailers don't just use gut instinct to guess what their customers would want. In the era of big data, they're using cold, hard numbers to figure that out. But how exactly do they make sense of all these numbers? Read on.

How do you analyze big data?

As we mentioned, Target has data on hundreds of millions of customers.[512] But how can they analyze this data to create metrics like the pregnancy prediction score? It's not like some analyst can just pop open an Excel file on his laptop — the data is too massive to store or analyze on a single computer, even the most powerful ones.[513] Imagine trying to multiply two 500-digit numbers on a four-function pocket calculator — no matter how good your calculator might be, a single calculator can't do it.

It'd be far too expensive to make a supercomputer powerful or big enough to handle all this data. Instead, the key is to break your data and computation into more manageable chunks, which you assign to an army of cheap, normal-sized computers. All these computers can work simultaneously, and once the last computer is done, you just combine their results into a final answer.[514]

As an analogy, imagine you want to count every person in your city. You could run around counting everyone yourself, but that would take far too long. Instead, you send one friend to each neighborhood and tell them to count all the people they see in that small area. You tell each friend to report their counts to you, and when the last friend gives you their count, you just have to add the totals together to get your answer.[515] This is far faster than counting by yourself, since your friends work on much smaller, and shorter, tasks "in parallel." (Fun fact: this is how the Roman Empire ran its censuses!)[516]

Google used this strategy for its famous "MapReduce" algorithms:[517] the "Map" step is when your friends counted each neighborhood, and the "Reduce" step is when you added up your friends' results.

The popular big data tool Hadoop uses MapReduce.[518] The idea is that you store all your data on a bunch of normal-sized servers — no supercomputers needed! — and then run the Hadoop software to crunch the numbers. The beauty of this approach is that the computers don't need to be physically

connected, and to add more data you just need to add more computers.[519] Hadoop is quickly becoming an industry standard. Besides Target,[520] companies like Netflix[521], eBay[522], Facebook[523], and many more use Hadoop. In fact, one 2014 analysis predicted that 80% of the Fortune 500 would use Hadoop by 2020.[524]

In short, analyzing big data is far more complex than just using Excel: there are specialized tools and techniques that you need to use. Big data analysis is so rigorous and important that it's spawned a whole new field of study: data science.[525] So if you like crunching huge amounts of information to find interesting patterns (and pregnancies), you know what to study.

Why do prices on Amazon change every 10 minutes?

Not a fan of the price of an item on Amazon? Just wait 10 minutes. It might just change.

Amazon changes product prices 2.5 million times a day,[526] meaning that an average product listed on Amazon changes prices every 10 minutes.[527] That's fifty times more often than Walmart and Best Buy![528] The constant price changes have annoyed some consumers when they see the price of an item drop right after they buy it,[529] but it's also helped Amazon boost its profits by 25%.[530]

How do they do it? Amazon has, simply put, tons of data. They have 1.5 billion items listed on amazon.com and 200 million users. And they have one billion gigabytes of data on their items and users.[531] If you put all that data on 500-gigabyte hard drives and stacked them up, the pile of hard drives would be over eight times as tall as Mount Everest.[532] Now that's some big data.

With all this data, Amazon analyzes customer's shopping patterns, competitors' prices, profit margins, inventory, and a dizzying array of other factors every 10 minutes to choose new prices for its products.[533] This way they can ensure their prices are competitive and squeeze out ever more profit. [534]

Through this process, one useful strategy Amazon has found is to undercut their competitors on popular products but actually raise the prices on uncommon products, such as by discounting bestsellers while jacking up prices on obscure books. The idea is that most people will just search for the most common products (which will end up being cheaper on Amazon), so they'll start to assume that Amazon has the best prices overall. That'll hook customers on Amazon and get them to pay more for the less-common things they'll buy down the road.[535]

Data-driven suggestions

There are plenty of other ways Amazon uses its data about you to make a buck. Based on your purchasing history, Amazon can bombard you with recommendations — look no further than the "Inspired by Your Browsing History" or "Customers Who Bought This Item Also Bought" sections you see around amazon.com.[536] Amazon can even use the words you highlight on the Kindle to predict what you're going to buy.[537] Amazon makes these recommendations by finding patterns in past customers' purchases. For instance, suppose Amazon noticed that millions of customers buy peanut butter, jelly, and bread together, and then you buy peanut butter and bread off Amazon. Using the pattern that it's found, Amazon could suggest you buy jelly.[538]

Predicting what you want to buy goes far beyond just recommended purchases, though. Consider Amazon's patented technique called the "Anticipatory Shipping Model."[539] When Amazon predicts that you're going to buy something (like how Target predicts when women are going to deliver their babies), they can ship that item to a warehouse near you, so that when you ultimately buy it, they'll get to you quickly and cheaply.[540]

As you can see, big data has tremendous economic value — so much, in fact, that the New York Times once compared it to gold.[541]

Is it good or bad that companies have so much data?

Usually, when companies use big data to become more efficient, nobody complains. For instance, no one minded when UPS used the data they collected from sensors on their trucks to optimize their delivery routes, saving $50 million. (Some people actually praised UPS for saving gas!)[542]

But controversy arises when companies collect personal data, like when retailers such as Target start gathering enormous volumes of data on customers.[543] Big data lets companies create targeted ads and recommendations, which can be very profitable. Google and Facebook rely on targeted ads for most of their revenue,[544] and Netflix says its recommendation system saves them $1 billion a year.[545] But does this help the consumer?

On one hand, targeted ads and recommendations can be useful for consumers. While Target might make money by sending you targeted coupons, the coupons might save you time and money. Even though Netflix has a shocking amount of information on everything you've watched, Netflix's movie and TV show recommendations are very popular.[546]

On the other hand, privacy advocates are enraged by how much personal information big companies are collecting about you.[547] Remember how Target can figure out your marital status, address, and estimated salary — things you probably wouldn't tell a stranger off the street.[548] If a company that has so much personal data gets hacked, the consequences can be dangerous. A famous example: in 2013, thieves stole 40 million Target customers' credit card numbers and 70 million customers' personal information, including names, emails, and mailing addresses. Those 70 million customers were at high risk of identity theft.[549]

But many companies argue that they're protecting people's identities by anonymizing data, but even anonymous data could be used to figure out who

you are, also known as "reidentifying" you.[550] For instance, an MIT study found that just knowing the dates and locations of four credit card purchases was enough to determine the identities of 90% of people tested.[551] Another study found that you could reidentify people by mashing up anonymous user data from Netflix and IMDb.[552]

So is big data good or bad for society? Like many things about technology, there's no black-or-white answer. While big data makes companies and products more effective, it can create problems for privacy. But whether or not you like it, big data will only keep getting bigger.

Chapter 8: Hacking & Security

Gone are the days where wannabe "Nigerian princes" would email you about "large amounts of money" they needed your help transferring — a ploy they said would help you earn a commission but would actually let them drain your bank account.[553] Hackers have become far more competent and subtle in their techniques.

So what are the newest additions to online criminals' bag of tricks? And what can we do about them? In this chapter, we'll learn how hackers can hold your computer for ransom or steal your identity using a fake Wi-Fi router. On the other hand, we'll talk about how encryption can keep internet users safe from some attacks — and why encryption was so powerful that the FBI sued Apple to try to bypass it. We'll even talk about how the illegal drug trade has set up an online presence, how their technologies work, and what that means for the rest of us.

Protecting the internet from hackers is more important than ever. Let's explore how to do just that.

How can criminals hold your computer for "ransom"?

In May 2017, a dangerous new piece of malware, dubbed WannaCry, infected computers in 150 countries, rendering thousands of computers unusable and causing an estimated $4 billion in damage.[554] Britain's National Health Service was crippled, stopping many vital surgeries.[555] Say hello to ransomware, a new kind of malware (or dangerous software that can infect computers and harm people.)

Ransomware

Ransomware like WannaCry is a piece of software that invades your computer, locks up your files, and threatens to throw away the key unless you pay the criminals behind the operation.[556]

First, a malicious piece of software lands on your computer, often via an email attachment[557] or dangerous download.[558] This "malware" often exploits a flaw in an operating system that lets an attacker run whatever code they want on your computer.[559] WannaCry, for instance, exploited a bug in Microsoft Windows (interestingly, this bug was first discovered by the National Security Agency).[560] It's as if the people who built your house made a mistake on one of the locks, which would let a thief with a lockpicking set break in.

Once the malware is on your computer, it runs a program that encrypts all of your personal files. Encryption jumbles up the contents of files so people and apps can't understand them. But every encryption comes with a special passcode to undo the encryption, so you can un-jumble your files if you have this "key."[561] For instance, we could encode the message *Meet me on the lawn* to *Zrrg zr ba gur ynja*. That wouldn't make any sense, of course, unless we told you that the way to decrypt it is to move all the letters 13 spaces down (so *a* becomes *n*, *b* becomes *o*, *c* becomes *p*, and so on). Once you did that to the encrypted text, you'd get back to *Meet me on the lawn*.

So this ransomware encrypts all of your files but refuses to tell you the key. The hackers say that, if you pay them, they'll give you the key and a program which will decrypt all your files. If you don't, they threaten to throw away the key forever, meaning your files will all be lost.[562]


```
You became victim of the GOLDENEYE RANSOMWARE!

The harddisks of your computer have been encrypted with an military grad
encryption algorithm. There is no way to restore your data without a spe
key. You can purchase this key on the darknet page shown in step 2.

To purchase your key and restore your data, please follow these three ea
steps:

1. Download the Tor Browser at "https://www.torproject.org/". If you nee
   help, please google for "access onion page".
2. Visit one of the following pages with the Tor Browser:

   http://golde        .onion/
   http://golden       .onion/

3. Enter your personal decryption code there:



If you already purchased your key, please enter it below.

Key: _
```

The screen shown to victims of a piece of ransomware called GoldenEye. Source: Wikimedia[563]

How do ransomers want you to send them money? You can't write them a check or Venmo them, because then people would know who they are and the government could crack down on them. Instead, ransomers demand payment through the anonymous online currency called Bitcoin.[564] Bitcoin is like an anonymous version of the money-sending app Venmo: anyone can send money to anyone else, but people are identified by anonymous codes called "Bitcoin addresses" instead of usernames.[565]

To unlock your computer, you'd need to visit a Bitcoin exchange website, which lets convert dollars (or any "normal" currency) to Bitcoin and back, just like you could convert between dollars and pesos at a bank.[566] There's an "exchange rate" between Bitcoin and normal currency, just as there is between dollars and pesos, though this exchange rate is very prone to fluctuations.[567] The ransom for WannaCry was $300 in Bitcoin.[568]

You'd then use a specialized app called a "wallet" (analogous to Venmo) to send coins to the scammers. Then, the criminals promise, they will give you

the key to unlock your files, and you'd be back on your way.[569]

If you're ever the unfortunate victim of a ransomware scam, we encourage you to not pay the ransom. If you do pay the ransom, you could be funding a vast online criminal enterprise[570] or evil governments; for instance, the NSA linked the WannaCry attack to the North Korean government.[571]

The criminals get professional

The economics of ransomware make for some very strange occurrences. Since the scammers are anonymous and take your money *before* decrypting your files, they could in theory just take your money and run without giving you the decryption key. However, the major ransomware attackers tend to actually give you the key. Why? Not because of the goodness of their own hearts (there probably isn't much there), but because the hackers realize that the only way they'll make money is if people keep forking over the ransom money. And people will only pay the ransom if they can trust that the scammers will decrypt their files.[572]

This has, strangely, led to scammers having excellent customer support, even sometimes having call centers and online chats with sales representatives.[573] Some even hire designers to make their websites look attractive.[574] They know that they need to build up a reputation of "trust" with their victims[575] — even though trust is a strange word to associate with someone who is extorting you and threatening to ruin your livelihood.

Preventing ransomware

One of the most effective ways for consumers and big organizations to protect themselves from ransomware is by keeping their computers updated. Microsoft, to their credit, quickly found the Windows bug that WannaCry exploited and issued security updates, which Windows users were encouraged to download.[576] Older operating systems are generally more at risk because they get fewer updates,[577] although it turns out that more Windows 7 systems were infected with WannaCry than Windows XP.[578]

Large organizations like businesses, hospitals, and governments should take

note. They're particularly attractive targets for ransomers,[579] and they're especially at risk because their IT departments are often slow to update old software.[580]

Another solution is to regularly backup your computer, so that even if ransomers encrypt all your files, you can just restore a recent version and forget about the encrypted files.[581] Clearly, you can't backup files to your hard drive, because the ransomware would encrypt the backups too; we recommend storing your backup files in the cloud (like on Dropbox) or on an external hard drive.[582] That way, your backups are stored somewhere besides your hard drive, so the ransomware won't be able to touch them.[583]

But the best solution is to be proactive and prevent malware from getting onto your computer in the first place. Avoid downloading pirated software and media, be careful which email attachments you click on, and get antivirus software that'll scan downloaded files for malware.[584]

Ransomware probably won't go away anytime soon — but with the knowledge you've gained here, plus some precautions and backups, you'll be well equipped to fight back.

# How do people sell drugs and stolen credit card numbers online?

In 2013, the American government took down a website called Silk Road,[585] a sort of Amazon for the illegal: drugs, fake passports, guns, hit men, and the like.[586] Over two years, the website had sold over $1 billion in contraband, and only a few of its buyers and sellers were caught.[587] Unfortunately, that wasn't the end; illegal marketplaces have spread like wildfire ever since.[588]

How do these illicit markets work? How do people buy and sell on them? And why can't authorities put an end to them? Let's take a look.

Deep and dark web

As you can imagine, Silk Road and its successor sites can't work like Amazon: if someone attached their name to every illegal transaction they did, it would be far too easy for the cops to find them. Instead, every buyer and seller on these sites is anonymous.[589] But that's not enough: users' computer's unique IP address could also be enough to identify them. So, all communication between users and Silk Road had to be scrambled so that no one could tell that the users were visiting Silk Road at all.[590]

The "normal" internet that we browse every day doesn't work like that. Instead, Silk Road and other illegal marketplaces have had to turn to a pair of related concepts, the "deep web" and "dark web."[591]
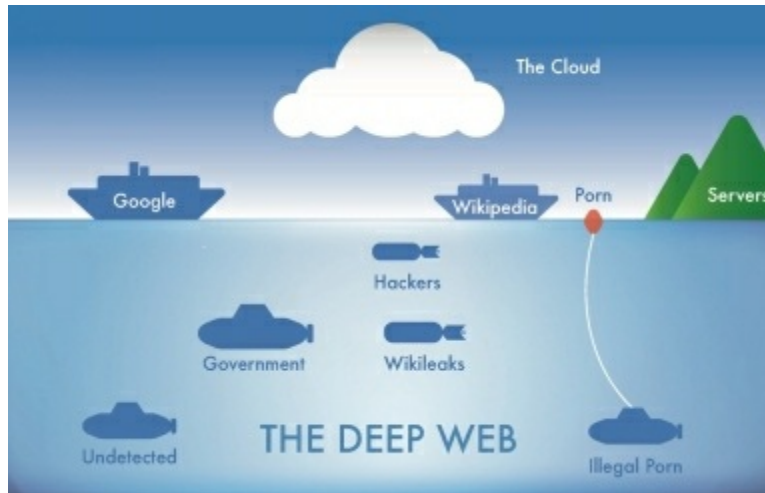
A schematic of the deep web. Source: ApploidWiz[592]

We'll start with the *deep web*. The deep web includes the information on the internet that you can find, but not through a Google search. For instance, you can see your friends' Facebook posts, but those won't appear as search results.[593] Neither will Google Drive documents, medical records, government reports, scientific papers, and so on.[594] Some people estimate that the deep web is 500 times larger than the "clear" web that we can find through Google.[595]

The deep web in itself isn't the key innovation behind the Silk Road. For that, look at the *dark web*. The dark web is a subset of the deep web that you can't access without special software to encrypt all communications and anonymize your IP address.[596] Dark websites have long, strange URLs that end in *.onion*, and they reject any visitor that isn't using the special software.[597] Illegal marketplaces like the Silk Road use dark websites so that all activity on the site is untraceable.[598] In fact, you can't even figure out where dark websites' servers are, making them very difficult to take down. However, programming errors can cause the servers' IP addresses to be leaked — and that's exactly what led to the demise of the Silk Road.[599]

Accessing the dark web with Tor

As we mentioned, you need special encrypting and anonymizing software to visit the dark web. The most common piece of software is called Tor, short for The Onion Router.[600] Normally, when your computer connects to a

website, your computer broadcasts its identity and which website it wants to visit, which makes it easy to track what websites everyone is visiting.[601]

But Tor is different. It's best to explain with an example. Imagine you live in Seattle and were mailing some potato chips to your friend William in Philadelphia. Normally, you'd write your return address and William's address on the package. Anyone who looks at the package could tell that you're trying to talk to William. But what if chips were outlawed (the horror!) and you didn't want anyone to know that you were sending some to him?

You could use several boxes nested inside each other. The outermost box would be addressed from Seattle to Denver. Inside that would be a box addressed from Denver to Chicago. And inside that would be a final box, addressed from Chicago to William in Philadelphia, containing your chips. You'd instruct the Denver and Chicago post offices to open their boxes and put the inner box in the mail. So when the Denver office got your box, they'd open it and see a box addressed to Chicago. When the Chicago office got your box, they'd look inside to find a box addressed to William in Philadelphia, and they'd send it to him. The beauty of this setup is that neither post office realizes that you're trying to talk to William — Denver thinks you're sending something to Chicago, and Chicago thinks someone from Denver is sending something to Philadelphia.

This is how Tor works: it wraps your communication in layers of encryption and bounces it around many intermediate "relay" computers, each of which only know the previous and next computers in the chain.[602] This way, it's nearly impossible for anyone to trace communication over Tor; even the NSA reportedly has trouble with it.[603]

Tor sends internet communications through several randomly-chosen intermediate computers, making it nearly impossible to track which websites you're visited. Source: Electronic Frontier Foundation via Wikipedia[604]

The nonprofit Tor Project has released a free browser called Tor, a modified version of Mozilla Firefox, that uses this technique.[605] So anyone who wants to hop on a dark website can just download Tor and start browsing.[606]

How to browse (and take down) a dark market

To summarize, anyone who wants to visit a dark website needs to start by downloading Tor. As we mentioned before, most dark web URLs are intentionally hard to remember: the investigative journalism nonprofit ProPublica has a dark website hosted at propub3r6espa33w.onion.[607] (Yes, it's a legitimate website — we'll talk about the legitimate uses of the dark web in a bit!)

Because it's so hard to remember dark web URLs, and because there is (by definition) no search engine for the dark web, people browsing the dark web start their search at a website called The Hidden Wiki (technically, there are many competing websites with this name, and no official one). The Hidden Wiki contains pages of dark web URLs so people can find the sites they need. [608]

Once a visitor makes it to a dark market like the Silk Road, the experience isn't much different than Amazon (besides the stuff on sale, obviously): sellers have profiles, products have images, previous buyers leave reviews. [609]

To preserve anonymity, all sales on dark markets are in anonymous currencies like Bitcoin. Buying something off a dark market isn't as simple as a direct payment. Instead, buyers send money to a centralized "escrow" account, which holds the money until the buyer confirms they've received the goods, at which point the money is released to the seller.[610]

Notice that transactions can only occur through the website, and at any given time a sizable amount of money is held in escrow. That centralization helps authorities take down illegal dark markets.[611] In the case of the Silk Road, some programming mistakes by the Silk Road creator helped feds find the physical location of Silk Road servers, which they seized in 2013. Since these servers contained the code behind the Silk Road website and data for the Bitcoins in escrow, the Silk Road was immediately killed — a huge win for authorities.[612]

Unfortunately, many copycat sites popped up, and trying to take them down has been a game of Whack-A-Mole.[613] A site called Silk Road 2 popped up right after Silk Road went down. Authorities took Silk Road 2 down in 2014, but immediately afterward, another market called AlphaBay popped up. AlphaBay was seized in July 2017,[614] but security experts fear that an even more dangerous black market — one immune to seizure — could be brewing.

An invincible black market?

Meet OpenBazaar, an online marketplace that joined the dark web in 2017.[615] Unlike the Silk Road, which had a central server (and, hence, an Achilles' heel), OpenBazaar is fully decentralized: every transaction happens directly between buyers and sellers. It's like going to a flea market instead of a supermarket. Flea markets are decentralized: shoppers and merchants exchange money directly. Supermarkets, on the other hand, are centralized: merchants sell their stuff to supermarkets, who then distribute items to shoppers. If the supermarket shuts down, no one can buy or sell anything. If the Silk Road is like a supermarket, OpenBazaar is like a flea market.

Instead of connecting to a central website, every OpenBazaar user downloads

some software that lets them talk to any other person using that software. When a buyer and seller find each other, they can agree on a price and trade directly.[616] Instead of having a centralized server to store Bitcoins in escrow, OpenBazaar lets buyers and sellers choose a third party to mediate disputes.[617]

In short, OpenBazaar has no central authority. Without a central authority, law enforcement can't take it down without seizing every single computer that runs the OpenBazaar software. That is, destroying OpenBazaar would be nearly impossible.[618] The founders of OpenBazaar say they won't police what's bought or sold on the site[619] — in fact, given the distributed model, they probably couldn't police it anyway.[620] It's a radical idea, but a dangerous one.

Legitimate uses for the dark web

When you hear about all the crime that happens on the dark web, it's easy to forget that there are plenty of legitimate uses for it. After all, the dark web is just a way to browse the internet anonymously.[621]

Several mainstream sites have started offering dark websites to protect their users. For instance, in 2014 Facebook made its website accessible over the dark web, which would make it accessible to political dissidents in countries where Facebook is restricted, such as China.[622] The whistleblowing nonprofit ProPublica also made a dark website in 2016 to help people avoid government censorship or online surveillance by tracking software that can target ads at them.[623]

Tor, the software used for accessing the dark web, is again nothing more than a privacy-enhancing web browser.[624] The Tor project names a wide list of people who can benefit from the anonymity of Tor:

> Individuals use Tor to keep websites from tracking them and their family members, or to connect to news sites, instant messaging services, or the like when these are blocked by their local Internet providers… Individuals also use Tor for socially sensitive

communication: chat rooms and web forums for rape and abuse survivors, or people with illnesses… Journalists use Tor to communicate more safely with whistleblowers and dissidents… Corporations use Tor as a safe way to conduct competitive analysis, and to protect sensitive procurement patterns from eavesdroppers.[625]

Finally, while Bitcoin is used a lot on the dark web, Bitcoin isn't part of the dark web — it's an independent technology that anyone can use. It has plenty of legitimate uses. Proponents argue that it protects buyers' and sellers' privacy,[626] and Bitcoin is less prone to political pressures since no government owns it.[627] But others fear that, if Bitcoin remains difficult for average users to learn, it will remain a tool primarily used by criminals.[628]

So if you ever see someone using the dark web, Tor, or Bitcoin, don't immediately assume they're up to something shady. The truth is that these technologies are neither good nor bad — they're just privacy protection tools.

How does WhatsApp encrypt your messages so thoroughly that even WhatsApp can't read them?

Whenever you're logging in to a website like Twitter, sending an email over Gmail, or buying something from Amazon, there are many situations when you'd want your communications to be encrypted so that eavesdroppers couldn't figure out your sensitive information.[629] For this, the web uses a technology called HTTPS, which automatically encrypts all information sent between your computer and a website's servers.[630]

Here's the catch, though: even though your information is encrypted between your computer and the server, the website can decrypt your information and read it.[631] Sometimes this is necessary; Amazon can't charge your credit card unless it can decrypt and read your credit card number. But Facebook has taken some heat for allegedly reading users' private messages,[632] and Google used to read your Gmail emails to target ads at you — at least until 2017, when they backed down.[633] Another danger is that, if companies can decrypt your information, governments could coerce them to hand it over.[634]

So the messaging app WhatsApp was widely praised when, in 2014, it launched "end-to-end encryption," which only lets you and your recipient decrypt your messages. Neither WhatsApp nor their owner Facebook can figure out what you're saying![635] Privacy advocates were thrilled by the move.[636] But how exactly could WhatsApp encrypt messages so well?

You've got (encrypted) mail
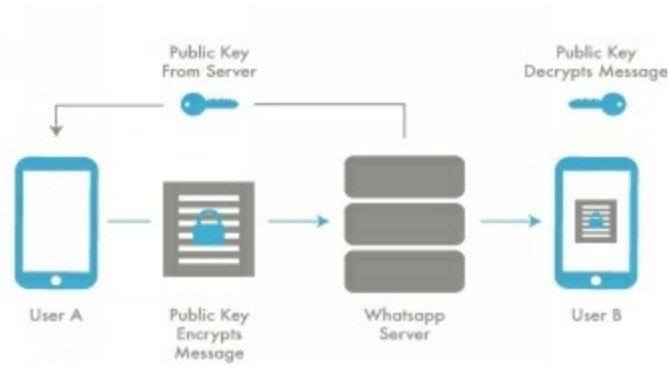
How end-to-end encryption works in WhatsApp. Source: Wired[637]

To explain end-to-end encryption, let's use an analogy. Suppose that in a particular country the postal service is evil and tries to open any package that's sent through the mail. Understandably, citizens are upset, but if they want to send things long distances, they have no choice but the postal service. So citizens devise a clever way to ensure that no one besides the intended recipient of a package, not even the postal service, can open the package.

Each person creates a key and hundreds of locks that can only be opened using that key. Everyone keeps their key in a secure place in their house, but they distribute their locks to hardware stores like the Home Depot around the country.

Say you lived in this country and wanted to send a box to your friend Maria. You grab one of Maria's locks from your local hardware store and attach it to your box. When you mail the box to him, the postal service intercepts it. Of course, without the key, they can't open it! But when Maria gets the box, she can open it because she has the only key to open her lock.

This system is secure, since only the intended recipient can open the box. It's also clever because anyone can send stuff to anyone else without having to coordinate ahead of time. You just need to grab someone's lock from the store whenever you want to send them something.

This is also how end-to-end encryption works; the method is called asymmetric encryption or public key cryptography.[638] With this method,

every user is given a "public key" (which, in our example, is a lock) and a "private key" (which is literally a private key in our example). Every message is encrypted using the recipient's public key and can only be decrypted using their private key and some math.[639] All the encryption and decryption is done on users' devices, so it's completely impossible for the app makers to decrypt messages.[640]

A double-edged sword

End-to-end encryption is a victory for anyone who values privacy.[641] Journalists are particularly interested in end-to-end encryption, since they need more secure ways to communicate with sources given the rise in political censorship.[642] Political dissidents in repressive regimes like Syria have also started using end-to-end encrypted messaging apps like WhatsApp to get around government snooping.[643]

Unfortunately, the added privacy can also help terrorists, such as the ones who used encrypted messaging apps like WhatsApp to plan the 2015 Paris attacks.[644]

Some of the implications of end-to-end encryption can be very good or very bad, depending on your perspective. End-to-end encryption makes life hard for law enforcement, who lose the ability to recover text messages, a key piece of evidence.[645]

One thing's for sure, though. For better or for worse, end-to-end encryption is here to stay.

Why did the FBI sue Apple to hack the iPhone?

In 2016, the FBI asked Apple to help it unlock an iPhone used by one of the shooters in the deadly San Bernardino, CA attack.[646] Apple had helped the government unlock iPhones over 70 times between 2008 and 2016,[647] but this time Apple refused, so the FBI sued them.[648] Why did all this legal drama happen? In a word: encryption.

Before this incident, Apple just bypassed the password lock and handed the iPhones' files over to the feds.[649] All 70 of those phones were running older versions of iOS, no newer than version 7, but the San Bernardino phone was on iOS 9.[650] The problem? In iOS 8, Apple removed the forced-bypass feature, making iPhones so secure that even Apple couldn't get in.[651]

Since iOS 8, an iPhone doesn't just check the password you entered matches the stored password. It mashes up the password you enter with a 256-bit code (called a UID) that's unique to the phone and only stored on a secure place in the phone, then compares your entered mashup with the master mashup it has on file. This mashup, or *hash*, can't be reverse-engineered, so there's no way to get in without knowing the stored password.[652]

If, like the FBI, you don't know the password to a phone, your only option is to randomly guess passwords, also known as brute forcing.[653] But Apple made this very hard too. Because you can't extract the UID from the phone, so the only way to try out passwords is the old-fashioned way — typing passwords in at the lock screen.[654] The nail in the coffin is that iPhones will wipe themselves clean after 10 failed login attempts.[655]

That put the Feds in a jam. There was no way to get into the phone without randomly guessing passwords, and even then they'd only have 10 tries.[656] They couldn't get Apple to disable the UID technology — that'd be physically impossible. But the FBI found a loophole: they pushed Apple to create a crippled version of iOS that didn't have the 10-try limit and would let

the FBI enter passwords through a computer program instead of manually typing them in, which would speed up the brute-force testing.[657] Apple refused, saying that being forced to write code would violate the company's free-speech rights.[658]

A fierce legal battle ensued.[659] The tech community feared that an FBI victory would set a dangerous precedent of letting the government seize whatever encrypted data they wanted.[660] The FBI, of course, needed evidence. In the end, the result was anticlimactic: the FBI somehow managed to break into the shooter's iPhone without Apple's help.[661] Regardless of the result, this story teaches a valuable lesson: technology and national security will forever be intertwined.

How can a phony Wi-Fi networks help someone steal your identity?

You walk into a Starbucks and turn on your Wi-Fi to bang out some emails. There are a couple open networks around called "Free Wi-Fi by Starbucks", "Google Starbucks", or "Free Public Wi-Fi". Which one do you connect to? (Choose one before you read on!)

Well, only "Google Starbucks" is a legitimate Wi-Fi network run by Starbucks.[662] If you chose one of the other two, you might be in trouble. Hackers often set up phony Wi-Fi networks designed to look like legitimate networks and try to dupe people into connecting to them.[663] If you connect to a hacker's network, that hacker's route sits between you and every website you want to connect to, so it can read every bit of information being sent back and forth.[664]

More sophisticated hackers realize that your computer broadcasts the names of networks it's connected to before, and it will automatically connect to any network with a name it remembers. So a hacker could read your device's network list and make their router spoof the name of a network your device remembers — and boom, your device will automatically connect to the phony router.[665] This way, a hacker could get you on their malicious Wi-Fi network without you doing anything!

Once you're on the hacker's Wi-Fi network, they can see and manipulate every message you exchange with websites.

Bypassing HTTPS

Hold on, you might be thinking. *Doesn't HTTPS encrypt all communications?* That's true — if your connection uses HTTPS, the hacker won't be able to understand any information you're sending, and you'll be safe.[666] But there's a catch.

In 2009, a researcher released a tool called SSLStrip,[667] which lets an

attacker fool your computer into talking with a server over HTTP instead of HTTPS.[668] You wouldn't notice a difference unless you looked at your address bar and realized there was no green padlock and no "https." Fortunately, web browsers have gotten pretty good at alerting users when they suspect an SSLStrip attack: they'll often cross out the "https://" in the address bar with a bright red slash, and they might show you an error like "This is probably not the site you are looking for!"[669]

But what if a hacker used SSLStrip and you didn't notice? You'd be connecting to websites using HTTP instead of HTTPS. To see what's so dangerous about that, let's use an example.

Man in the middle

Suppose a woman named Sarah does online banking with Bank of America. Whenever she logs in, her browser sends her username and password to https://bankofamerica.com; the message could be "Hi, I'm SarahTheGreat and my password is OpenSesame." Since bankofamerica.com is served using HTTPS — the secure, encrypted method of connecting to websites — this message gets encrypted, or scrambled, before it's sent. Only Bank of America would be able to decrypt it and figure out Sarah's username and password. If a hacker gets his hands on Sarah's message to Bank of America, it would be gibberish, like "Uv, V'z FnenuGurTerng naq zl cnffjbeq vf BcraFrfnzr."[670]

But now suppose that Sarah goes to Starbucks and connects to the hacker's phony Wi-Fi. She opens up https://bankofamerica.com. But the hacker's router is using SSLStrip, and the router gives her http://bankofamerica.com instead. (Notice the difference? It's sent over HTTP instead of HTTPS!) One letter might not seem like a big deal, but because Sarah's only using HTTP now, her communication with bankofamerica.com isn't encrypted.[671] So when she logs in and sends the message "Hi, I'm SarahTheGreat and my password is OpenSesame," the hacker's router can see that message in plain text — it isn't encrypted![672] The hacker could pass that information to bankofamerica.com, which wouldn't notice the difference; the hacker sent the right username and password, so it lets the hacker in.[673]

This is what's called a "man-in-the-middle" attack.[674] Once the hacker made Sarah communicate over unencrypted HTTPS, he could sit in the *middle* of Sarah and Bank of America and "hear" everything they were saying to each other. By getting Sarah's unencrypted password, the hacker could log into Sarah's account himself and, say, send funds to his account!

It's not just a danger with banking, though. With man-in-the-middle attacks, hackers could impersonate you to e-commerce sites, email, social networks, and the like — which could be devastating.[675]

Hackers using "man-in-the-middle" attacks aren't always out to just make a buck. In one famous case in 2013, the National Security Agency (NSA), which has long been criticized for spying on citizens, allegedly used a man-in-the-middle attack to impersonate google.com and spy on anyone who visited their impersonated page.[676]

Stay safe: use a VPN

Man-in-the-middle attacks succeed because of the innate insecurity of public Wi-Fi networks.[677] To protect yourself, experts recommend using a VPN, or virtual private network. VPNs create a sort of end-to-end encryption between you and the websites you're visiting, so your router can't harm you.[678] Technologists often say that VPNs create a direct, secure "tunnel" between you and websites.[679] Simply put, VPNs let you effectively turn a public Wi-Fi network into a private one.[680]

There are plenty of free or cheap VPNs out there.[681] We encourage using VPNs whenever you're on a public Wi-Fi network!

To summarize, how could a phony Wi-Fi network help someone steal your identity? Well, if a hacker got you to connect to their network and used SSLStrip, they could do a man-in-the-middle attack to get your passwords and other identifying information. That way, they could steal your identity without you ever knowing! As we mentioned in this last section, the best way to fight back against these man-in-the-middle attacks is to use a VPN.

Chapter 9: Hardware & Robots

Throughout this book, we've focused on software. But even the coolest apps are useless without hardware to run them on — phones, tablets, computers, watches, glasses, you name it. These devices are more than dumb platforms for housing apps: phones can replace credit cards,[682] sunglasses can record video,[683] and robots can fight wars without human intervention.[684]

So how do these silicon-based wonders work? That's what we'll investigate in this chapter. We'll start off by meeting the key pieces of your computer and explaining terms like "CPU," "RAM," and "SSD." We'll look at how — and why — phones age. With those basics under our belt, we'll jump into an exploration of several exciting pieces of hardware: fingerprint scanning, Apple Pay, augmented reality, robots, and drones. It'll be a fascinating ride. Let's jump in!

What are bytes, KB, MB, and GB?

Whether you're shopping for a 128GB iPhone, downloading an app that's 50 MB, or editing a 15 KB document, you've probably run into these measures of how big digital things are all the time. But what do KB, MB, and GB actually mean?

First, let's start with the basics: how do you write down information? We English-speakers write down information using the 26 letters and 10 digits, stringing them together into words and numbers, respectively. Meanwhile, computers only have 2 letters — 0 and 1 — and store all kinds of information, from text to images to movies, using a series of 1's and 0's. Each 1 or 0 is called a bit; string eight of those bits together and you get a byte.[685] Bits are too small to be of much use on their own, so nearly everyone measures data in bytes. A byte is just a unit of measure of information, the same way an inch is a measure of distance.[686]

You can store numbers which have between 1 and 8 bytes, depending on the size of the number.[687] For instance, the number we'd call 166 is 10100110 in binary. Text takes 1 or 2 bytes per letter.[688] MP3 music files, meanwhile, can take up to 1 to 2 million bytes per minute of music.[689] And high-definition movies can be up to 25 billion bytes.[690]

Since bytes are units of information, we can measure the size of files and the capacity of computer storage in bytes. In other words, much like you can measure the length of a book in pages, you can measure the size of a file in bytes.

Since files can get so big, we have a variety of units to measure file storage, just like we have centimeters, meters, and kilometers for measuring distance. A kilobyte (KB) is a thousand bytes, a megabyte (MB) is a million bytes, and a gigabyte (GB) is a billion bytes.[691]

Beyond these "normal" units, there are terabytes (a trillion), petabytes (a quadrillion), and exabytes (a quintillion), if you want to get really crazy.[692]

Sometimes these units are useful: for instance, total internet traffic in 2013 was a jaw-dropping 5 exabytes, which is 5 billion GB, or 5 quintillion bytes. [693]

What do CPU, RAM, and other computer and phone specs mean?

When you go to buy a MacBook, Samsung Galaxy phone, or any other device, you'll be bombarded with "specs": numbers that explain how powerful and fast your device will be.[694] Some of them are pretty simple, like when the iPhone 7 says it comes with 32GB of storage.[695] But some of them are positively mystifying. MacBook Pros come with "Storage: 512GB PCIe-based onboard SSD" and "Processor: 2.9GHz quad-core Intel Core i7, Turbo Boost up to 3.9GHz, with 8MB shared L3 cache."[696] Or, Samsung's Galaxy S8 comes with "Display: 5.8" Quad HD+ Super AMOLED (2960x1440) 570 ppi" and "Camera: Dual Pixel 12MP AFOIS (Optical Image Stabilization) F1.7 aperture."[697]

It's enough to make your head spin. We could write a whole book about these specs, but let's look at the most important ones. Every computing device (laptops, tablets, phones, smartwatches, etc. — anything with an interactive screen) has these same features.

CPU: the Central Processing Unit

We'll start with the "brains of the operation," the Central Processing Unit, or CPU.[698] The CPU is a small, square chip that runs all the computations that make your device work, such as deciding what to draw on the screen, connecting to the internet, or crunching numbers.

The inside of an Intel CPU chip. Source: Eric Gabal[699]

CPUs are made of several smaller sections, called "cores", each of which can run computations separately.[700] CPUs with more cores are faster and can do more tasks at once.[701] It's like how, if four people are shoveling snow off a driveway at once, they can finish the job four times faster than if one person was trying to do it alone. So devices whose CPUs have more cores can run more computation-intensive tasks like video editing apps, graphics-heavy games, or number crunching, similar to how a team of four shovelers can handle heavier snowfalls than a single person.[702]

CPUs also have a clock speed, which is the number of calculations per second they can carry out.[703] Clock speeds are usually measured in gigahertz (GHz), which is a billion calculations per second.[704] In theory, a higher clock speed means a faster CPU. But most people don't really use clock speed to compare CPUs anymore, largely because there are too many other factors that determine CPU speed and because you can't really compare clock speeds across different brands of CPUs.[705]

Comparing CPUs head-to-head is tough because there are so many different factors that affect speed and power. To get a rough estimate of how two CPUs stack up, use the series number: Intel's chips have numbers like i3, i5, and i7. Generally, the higher-numbered chips are faster and more powerful

than the lower-numbered chips.[706]

So what's the best CPU? It depends on what you need. The more powerful your CPU, the more it costs and the more battery it drains.[707] So if you're just browsing the internet, you don't need a lightning-fast CPU, just like you don't need a Ferrari if all you do is drive to the grocery store and back.

Storage: long-term memory

Your device needs to store images, apps, documents, and other stuff you want to keep track of. For this, you need some form of long-term storage.[708] Let's start by looking at what's available on computers (that is, not phones or tablets — we'll talk about those in a bit).

The traditional way of storing digital data is the hard drive (HDD), which is a spinning metal plate coated with a layer of magnets that store your information. There's a special arm that reads and writes data to the drive.[709]

A hard drive. Most hard drives are 2.5-3.5 inches in diameter.[710] Source: Wikipedia[711]

Then there's the newer solid-state drive (SSD), which has no moving parts but instead stores information in a huge grid of tiny boxes, called "cells."[712] Each tiny cell stores a 0 or 1.[713] (It's like how a waffle has a grid of squares

on the surface, and you can pour syrup into individual squares if you want.) This technology is called "flash memory," and it's very common: SSDs, flash drives, and SD cards all use flash memory to store information.[714] A final note: since an SSD is little more than a bunch of cells, it has no moving parts. We'll get to why this is important in a bit.

A solid-state drive. Notice there are no moving parts. Source: Wikipedia[715]

Hard drives vs. solid-state drives

So which form of storage is better? Hard drives are made of moving parts with fragile arms and discs[716], so they break down faster (even with normal use), make noise, are heavy, and use lots of power.[717] Meanwhile, SSDs have no moving parts, so they're much sturdier, quieter, lighter, and more efficient.[718] Plus, hard drives need to spin around a moving disc to find information while SSDs just need to send pulses of electricity, making SSDs a good deal faster than hard drives.[719]

In other words, SSDs beat hard drives in almost every way: they're lighter, quieter, sturdier, and more efficient.[720] The only place where hard drives win is on price and capacity — each byte of storage on a hard drive costs less than on an SSD, though the cost of SSDs is going down every year.[721]

As we mentioned, both hard drives and SSDs work on computers (that is, laptops, desktops, and servers, the machines used to run huge websites).[722] How about phones?

Phones, tablets, and cameras can only ever use flash memory.[723] (Remember, SSDs are just a special kind of flash memory designed for laptops.[724]) For one, you can't even make a hard drive small enough to fit in today's mobile devices, since you can only shrink the spinning plates so much.[725] Therefore, smaller devices have had to use flash memory. Plus, flash memory is small, energy-efficient, and resistant to drops, which are all very useful to have in mobile devices.[726]

But even in the world of laptops, SSDs are winning out. You can't even get MacBooks[727] or Microsoft Surfaces[728] with hard drives as of 2017; they all offer only SSDs.

RAM: short-term memory

RAM, or random access memory, is your device's short-term memory. (Humans have short-term memory too: it's what you use to temporarily remember a phone number as you're trying to type it in.[729]) Each app that you run, each browser tab you open, and each Word document you open consume some RAM as your computer tries to remember everything you're doing.[730] It's important to note just how fleeting RAM is. Whenever you restart an app, its RAM gets cleared — that's why, if you close a Word document without saving it, the contents will disappear. Similarly, whenever you restart your device, all your RAM is cleared. That's why your phone and computer have no running apps whenever you power them back on.[731]

Why do you need both RAM and storage, like flash drives or SSDs? As an analogy, imagine you're doing some math homework on your desk and need to reference lots of notes and books. If you kept all your notes and books in your bookcase (which represents storage), you'd have to get up and walk over to the bookcase every time you wanted some information. That would be slow and inefficient. Instead, you could open all your books on your desk and sprawl out all your notes, which would make it easier for you to get all the information you need at a glance; this represents RAM. The caveat: the more stuff you put on your desk, the more cluttered and chaotic it gets, and eventually you'll just run out of room. That's like RAM: it helps your

computer do many computations at once, but there's only a limited amount.
[732]

What happens if you run out of RAM? (This might happen to you if you're like our friends and keep 2000 tabs open.) Your computer will borrow some space from your hard drive or SSD and treat it like extra RAM, but remember that this borrowed space takes much longer to access. As a result, your computer will run far more slowly.[733] That's why your computer crawls when you have a ton of apps, games, and tabs open, and why opening up a massive game like Clash of Clans slows down your phone so much. If this happens to you, you can close the memory-hogging apps to save RAM. Or you can just restart your device, which will wipe clean your RAM and let you start over.[734]

Overall, more RAM is better, though of course it costs more.[735] More RAM helps your computer handle heavy gaming, video editing, and working with apps that analyze lots of data. But if you're only going to be checking email or browsing the internet, you can get away with less RAM.[736] More RAM will often make your computer faster, though it isn't a silver bullet because there could be other factors slowing you down, like the CPU.[737]

Tradeoffs

The big lesson to take away from this section is that hardware makers always need to make tradeoffs when designing devices. For instance, gaming laptops try to maximize RAM, but to keep costs down, they have to sacrifice battery life.[738] Some servers (the big computers that run websites) are specially designed to store images; they have more storage but sacrifice some RAM, since they won't be running many apps.[739] You can't have it all, so you'll have to figure out which features are the most important to you.

Why does your phone always seem to slow to a crawl after a few years?

Ever feel like your phone starts wearing down and eventually becomes useless exactly when the next upgrade becomes available? Apple and other phone makers deny it, but many consumers theorize that companies deliberately design phones to break down quickly, a strategy called "planned obsolescence."[740] Is this for real?

Well, first, why do phones (and other hardware, for that matter) break down over time? Well, like any product, from cars to shoes, phones suffer wear and tear: moisture can corrode circuits, moving parts in the phone can break, and so on.[741] But even if you're extremely careful with your phone, the lithium-ion batteries used in phones wear out after about 300 to 500 charge cycles. [742] And finally, as apps and operating systems get more and more capable, they demand more and more powerful hardware, so your phone will start falling behind.[743] So your phone won't last forever even in the best situation.

Why not just swap out the aging parts? That's the rub: you can't. In an effort to make phones as sleek as possible, phone makers like Apple have sealed batteries into the phone case, making them impossible to remove[744]. In 2011, researchers found that you couldn't replace an iPhone's battery yourself, and if you sent it in to Apple to get it fixed, they'd charge you $85, wipe your phone, and take a week to send it back — not that convenient[745]. At a certain point, it's just easier to buy a new item instead of repairing the old one. Consumers who accuse Apple of planned obsolescence pointed to this as the smoking gun.[746]

But do companies actively try to make their products become obsolete? The jury is still out, and tech companies are tight-lipped.[747] On one hand, there are powerful incentives for companies to plan for obsolescence. Forcing customers to keep buying new stuff boosts sales.[748] Naturally, this annoys customers, but if customers are "locked in" to your platform (for instance, it's hard to leave Apple's ecosystem because you're probably so stuck on iOS-

only apps and services), there's less need to keep them happy.[749] However, there are also strong reasons to *not* plan for obsolescence. Planned obsolescence can hurt your brand[750], and with such a competitive smartphone market, savvy customers will avoid non-durable phones[751]. So it's unclear whether companies would actively build in planned obsolescence.

Whether or not companies are engaging in planned obsolescence, there's no question that hardware degrades quickly. There are some obvious environmental downsides to this, like huge amounts of electronic waste piling up in landfills.[752] But planned obsolescence might just have some upside: making goods fragile makes them cheap, and that improves the standard of living around the world.[753]

How can you unlock your phone using your fingerprint?

As much as we love "swipe to unlock" lock screens on phones, we're excited about a new way of unlocking your phone: with your fingerprint. Since 2014, Samsung's Galaxy S phones have let you unlock the display using a fingerprint scanner.[754] Similarly, iPhones since the 5S (with the notable exception of 2017's iPhone X[755]) have offered fingerprint scanners, a technology Apple has branded Touch ID.[756] But how does fingerprint recognition work?

An iPhone whose home button is also a fingerprint scanner. Source: Wikimedia[757]

Optical scanning

The oldest method of fingerprint scanning is optical scanning, where a miniature camera literally takes a picture of your fingerprint. It edits the picture to make the "ridges" of your fingerprint black and the "valleys" white, generating a high-contrast version of your print. Then it compares that to an internal database of fingerprints to see if there's a match[758].

The problem is that these scanners aren't very secure.[759] Since optical scanners just take a photo, you could fool a scanner by holding up a photo of a matching fingerprint; researchers even found one "master set" of prints that can trick 65% of optical fingerprint scanners.[760]

Capacitive scanning

These days, most people use a more secure method called capacitive fingerprint scanning. Here, the sensor is covered with capacitors, which are just tiny batteries.[761] The raised ridges of your fingerprints increase the charge stored in the capacitors they touch, while the capacitors under the valleys of your fingerprints don't see a change in their capacitance. The phone uses the patterns of charge to build a high-resolution image of your print, and it checks the print against its database of prints as before.[762]

Proponents say that capacitive scanners are much more secure since you can't just fool them with a photo.[763] But one researcher hacked it anyway: he used a high-resolution image of his own thumb to make a plastic mold, which he used to fool his capacitive scanner.[764]

So even the best fingerprint scanning systems aren't entirely secure. That's why many phones have started offering more secure "biometric" login systems like iris recognition[765] and face recognition, which showed up in 2017's iPhone X.[766] And the Apple Watch reportedly considered identifying users based on their heartbeat patterns.[767]

Oh, before you get too comfortable, it's possible to hack these "more secure" biometric systems too. The researcher who hacked a capacitive scanner using a fingerprint mold showed that he could also fool iris recognition hardware using high-resolution photos of his own eyes.[768] That just goes to show: no biometric identification system is perfect.[769]

How does Apple Pay work?

Since 2014, you've been able to pay for food, clothes, and other items in stores just by tapping your iPhone to a reader at the checkout line, a technology called Apple Pay.[770] Google followed suit with a similar service, Android Pay, in 2015.[771] How does this "magical" tap-and-pay system work?

Apple Pay in action. Source: Wikimedia[772]

Both Apple Pay and Android Pay are built off a technology called NFC, or Near-Field Communication.[773] With NFC, two devices (whether phones, cards, or payment terminals) containing a particular chip can exchange small amounts of information when touched together.[774] The devices exchange information using radio waves (incidentally, the same waves that Bluetooth uses.[775]) NFC requires very little energy, with some chip-holding devices not even needing any power to operate.[776]

Your phone has an NFC chip embedded in it, as does an Apple Pay payment terminal. When you tap your phone against the terminal, the two chips exchange information using radio waves. The terminal charges your credit card, and you've just bought your item.[777]

Another example of NFC: say you have a card that you use to pay for a

subway or bus ride around town. The card contains a *passive* NFC chip that needs no power to operate. You touch the card to a reader, which contains an *active* chip that requires power, and the chips communicate. The reader subtracts the fare from your account balance (which the transit authority keeps on its servers) and opens the gates to let you in.[778]

Chicago's NFC-powered Ventra card, which you can use to pay for the subway. Source: Wikipedia[779]

Strengthened security

So how does Apple Pay keep you safe? Don't worry, your phone doesn't just send your credit card number to the store when you're using Apple Pay. Instead, Apple has worked closely with credit card vendors to make an extremely secure system. Whenever you use Apple Pay, the credit card vendor (like Visa or MasterCard) makes up a random 16-digit token that it associates with your card, encrypts the token, and sends it to your phone. When you tap on the terminal, your phone sends the encrypted token. The terminal sends the token to the credit card vendor, who validates that it belongs to you and then charges you. This is a clever setup because, even if a hacker gets hold of your token, there's no way to reverse-engineer your credit card number; only the credit card vendor could do that. Furthermore, on iPhones that have Touch ID, Apple makes you verify the payment with a fingerprint. As a result, commentators call Apple Pay "much safer" than

credit cards.[780]

So it's no surprise that stores are eager to start accepting Apple Pay, since it makes them immune from hackers who try to steal their credit card data[781] — such as when Target was hacked for 40 million credit card numbers in 2013.[782] This became even more important in 2016, when new laws made retailers (instead of card issuers) financially liable for any hacks that occur because of the old magnetic-swipe credit card reading technology.[783] Chip-based credit cards would also help retailers avoid hacks, but they're much slower than magnetic-swipe cards, making Apple Pay a more attractive alternative.[784]

Apple Pay is a win-win, so we imagine that Apple Pay and other NFC-based mobile payment systems will see even more uptake in the coming years.

Other uses for NFC

NFC is pretty simple — touch your phone to something to exchange money or information — but that simplicity makes it a powerful tool that might have many farther-reaching applications.

A first example: there are a huge variety of things you can start paying for using NFC. San Francisco has started letting you pay for parking meters by tapping your phone against an NFC sticker.[785] And Chicago has started letting you use Apple Pay to pay for the subway.[786]

Furthermore, with NFC, you can tap your phone against anything with a special sticker to get more information about it. Marketers could embed NFC stickers into advertisements or flyers, and people could just tap their phone against the stickers to learn more. In certain French cities, you can tap your phone against NFC stickers to get maps of the area. And NFC could also help in retail shopping: tap your phone against a package to comparison shop or find coupons, for instance.[787] NFC is helping blur the line between the physical and digital world, and we think the uses of NFC will get more and more exciting.

How does Pokémon Go work?

The mobile app Pokémon Go took the world by storm in 2016 by letting you find Pokémon, the virtual cartoon monsters, just by walking around the real world.[788] One of the most popular features of Pokémon Go was how it overlaid the world of Pokémon on top of your world, a technique called augmented reality (AR)[789]. For instance, you could see PokéStops (places to find items) and Pokémon Gyms (places to battle other Pokémon) at real landmarks around your town.[790] You also find Pokémon in their "natural habitats": water-typed Squirtles on the beach, for instance, or bat-like Zubats at night.[791] It's thanks to a mashup of crowdsourced location information, your phone's internal clock, and some geographic data that classifies an area based on its "climate, vegetation, and soil or rock type."[792]

The more technically interesting part is where you can see a Pokémon overlaid on your immediate environment while trying to capture them. For instance, if you're trying to catch a Pokémon in a park, it could be "jumping" around on the grass or splashing in a fountain.[793]

How does your phone know where to put the Pokémon? First, it uses your camera to get a sense of the immediate environment; in the picture above, for instance, it's a grassy area in front of a bay. Pokémon Go then uses some algorithms to figure out where the ground is and draws the Pokémon standing there.[794] Then it uses your accelerometer, compass, and GPS to notice if you're moving around, in which case the game moves and rotates the Pokémon appropriately.[795]

It's an exciting time for augmented reality, in no small part because of Pokémon Go. In 2016, one expert predicted that AR would be a $90 billion market by 2020.[796] Game developers are especially excited.[797] But for now, at least, go catch 'em all.

How does Amazon manage to offer 1-hour delivery?

Amazon's Prime Now, an add-on to their Prime subscription service, lets you get a huge range of items delivered to your door in an hour or less[798] in over 30 cities across the US, as of 2017.[799] But flying cross-country takes at least 5 hours[800] — so how on earth could Amazon pull off 1-hour delivery?

Amazon uses a combination of software, robots, and humans to pull this off. First, the software: Amazon uses data about its Prime subscribers in an area to decide what items to store in warehouses in the area, a move designed to optimize the speed of deliveries.[801]

The center of the action is Amazon's warehouses, which it calls fulfillment centers, located right outside the major metro areas that Prime Now serves. For instance, there's one in Union, NJ, right outside New York City[802]. Some of these warehouses can be over a million square feet in size.[803]

Inside, products from granola bars to skateboard shoes are stacked on shelves scattered around the warehouse floor. A fleet of hockey puck-shaped robots move around the warehouse to find shelves containing the proper product and move them toward a human employee, called a "picker", who grabs the item from the shelf.[804]

While products in most stores are sorted thematically (with, say, all the breakfast foods in one aisle), items in the Amazon warehouses are scattered randomly (with, say, potato chips next to a board game) that the robots will never be too far from any particular item.[805] The human workers would never be able to track down a particular item, but that's okay because Amazon's huge databases keep track of exactly where each item is. Plus, sophisticated algorithms control what items go where, what routes the robots take, and what routes the employees take around the warehouse.[806] Amazon claims that the robots and algorithms can help Amazon retrieve a customer's items in just a few minutes, instead of the hours it'd take otherwise.[807]

Once the items are in bags, Amazon hands them off to a team of "couriers", people who use any means necessary — subway, car, bike, or foot — to get the item to the customer before the hour is up.[808]

This case is an interesting look into the future of the workplace, where humans and robots cooperate together. Robots can find and move items around much faster than humans can, especially since these robots can tap into algorithms to minimize their travel time. But humans have the uniquely nimble fingers needed to grab items out of the shelves, scan them, and put them in bags.[809]

What does that mean for jobs? It's a little paradoxical. E-commerce is eliminating thousands of retail jobs, but Amazon's robots and algorithms make rapid fulfillment centers possible, and that ends up *creating* jobs.[810] Perhaps the best example of this irony: technology and automation have killed thousands of jobs in the Rust Belt town of Joliet, Illinois, but Amazon brought 2,000 jobs back when it opened a fulfillment center there in 2016.[811]

So if you ever need to get something urgently and rely on Prime Now, be sure to thank the people — and robots — who made it happen. It's an interesting collaboration.

How could Amazon deliver items in half an hour?

Think one-hour delivery was impressive? Amazon won't stop there. They want half-hour deliveries using drones. But how?

Amazon's idea for this service, called Amazon Prime Air, is to start the packaging process the same way as in the one-hour case, but replace human deliverers with drones — or "unmanned aerial vehicles," as Amazon calls them.[812]

At the warehouse, Amazon would strap a package to a drone. The drone would fly to the recipient's house and either drop the package via parachute or land on a specially marked pad. And it would do so without any human control.[813]

An Amazon drone delivering a package. Source: Amazon[814]

So, is this coming soon? We wish. Amazon still needs to teach its drones how to manage bad weather and avoid buildings and other drones.[815] Another issue is that Amazon only has drone fulfillment centers in 24 American states, most of them along the coasts.[816]

But the biggest issue is regulation; the Federal Aviation Administration (FAA) has proven to be a thorn in Amazon's side. One regulation says that drones can't fly within 5 miles of an airport, which blocks out most of New York City.[817] Another policy issued in 2015 said that autonomous drones couldn't fly outside the operator's field of vision, which would prevent drones from flying autonomously.[818] Amazon's been trying to push the FAA to loosen these regulations; they scored a win when the FAA dropped the field-of-vision rule in 2016[819] — probably in large part due to Amazon's pressure. (Tech companies have a pretty shocking amount of power over policy makers.)

Still, Amazon is still frustrated by the FAA's regulations. Amazon is so annoyed, in fact, that they opened up a drone testing center in Canada just 2000 feet from the American border[820]. And because the FAA hasn't been helpful, Amazon has done most of their drone testing in the United Kingdom. [821] In fact, the first successful Amazon drone delivery took place in Cambridgeshire, England in December 2016.[822]

Amazon's delivery drone up close. Source: Amazon[823]

While it might seem weird to imagine delivery drones buzzing around in the air, Amazon envisions that, one day, they'll be a perfectly normal sight.[824] Eventually, these drones might even become as common as FedEx or UPS trucks.

To conclude, it's nice to get some perspective. Imagine if you went back in time to 50 years ago and told people that you owned a handheld computer

(i.e. a phone), wirelessly bought an item with that computer, and got that item delivered to you by a flying robot with wings. They'd think you're crazy. But, as you now know, it's real, and it's really exciting.

Chapter 10: Business Motives

In 2017, the five largest companies in the world by market capitalization were all tech companies: Apple, Alphabet (Google's parent company), Microsoft, Amazon, and Facebook, in that order.[825] All five companies rose swiftly not just because of their great technology but also because of their smart business strategies. And traditionally non-tech companies, from retailers to banks, need to use technology intelligently to avoid being left behind.

So why do tech companies decide to acquire startups? How do they decide to launch new products, or even rethink the way they make money? And how do non-tech companies adapt to the digital age? In this chapter, we'll explore these topics and more.

We'll start off this chapter by meeting retail stores that have found clever ways to bring in technology, and not in the way you might expect. Then we'll move to the tech industry, where we'll unpack why Amazon and Uber made seemingly-strange business moves — and why we think they're actually great ideas. We'll finish up by looking at a quartet of acquisitions, where major software companies like Facebook and Microsoft bought out startups. We'll explore why the big companies made these decisions and how successful (or not) they were. Let's get to it!

Why does Nordstrom offer free Wi-Fi?

You've probably gotten used to free Wi-Fi at coffee shops like Starbucks, which has offered Wi-Fi to coffee drinkers since 2010.[826] It makes sense why they offer it — people who want to get some work done flock to Starbucks.

In 2012, the retailer Nordstrom started offering free Wi-Fi in stores,[827] and other retailers like the Home Depot and even Family Dollar are jumping on the bandwagon too.[828] But why? No one goes to Nordstrom to fire off some emails. (If you do, we won't judge.) Do stores offer free Wi-Fi just to be nice?

It turns out that offering free Wi-Fi can be quite profitable for Nordstrom. To understand this, let's first think about how Wi-Fi works. When you turn on Wi-Fi on your phone, your phone sends out a radio signal to find nearby Wi-Fi hotspots (also called routers), which are those boxes with antennas that you might have in your house.[829] Hotspots let your phone connect to the internet. Your phone's radio signals include a unique code that's embedded in the phone, called the MAC address.[830] So, whoever owns the hotspots can use the MAC address to identify your phone whenever it connects to a hotspot.[831]

An example of a wireless hotspot, also known as a wireless router. Source: Wikimedia[832]

In 2012, retailers like Nordstrom realized they could use their Wi-Fi routers to track customers' locations in their stores.[833] But how could Nordstrom figure out exactly where someone was standing just based on the hotspots they're connecting to?

The secret is a technique called triangulation, which, incidentally, is also how your GPS system knows where you are.[834] Triangulation starts when you're connected to three hotspots. Each hotspot will see your MAC Address, so they'll all know it's you. Then each hotspot will measure the strength of the radio signal from your phone to the hotspot to calculate how far your phone is from the hotspot; the farther away you are, the weaker the radio signal.[835] Finally, the hotspots work together to pinpoint where you must be. The owner of a company that uses triangulation says they can figure out someone's location within 10 feet.[836]
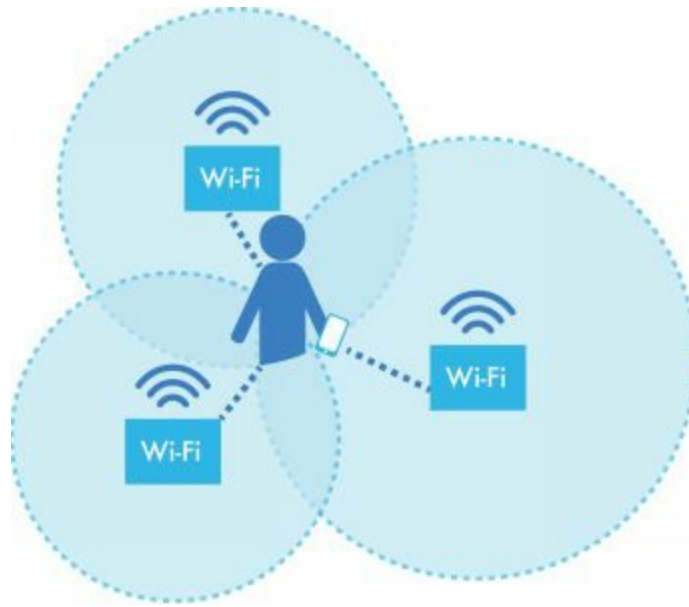
Wi-Fi triangulation, which lets Wi-Fi network owners pinpoint where a shopper is standing. Source: Skyhook[837]

With triangulation technology, retailers like Nordstrom can monitor shoppers' locations and movements throughout a store.[838] This can be pretty useful. For instance, if a store notices that most people walk straight through the hats department to get to the women's department, they could reduce their inventory of hats and stock up on women's clothing.[839] They can figure out which days and times are the busiest and adjust the number of salespeople or cashiers accordingly. One company even lets retailers measure how many people pause outside the storefront and then walk in — which helps the retailers figure out which window displays are the most effective.[840] It's highly profitable.[841]

So, why do stores like Nordstrom offer free Wi-Fi? Offering Wi-Fi hotspots gets visitors to turn on their Wi-Fi so their phones start shooting out radio waves, which Nordstrom can use to track them through the store. And that, in turn, means big bucks.

Digging up more data

When Nordstrom started using Wi-Fi triangulation software, they argued it was all anonymous, so it was no big deal. They would know your phone's MAC address, but that wasn't enough to figure out who you were.[842] (Think

about it — do you even know your own phone's MAC address?)

But companies have clever ways of figuring out who you are based on your MAC address. For instance, stores can make you sign in with your email address before you can use their free Wi-Fi, which lets them tie your MAC Address with your email address. Then, stores can link your in-store activity with your online activity. For instance, if you were browsing for scarves on macys.com, you could suddenly get a coupon for scarves as soon as you walked into a Macy's store.[843]

Stores could make this data even more powerful by combining it with video surveillance. Some new video cameras installed in stores are reportedly so good that they can make out your age, gender, and ethnicity just from video footage.[844] They can also tell which specific products you looked at and how long you looked at them.[845] Combine that with your in-store movement data and online purchase data, and stores can get a juicy dossier of your tastes.

Eventually, stores could even start sending you targeted coupons via push notifications if you start looking at a product but start walking away.[846] (There's another reason to offer free Wi-Fi — it lets you send information to customers over the internet connection.)

Love it or hate it?

Tracking customers with tools like Wi-Fi and video surveillance is clearly profitable for retailers, who are struggling with problems of "showrooming", where people look for things in stores but eventually buy them online.[847] The more data stores get on users, the better positioned they are to make the sale.

So how about customers?

Well, on the plus side, this could help stores give you a better experience by getting rid of unpopular products or ensuring there are enough employees on the floor at any time.[848] If stores knew how often you came to shop, perhaps they could start offering loyalty programs that would help you out. And the

targeted coupons could help you find a bargain.[849]

The downside is privacy. It's shocking how much information stores can learn about you — from your shopping habits to your physical appearance, and they can literally track your every move.[850] The worst part about Nordstrom's case is that the retailer didn't tell their customers that they were being tracked — and when people found out, they weren't happy.[851] To combat this problem, Nordstrom offered a way for customer to opt out of being tracked. But notice that the customer never explicitly opted in.[852] Nordstrom's hope was that the customer wouldn't be bothered with opting out.

It's hard to stop the surveillance. Researchers found that some phones scan for Wi-Fi networks even if you have turned off Wi-Fi, meaning that you'd need to turn off your phone to stop the tracking. But some phones will still search for Wi-Fi networks even when they're off. You'd have to take your phone's battery out (or smash it with a hammer) to completely put a stop to this. But even then, you can't avoid video tracking.[853]

In response, retailers say that Wi-Fi tracking is no worse than shopping online, where e-retailers like Amazon can track your every click.[854] But privacy advocates would probably argue that tracking someone's clicks is much less creepy than tracking someone's physical movements.

So it's a mixed bag. But whatever you think of Nordstrom's free Wi-Fi, you've got to admit that it's a clever business move.

Why does Amazon offer free shipping with Prime membership even though it loses them money?

Since 2004, Amazon's Prime service has let you get free two-day shipping on millions of products[855] if you subscribe for $99 a year[856]. It's a huge program: two-thirds of all American households are on Prime.[857]

Shipping things quickly and freely across the globe isn't cheap, though. In 2016 Amazon lost $7.2 billion on shipping, up from $5 billion the year before, largely due to Prime.[858] If Prime loses them so much money, why does Amazon offer it?

Before we explore some reasons, it's important to note that Amazon tends to care more about increasing revenue than increasing profits. That's because it's historically reinvested its revenue back into the company instead of giving it to shareholders.[859] The idea is to grow the business as quickly as possible to maximize long-term growth,[860] and also because retail is a low-margin business in general.[861]

As such, Amazon has intentionally taken in very little profit. For instance, in 2016 Amazon made $136 billion in revenue but took a puny $2.4 billion in profit.[862] That's actually way more profit than previous years, where their profit hung around zero; in 2012, Amazon actually lost $39 million[863] despite taking in $61 billion in sales.[864]
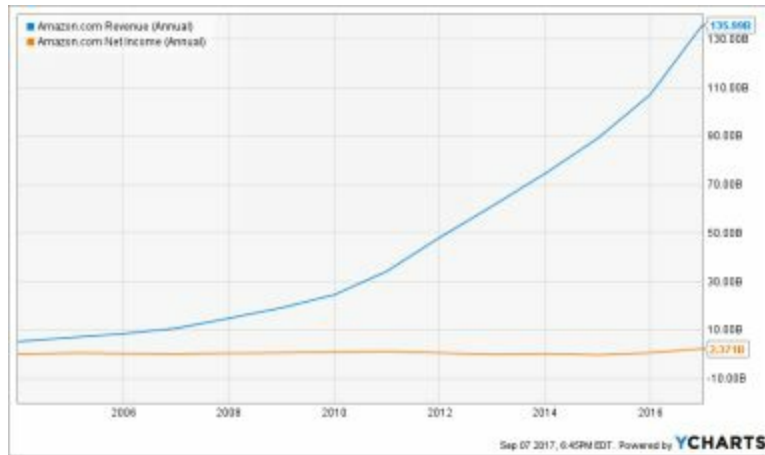
Amazon is growing like crazy, but they've been intentionally keeping their profit (or "net income") low. Graph made in September 2017. Source: YCharts[865]

How Prime cashes in

So, Amazon's goal with Prime is probably to grow their revenue. Here a couple key ways Prime helps Amazon bring in more sales.

First, Prime is a powerful loyalty program that gets customers to spend more and more money on the platform. A study by Morgan Stanley found that Prime members spend a staggering 4.6 times as much on Amazon per year than non-members.[866] Granted, part of this is because bigger spenders are more likely to join Prime in the first place. However, there are a few reasons why just joining Prime could get someone to spend more. One reason is instant gratification (well, more instant than normal shipping), which enables "thoughtless" impulse buying.[867] A second reason could be that, once people commit the $99 a year for Prime, they feel the need to buy a lot of stuff (and get a lot of free shipping) to justify that spending.[868] Data seems to support this theory: one study found that loyalty programs increase sales by 20%.[869]

Second, Prime members do a greater proportion of their shopping on Amazon. Many Prime members default to shopping on Amazon even if the item they want to buy is cheaper somewhere else, perhaps because using Amazon has just become a habit.[870] Plus, it's hard to beat free two-day shopping, so many Prime members will buy from Amazon even if they originally found the product on another site.[871] The numbers are stunning: a

Prime member who starts shopping on Amazon is 12 times less likely to also visit Walmart.com than a non-Prime member.[872] In other words, Prime makes customers even more loyal.

Third, Prime started a race to the bottom, which hurts its competitors. Prime has conditioned customers to expect two-day shipping,[873] so Amazon competitors are being forced to offer free two-day shipping just to stay competitive. There are plenty of examples. Target offered free shipping during the 2014 holiday season.[874] In 2017, Walmart started offering free two-day shipping on orders over $35.[875] And in 2010 a consortium including Toys "R" Us and Barnes & Noble even created a Prime clone called ShopRunner, which had the same benefits (free two-day shipping if you buy from any of the companies) and price point as Prime.[876] The spread of two-day shipping is great for consumers, but it could be a death sentence for retailers without the money or infrastructure to ship that much stuff that fast.[877]

Growing Prime

It's clear that it's in Amazon's best interest to get more people to join Prime. So it's no surprise that Amazon keeps cramming as many features as possible into Prime. Prime includes not only free shipping but also free movies; 600,000 free Kindle eBooks; and music streaming.[878]
Amazon cares so much about Prime that it moved its grocery delivery service AmazonFresh into Amazon Prime in 2014.[879]

Even though Prime might look like a losing proposition on the surface, it's a treasure trove for Amazon. Bloomberg even called it "most ingenious and effective customer loyalty program in all of e-commerce, if not retail in general."[880]

Why does Uber need self-driving cars?

In 2015, Uber poached an entire team of robotics faculty from Carnegie Mellon[881] and set up an office in Pittsburgh dedicated to self-driving cars. [882] Former Uber CEO Travis Kalanick said that developing an autonomous vehicle was "basically existential" for the company.[883] Why does Uber have such drive to self-drive?

The first reason is money. Uber isn't in the best financial position: the ride-sharing company lost money every quarter, except one, between 2012 and 2016.[884]
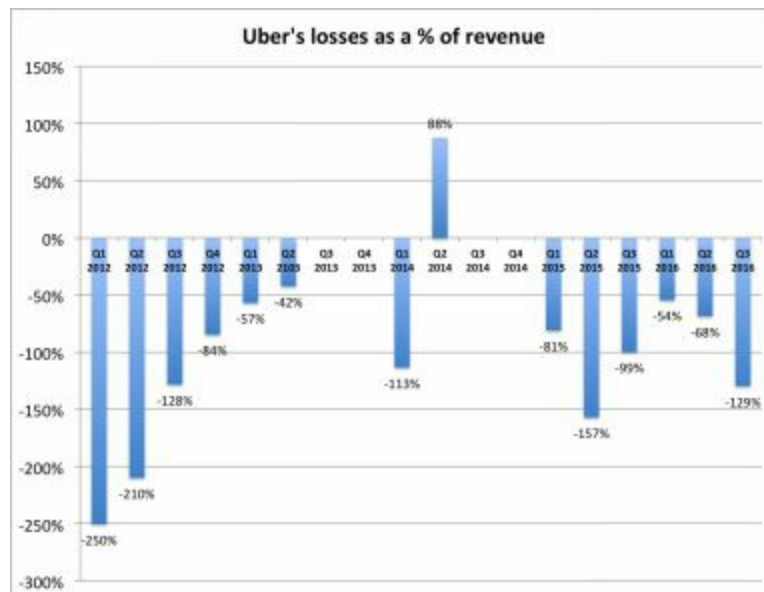
Uber lost money every quarter, except one, between 2012 and 2016. Source: Business Insider[885].

Uber isn't losing money because its growth is slowing. Its growth is actually excellent: Uber took in $1.7 billion in the last quarter of 2016, up 240% from the same time in 2015 (or *year-over-year*) and almost 90 times more than the same period in 2013.[886]

So why is Uber bleeding so much money? One reason is that Uber subsidizes each trip to grow its user base,[887] which leads Uber to lose money on most rides.[888] The bigger reason is that Uber just doesn't take in enough money: it

only takes roughly a 20% cut on each ride,[889] presumably because it needs to pay the rest to drivers.

But with self-driving cars, Uber would have no drivers to pay. Sure, Uber would need to take on the costs of gas and maintenance of the cars (which are currently the drivers' responsibilities), but this pales in comparison to how much Uber would save by not having to pay drivers.[890] One study found that a self-driving fleet would cost just one-tenth as much to operate as a normal taxi fleet — something that would definitely help Uber move toward profitability.[891]

Second, riders would have strong reasons to prefer self-driving cars. Autonomous Ubers would be far cheaper for consumers[892] and, according to one expert, would cut accident rates by 90%.[893] So offering self-driving cars would help Uber attract customers and grow its user base.

The third reason is the "feverish" competition.[894] There are a lot of players making big bets on self-driving cars: Google's self-driving car project Waymo started collaborating with Lyft to create self-driving cars in May 2017,[895] Ford invested $1 billion in a self-driving car startup called Argo AI, and Tesla has built the hardware needed for its cars to be autonomous.[896] Every company wants to be the first to master self-driving cars.[897] Because self-driving cars will be so much cheaper to operate, the first company to bring them to the mainstream can get a significant edge,[898] and the winner will also be able to earn money by licensing their self-driving software to competitors.[899] In other words, Uber would rather make its own autonomous car instead of being forced to buy solutions from its rivals.

Why did Microsoft acquire LinkedIn?

In 2016, Microsoft bought professional social network LinkedIn for a jaw-dropping $26.2 billion — Microsoft's largest acquisition to date, and the third-biggest tech acquisition in history as of 2016.[900] Why would Microsoft splurge so much on a social network?

Owning the enterprise

Microsoft's traditional business, Windows and devices, have long been on the decline.[901] Sales of PCs and Surface tablets shrank 26% from 2016 to 2017 alone.[902] Microsoft was never able to get a foothold in the massive mobile space; Windows Phone was a flop.[903] Instead, Microsoft knows that its future (and present) is in enterprise software, or tools built for businesses; Azure (Microsoft's cloud computing platform aimed at businesses) and Office 365 are their most profitable and fastest-growing segments.[904]

So the LinkedIn purchase was very important for Microsoft, because it cemented the company's place as a leader in the enterprise space.[905] Let's break down a few ways it does.

First, acquiring LinkedIn helps Microsoft become the center of the businessperson's world, much like Facebook or Instagram might be the center of your online social life.[906] Making a presentation with PowerPoint? You're using Microsoft products. Taking a Windows laptop to a meeting? You're again using Microsoft products. Trying to find your next job with LinkedIn? Now, you're using Microsoft products. Because so much of business workers' work-related stuff — emails, documents, professional profile, etc. — lives on Microsoft products, Microsoft thinks it can make your LinkedIn profile your central professional "source of truth."[907]
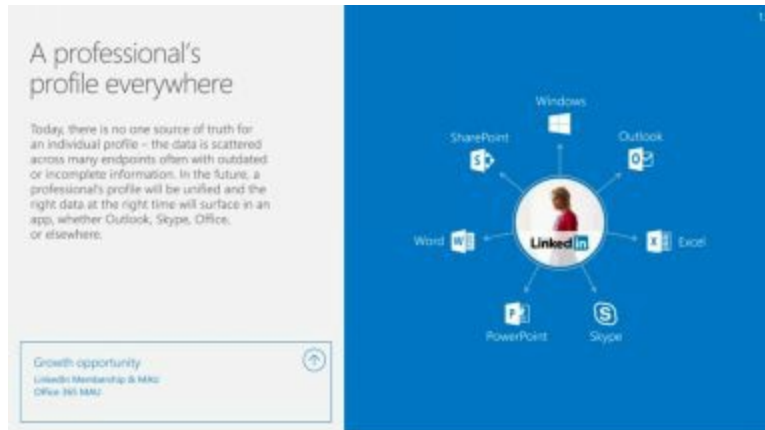
With LinkedIn, Microsoft wanted to become the center of people's professional lives. Source: Microsoft SEC filing[908]

Second, by acquiring LinkedIn's 433 million users,[909] Microsoft got a huge data source — which it calls "the social graph"[910] — that can improve its existing enterprise offerings. That is, Microsoft could mix LinkedIn's data and profiles into tools like Office apps. For example, your Outlook calendar could show the LinkedIn profile of the next person you're meeting with, and Cortana (Microsoft's version of Siri or Alexa) could give you tips on how to impress them. Salespeople using Microsoft's customer relationship management tool, Dynamics CRM, could use potential clients' LinkedIn profiles to have a better idea of how to pitch their product. Or, Office 365 could analyze a company's organization chart on LinkedIn to see what kinds of talent they need to add.[911] With this exclusive data, Microsoft can build features that set its products apart from competitors like Salesforce (a CRM system that competes with Microsoft's Dynamics)[912] or Google's G Suite (basically Google Drive and Gmail for businesses).[913]

Microsoft wants to combine its data on business workers, like email and calendar, with LinkedIn's data, like workers' relationships with colleagues and their list of past jobs. They call the combined dataset the "Economic Graph." Source: Microsoft SEC filing[914]

The third reason is simply that Microsoft wants to keep LinkedIn's valuable data and gigantic user base away from its competitors. Google and Facebook have both tried to make moves into the profitable enterprise space,[915] but Microsoft's purchase kept them locked out and feeling pressure to respond.[916] With the LinkedIn purchase, Microsoft also struck back against Salesforce, a CRM company that competes with Microsoft's Dynamics software. Salesforce was actually scared that Microsoft's windfall of data would make Dynamics far better than their product![917]

Some other reasons

As we've seen, the LinkedIn purchase was designed to help Microsoft solidify its stronghold on the business market. There are a couple reasons that the purchase helped Microsoft in the long run.

One is simple: money. LinkedIn pulled in a small profit ($71 million) a year before Microsoft acquired them,[918] which is always a welcome addition. LinkedIn has good revenue prospects because it has a nicely diversified revenue stream, split between premium subscriptions, advertising, and tools for recruiters.[919] Furthermore, LinkedIn continued to grow quickly, adding 70 million users (or 15%) within 10 months of the acquisition.[920] All of these are positive signs for further earnings for Microsoft.

The other key reason is the people. LinkedIn's chairman Reid Hoffman, who also founded giants like PayPal and worked on startups for 20 years, is one of the best-connected and most-liked people around Silicon Valley.[921] When Hoffman joined Microsoft's board, he said he would help Microsoft build stronger connections around Silicon Valley[922] — a very important asset for Microsoft, which for many years was unpopular in the Valley.[923]

So, in summary, why did Microsoft buy LinkedIn? There are many factors,

but the underlying theme is that it helped Microsoft maintain its much-needed chokehold on the enterprise space and keep the valuable business and data of LinkedIn away from its opponents.

Why did Facebook acquire Instagram?

In 2012, Facebook bought the hot photo-sharing social network Instagram for $1 billion.[924] But, at the time, Instagram had zero revenue and no plans to make revenue — so why would Facebook spend so much to buy them?[925]

While pundits threw around dozens of ideas,[926] the main reason could be summed up in two words: *mobile photos*.

First, *mobile*. Facebook started as a desktop web company, but by 2012 they began to realize that the future was on mobile devices.[927] While half of Facebook's users logged in on a mobile device in 2012, Facebook hadn't figured out how to monetize mobile at all, and their mobile apps and website were accused of clutter and long page load times.[928] Facebook announced it wanted to be a mobile company, but it wasn't sure how to.[929]

Enter Instagram, an up-and-coming, mobile-native social network.[930] Its Android app picked up a million users in the first day it was available.[931] This in itself would have given Facebook a strong reason to want to acquire Instagram.

Don't forget the second part: *photos*. Photos are what built Facebook up; its timeline relies on bright, colorful photos to be more than just a sea of text.[932] Mobile users seemed to prefer Instagram's photo-sharing experience to Facebook's, probably since Instagram was cleaner and photo-centric — not to mention the filters.[933] Facebook recognized that Instagram was doing a better job with mobile photos[934] and feared that Instagram would become the primary way people shared photos with the world.[935]

By buying Instagram, Facebook (the company) ensured it owned the future of mobile and photos, even if their flagship app wouldn't.[936] Rumors swirled that Google[937] and Twitter[938] wanted to buy Instagram, so it's little wonder that Facebook swooped in so decisively.

The verdict

Back in 2012, commenters were unsure if the Instagram acquisition was a smart move, with some calling it a sign of a "Web bubble."[939]

But in 2016, Time called Instagram "one of the smartest acquisitions ever."[940] Why? For one, Instagram kept up its breakneck growth, expanding from 30 million users in 2012 to over 400 million (more than Twitter!) in 2015.[941] More notably, Instagram succeeded in bringing targeted ads to a platform that originally had no monetization strategy: Instagram ads brought an estimated $3.2 billion to Facebook in 2016.[942]

Though Instagram had no revenue when it was bought, Facebook noticed Instagram's potential for incredible growth. Combined with Facebook's skills in advertising, Instagram quickly became a money-making machine.[943]

Why did Facebook acquire WhatsApp?

In 2014, Facebook made waves by acquiring the hyper-popular messaging app WhatsApp for $19 billion — that's $42 for each of WhatsApp's 450 million users at the time,[944] and vastly more than Facebook paid for Instagram. But why did Facebook spend so much on a company that many Americans hadn't even heard of,[945] especially when Facebook already had its own Messenger app?

The first reason is precisely because Americans hadn't heard of WhatsApp. WhatsApp is pretty similar to Facebook Messenger in that they both allow real-time text messaging over the internet.[946] But WhatsApp is huge in markets where Facebook and Facebook Messenger are weaker[947], especially in developing countries like Brazil, Indonesia, and South Africa.[948] (Interestingly, the only major markets where WhatsApp hasn't taken off are China, where it's banned,[949] and the US, where mobile carriers made SMS much cheaper than data.[950])

By buying WhatsApp, Facebook made a smart defensive play. WhatsApp is strong in the exact countries where Facebook is weak, so the purchase shored up Facebook's international presence.[951] In other words, WhatsApp is no longer a competitor; people who were using one of Facebook's main rivals now belong to Facebook anyway![952]

The second reason is data. WhatsApp could provide Facebook troves of personal data on its millions of users — especially in developing markets — which would help Facebook better target its ads and services.[953] Targeted ads, of course, are how Facebook makes money.[954]

A third reason is photos, which should sound familiar from the Instagram story. Dominating the world of photos is one of Facebook's core goals,[955] and it had reason to worry about WhatsApp. WhatsApp users sent 500 million pictures a day in 2014, which was more than Facebook and Instagram combined.[956] Snapping it up was, like Instagram, a smart move to regain dominance over photos.

Pundits have put forward many more reasons,[957] but the last one we'll cover is the mobile space. Mobile is particularly critical for Facebook, since as of 2017 mobile ads account for 86% of Facebook's revenue.[958] So, without a mobile operating system of its own (unlike its archrivals, Apple and Google), Facebook realized it needed to control as many popular apps as possible.[959] So it makes sense why they'd want WhatsApp, the 2nd most popular Android app as of 2016.[960]

In short, buying WhatsApp filled several of Facebook's biggest holes: developing countries, data, mobile, and photos. It was an expensive but savvy move — Business Inside even praised the WhatsApp purchase as Facebook's "best ever."[961]

Why did Facebook buy a company that makes virtual reality headsets?

Facebook shocked the tech world when, in 2014, it acquired the makers of a virtual reality headset called the Oculus Rift, which was mostly used for video games.[962] When the social media giant acquired two more social networking apps, WhatsApp and Instagram, the rationale seemed pretty clear. But the purchase of this VR video game company, called Oculus, seemed bizarre.[963]

The purchase didn't seem to make much immediate financial sense. VR has had a sluggish consumer debut,[964] as evidenced by the Oculus Rift's repeated price cuts since its launch.[965] Instead, Facebook CEO Mark Zuckerberg admitted the purchase was a long-term ploy, saying in 2016 it would take another 10 years for VR to reach mass market.[966]

Facebook imagined that virtual reality would be the future of communication.[967] Instead of just connecting over text, images, or videos, Zuckerberg explained a future where you could use VR to experience sports games, university lectures, appointments with doctors, and adventures with friends all from the comfort of your home.[968] (Critics said that seemed a bit far-fetched, since strapping on a heavy, expensive headset just to chat with friends might get tiring after a while.[969])

We'll have to see how the future of communication plays out, but if Zuckerberg ends up being right, owning the socially-focused Oculus headset could be valuable for Facebook. Facebook's strategy has long been to maximize how much time people spend on its platforms;[970] more time equals more chances to show ads and more user data to make the ads better-targeted.[971] Perhaps Facebook's strategy could be to get users to spend lots of time on Oculus, at which point Facebook could start sliding in engaging new forms of advertising: product placement, game-like ads, or immersive ads for concerts, to name a few ideas.[972]

For evidence of this theory, consider how Facebook started letting Oculus Rift owners stream live VR videos to their Facebook timelines in July 2017. [973] Oculus owners could start hanging out around a table in VR, doing things like answering audience questions (avatars can "grab" posters containing audience comments), chatting, or doodling in the air.[974]

An example of a VR live video on Facebook: virtual office hours with a professor. Source: Facebook[975]

This new feature is a clever way to build buzz around virtual reality,[976] which could encourage curious viewers to buy headsets.

So why did Facebook acquire a virtual reality headset company? It's not just for video games. Facebook sees VR as the future of computing and social networking, and they want to be a leader in that space.[977]

Chapter 11: Technology Policy

Within the last few decades, the internet has become the way we shop, communicate, research, share, and do business. As such, it should be no surprise that the world of technology has come crashing headfirst into long-standing policy and legal debates. How should the government regulate big businesses? Is free speech or privacy more important? Who can control what gets said? In this chapter, we'll discuss real-world examples of these questions and more.

We'll start off the chapter by meeting the giant companies that connect you to the internet, like Comcast, AT&T, and Verizon.[978] We'll explore the giant tug-of-war between these companies, regulators, and citizens over issues like broadband privacy and net neutrality — a struggle which has been called "the fight for the soul of the internet."[979]

Then we'll turn to the brewing battle between tech companies and regulators over a European law called the "right to be forgotten."[980] Along the way, we'll explore how technology is affecting the freedom of the press and the right to privacy.[981]

We'll finish up with a look at data, the "new raw material of the 21st century."[982] We'll show how data could create trillions of dollars in economic value. But we'll also show the dark side of data, looking at how data leaks could harm people — and what we can do about it.

Buckle up — let's jump into the world of technology policy.

How can Comcast sell your browsing history?

In 2016, the Federal Communications Commission (FCC), the US government's department that regulates telecommunications and the internet, released rules that made internet service providers (ISPs) get your consent before selling your browsing history to advertisers.[983] But in 2017, Congress passed a bill that killed these "broadband privacy" regulations.[984] In other words, the 2017 ruling lets ISPs sell your information whenever and however they like.[985] Consumer advocates were outraged.[986]

But who exactly are these ISPs? What data do they have about you? And what's wrong with them selling that data? Let's break it down.

A game of Monopoly

Whenever you connect to the internet over Wi-Fi or watch TV over cable, you're consuming so-called "broadband" content.[987] Companies called internet service providers, or ISPs, deliver that content to you; in other words, they're the people who provide your cable and home internet.[988] The largest ISPs in the US include Comcast, AT&T, Verizon, CenturyLink, Cox,[989] and Spectrum.[990]

Don't confuse these with the telephone companies that bring you 4G and mobile service. Those include Verizon, AT&T, Sprint, and T-Mobile.[991] (Note that Verizon and AT&T are on both lists!)

Because ISPs sit between you and every website you visit, they can track your entire browsing history. Then they can sell this information, along with demographic information like your age and location, to advertisers, who can use the data to target ads at you.[992] This is a treasure trove of information — which dwarfs even what Facebook and Google have on you.[993] Privacy advocates say that ISPs can even hijack your Google searches or inject ads into websites you browse.[994]

If you don't like this, tough luck. Thanks to a spate of mergers and

acquisitions, ISPs have monopolies in much of the country:[995] the Federal Communications Commission (FCC) estimated that 75% of American households have zero or one option for high-speed ISPs — in other words, their ISP is a monopoly.[996] And, predictably, the monopolies have led to slower internet and higher prices.[997] For instance, AT&T has a monopoly in Cupertino, CA but competes with another ISP in Austin, TX — and AT&T charges consumers in Cupertino $40 more for the exact same basic service! [998]
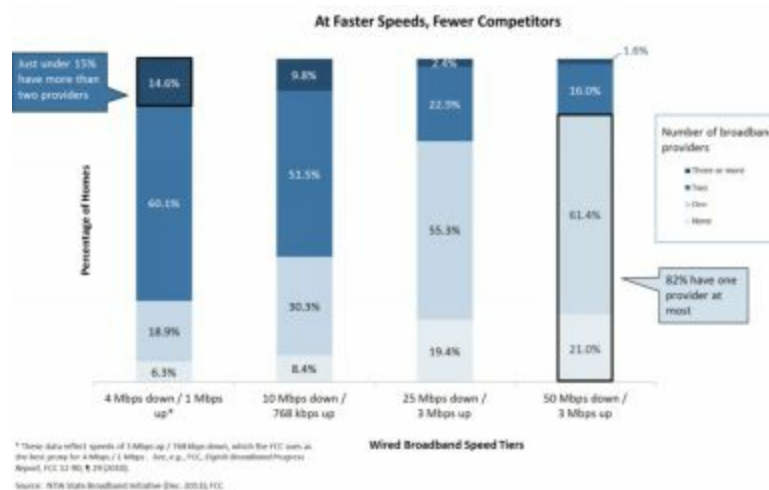
More than three-quarters of Americans have zero or one choice of ISPs for high-speed internet, defined as 25 Mbps or more. That's a troubling sign of a monopolistic market. Source: FCC[999]

Unfortunately, these monopolies seem tough to break up or regulate due to lax anti-trust regulations and the high barriers to entry in the telecom business.[1000] Setting up the massive infrastructure required to deliver the internet is so hard that even Google had trouble doing it; Google tried creating its own super-fast ISP called Google Fiber, but it was met with difficulty and significantly scaled down in 2017.[1001]

Because ISPs are nearly monopolistic, their information-selling habits are particularly dangerous for consumers. If your ISPs are selling your browsing history but you don't like it, you're out of luck — there aren't many other options besides ditching the internet entirely.[1002]

Regulation — or not

Before 2016, there were few regulations against ISPs selling user data to marketers.[1003] But in 2016, the Federal Communications Commission (FCC) passed a rule saying that ISPs had to get explicit opt-in permission from customers before they could sell people's browsing history to marketers.[1004] Broadband privacy advocates celebrated the victory.[1005]

But in 2017, a new FCC chairman named Ajit Pai came to power, and with his support Congress axed the rule.[1006] That meant that ISPs could continue selling people's data to marketers without their consent.[1007]

Consumer advocates decried this ruling, calling it a power grab by ISPs and an invasion of consumer privacy.[1008] Supporters of the move said it was only fair, since the data-selling regulations didn't apply to Facebook or Google, which also make billions by using data to target ads.[1009] They said that ISPs needed ad-targeting power to compete with Google and Facebook. But it's worth noting that companies that provide internet access are very different than companies that provide services *over* the internet, much like a truck is different than a highway.[1010] Plus, Google and Facebook are free and need ads to make money, whereas you already pay your ISP for internet service.[1011]

The contentious debate will likely rage on. But fortunately, there's at least one funny result. After the FCC rolled back the broadband privacy rules, the tech news site ZDNet filed a Freedom of Information Act request asking to see the browsing history of the new FCC chairman Ajit Pai, who fought for the new rules. The FCC said it didn't have any information.[1012]

Why does Comcast need to be regulated like FedEx?

You might have heard the term "net neutrality" being thrown around on the news — but it's wrapped up in all kinds of legal jargon and impassioned speech. Here, we'll explain what net neutrality is, why it matters, and where the policy battle around it stands.

Common carriers

Let's begin our story with some offline analogies to net neutrality.

Delivery companies like FedEx, UPS, or the US Postal Service can't discriminate[1013]. FedEx can't ship packages from Amazon but not eBay. UPS can't look inside your packages and ship books it doesn't like more slowly. And the USPS can't take bribes to deliver certain letters faster than others.

More generally, if you're in the business of shipping goods or carrying people, the US has laws that prevent you from discriminating. You have to charge everyone the same price for the same service, providing the same speed and quality as well.[1014] Companies that accept payment to move goods or people are called "common carriers,"[1015] and a surprising number of businesses fall into this category. Public utilities like oil and gas companies have to give everyone the same service for the same price,[1016] telecom providers like AT&T can't decide what gets said over their phone lines[1017], and even Disneyland can't charge someone more for the same ride. That's right, Disneyland is classified as a common carrier because you pay them to move you around a track in a fun and exciting way.[1018]

Why do we need common carriage laws? They protect consumers[1019], and they're just fair: everyone should have equal access to public services. It's the same reason that stores can't turn away customers because of their race.[1020]

In 1934, Congress passed the Federal Communications Act, which formed

the Federal Communications Commission (FCC) to create and enforce common carriage laws. The FCC originally regulated telegraph operators and telephone companies under a provision called Title II.[1021] But when the internet came along many decades later, the low-profile agency was suddenly thrust into the limelight.

ISPs as common carriers

What do 20th-century regulations on mail carriers and amusement parks have to do with the internet? Think about it. You pay FedEx to ship books, smartphone accessories, and all manner of physical items to and from you using their delivery trucks. Similarly, you pay ISPs like Comcast to "ship" Tweets, videos, and other information to and from you over the internet. The core idea of net neutrality is that ISPs should be treated as common carriers (like FedEx) under Title II[1022], which would prevent them from discriminating.[1023] In other words, FedEx is currently required to treat all packages equally. Net neutrality says that ISPs like Comcast should treat all web traffic equally.[1024]

Concretely, there are three main discriminatory practices that Title II would prevent ISPs from doing: blocking, throttling, and paid prioritization.[1025]

"Blocking" is when ISPs outright ban traffic on their networks. There are a few real examples of this happening. For instance, in 2007, Comcast was accused of blocking BitTorrent, a technology that many people use to (legally or illegally) share media files like movies.[1026] Vonage, a VoIP provider which lets you make phone calls over your internet connection, saw its website blocked by a competitor in 2004.[1027] And AT&T took heat in 2012 for trying to ban FaceTime for customers who didn't pay extra.[1028] Blocking a website entirely is pretty obvious, so many ISPs prefer a more subtle approach: "throttling."

"Throttling" is when ISPs slow down content from any specific website;[1029] in other words, it's when they don't serve everyone equally. In 2013 and 2014, Comcast and Verizon famously slowed down content from Netflix[1030], perhaps because they wanted to boost their own video-streaming

services[1031]. It got so bad that Netflix had to pay Comcast and Verizon to stop the throttling.[1032]
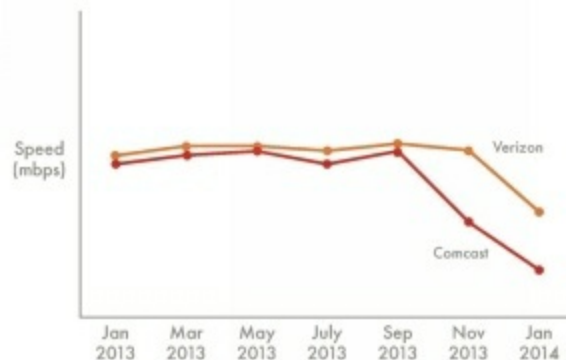
In what appears to be a case of throttling, Netflix saw sudden drops in speed on Comcast and Verizon. Netflix eventually had to pay Comcast and Verizon to stop the throttling! Source: Consumerist[1033]

Third is "paid prioritization," which is where an ISP can strike deals with websites to send that website's information faster than their competitors'.[1034] Economists have argued that paid prioritization is the same thing as throttling: if you preferentially make one piece of information move faster, every other piece moves slower, which means it gets throttled.[1035] It's like if someone cuts ahead of you in line: they wait less, but you wait more.

Sounds pretty cut and dry, right? Net neutrality is an obvious win for consumers.[1036] But, unfortunately, the policy battle over net neutrality has been anything but simple.

The history of net neutrality

When the FCC first tried regulating internet providers in 2002, it didn't place them under Title II, which would have classified them as common carriers. [1037] Instead, it placed them under a provision called Title I, which classified them as "information services" and didn't ban blocking, throttling, or paid prioritization.[1038] In other words, Title I is a much less stringent regulation than Title II.[1039]

In 2010, the FCC started looking into reclassifying ISPs as common carriers

under Title II.[1040] something that it managed to do in 2015.[1041] much to the excitement of net neutrality supporters.[1042] But then, in May 2017, the new FCC chairman Ajit Pai announced he was going to reclassify ISPs under Title I,[1043] saying net neutrality's "days are numbered."[1044] (Pai might have some financial incentives for being pro-ISP: he was formerly a lawyer for Verizon![1045])

As you can tell, net neutrality is a politically fraught topic and the subject of a tug-of-war between politicians. Net neutrality advocates argue that Title II regulation is critical; without it, a few big companies could control the internet, stifling innovation and hurting consumer choice.[1046]

For net neutrality advocates, the nightmare scenario is a future where ISPs would only let you access a handful of pre-approved websites. To get more websites, you'd need to pay a lot extra. ISPs could even prevent you from getting non-approved websites at all![1047] It's scary to imagine, and what's scarier is that there could be no alternatives to the ISPs — remember how we mentioned that they're almost monopolies in many places, and it's very hard for new companies to break into the space.

Opponents of net neutrality say that Title II regulation is "outdated" and too strict.[1048] Pai's FCC argued that forcing net neutrality made ISPs slow the expansion of broadband, however a pro-net neutrality group argued that Title II had no such impact.[1049]

What's next? No one can tell, but we're sure the debate will rage on.

How did a British doctor make Google take down search results about his malpractice?

In 2014, a British doctor asked Google to take down 50 links to newspaper articles about some botched medical procedures he had done in the past. Due to a new European law,[1050] Google agreed, removing links to 3 search results that would appear if someone Googled the doctor's name.[1051]

Understandably, the public was outraged. People often choose doctors based on what they find from Google searches — and if malpractice results don't show up, patients could make uninformed decisions that could harm their health.[1052] Why was Google forced to comply with this request, and is this trend a force for good or bad?

The right to be forgotten

The story of forcing Google to remove unflattering links starts in Spain in 1998. A man named Mario Costeja Gonzalez racked up some debts that local newspapers reported on. In 2010, he was dismayed that Google searches for his name still showed these articles that hurt his reputation, even though it was over a decade later. So he asked Google to take down the search results. This escalated into a lawsuit that reached the European Court of Justice in 2014, when the court ruled that the right to privacy includes a "right to be forgotten."[1053]

Under this law, if you search for your name on Google and see a link to an website that contains "inadequate, irrelevant or no longer relevant" information about you, you can ask Google to remove that website from search results for your name.[1054]

Users can ask for a takedown using a form on Google's website.[1055] Google has to then decide whether or not to keep the page. The company has to weigh how much hiding the information would help the person against how important it is for the public to know this information[1056]. If Google doesn't comply or the EU doesn't like their decision, the EU can take legal action

against the company.[1057]

If Google decides to censor search results for a particular term, it'll show you a notification at the top of the page:

> Some results may have been removed under data protection law in Europe.[1058]

The "right to be forgotten" law has been invoked millions of times. Google started accepting takedown requests in May 2014, and within a month it got 50,000 takedown requests.[1059] Within 3 years, Google was asked to remove over 2 million URLs, 43% of which it took down.[1060] The websites most targeted for removal from search results included Facebook, YouTube, Twitter, Google Groups, Google Plus, and Instagram.[1061]

Most of the takedown requests are pretty innocuous: an estimated 99% of the takedown requests were just to protect innocent people's private information. [1062] For instance, a sexual assault survivor got Google to hide newspaper articles about the crime.[1063] But some requests were more sinister, like the malpracticing British doctor we mentioned earlier, a politician who wanted to hide unflattering articles about his past, and a convicted criminal who wanted to remove mention of his wrongdoings.[1064]

It's important to note that invoking the right to be forgotten doesn't let you flat-out delete something from the internet. Even if Google hides the link to an article from search results for your name, the link will still show up in other searches.[1065] For instance, consider the British doctor: the malpractice articles wouldn't show up on a search for his name, but they might show up for a search like "British doctor malpractice." And, of course, the article would still exist on the original site. More notably, the ruling only applies to Google's European search engines. A removed search result could be gone from Google.de or Google.fr, but anyone searching on Google.com — even someone in Europe — could still see the result.[1066] France's data protection authority noticed this loophole, though, and has ordered Google to remove results from all of its search engines worldwide.[1067]

Forgive and forget?

Commentators around the world were outraged at the "right to be forgotten" law, saying it restricted the freedom of speech and the press.[1068] Google called it a "disappointing ruling for search engines and online publishers in general,"[1069] and Google cofounder Larry Page warned that the ruling could stifle internet startups.[1070] Others feared that tyrannical governments could use this law as a precedent to justify mass censorship.[1071] More philosophically, some observers thought it was strange that a search engine company now has to be the judge of free speech.[1072]

But supporters of the law called the right to be forgotten an individual right. [1073] Some privacy advocates see it as a victory.[1074] The law could also stop youthful indiscretions from coming back to haunt people forever — in this world where everything is permanently recorded on the internet, the ability to forgive and forget can be a welcome change.[1075]

The debate might just boil down to a question of values, though.[1076] Whereas Americans value free speech above almost anything else, Europeans generally place more emphasis on the right to privacy.[1077] That might explain the differing opinions on the right to be forgotten — and it hints that the battles over the law will not be forgotten anytime soon.

How did the American government create the multi-billion dollar weather industry out of thin air?

Before 1983, the only source of weather data and predictions — from temperatures to tornadoes — was from the National Weather Service, an American government agency that had been dutifully collecting data since 1870.[1078] In 1983, the NWS took the unprecedented step of offering its data to third parties. Private companies could buy NWS data and use it in their own products or forecasts.[1079]

Whether or not the NWS expected it, this simple move spurred the creation of a private-sector weather prediction industry.[1080] The weather industry, which includes big companies like AccuWeather, the Weather Channel, and Weather Underground, is now valued at about $5 billion.[1081] In other words, the US government created a $5 billion industry out of thin air just by releasing data to the public.

It's a natural partnership. Private industries can't build the satellites and radar needed to take millions of accurate weather measurements, but the government can provide it. In exchange, weather companies create forecasts and tools that help citizens and businesses.[1082] For instance, AccuWeather built software that lets them pinpoint severe weather risks so precisely that they can tell which segments of a railroad will be hit. AccuWeather noticed that a tornado was going to hit a town in Kansas and alerted a railroad company in that town. The railroad stopped two trains heading toward town, and "the crews watched as the massive tornado, illuminated by lightning, passed between them."[1083]

Welcome to the world of *open data*: the idea that institutions like governments should make data publicly available, free to reuse, and easy for computers to analyze.[1084] Besides the weather industry, open data has made, and can make, a tremendous economic impact. For instance, in 1983 the US

government made GPS data publicly available — and today over 3 million jobs, from truck driving to precision farming, rely on open GPS data.[1085] (Self-driving cars will, too.[1086]) As if that wasn't enough, McKinsey estimated that government open data could unleash $3 trillion a year in economic activity.[1087] That's right, three trillion dollars.

Open data can also have widespread social benefits. Open data can help citizens hold government accountable, like when a team of journalists used public purchasing data released by the Ukrainian government to identify widespread corruption.[1088] It can also help citizens and companies make useful apps: for instance, in 2013 Yelp integrated open restaurant inspection scores from San Francisco and New York into its app so that Yelp users could see restaurants' hygiene ratings.[1089] And it can lead to massive cost savings: a British researcher found that one public dataset could help the National Health Service (the UK's national hospital system) save hundreds of millions of pounds.[1090]

Clearly, open data is amazing. So how do we get some?

The policy and politics of open data

You can't just wave a wand and make governments release their data; it takes some serious policy muscle.[1091] Fortunately, many governments have been taking initiative. The UK government committed to the Open Data Charter in 2013, which made its agencies commit to publishing their data by default. [1092] The US followed suit with the 2013 Open Data Policy, which required all new agency data to be released publicly on a website called data.gov.[1093] Data.gov contains free data on everything from the price of college to agriculture to consumer complaints against big businesses.[1094] And in 2014, the American government mandated that all spending data be made public at usaspending.gov with the Digital Accountability and Transparency Act (known as the DATA Act).[1095] This led to like San Francisco[1096] and Boston[1097] creating their own open data portals, similar to countries like the UK[1098] and Japan.[1099]

These policies haven't been free from bureaucratic pushback, however. The

UK's government agencies, for instance, were initially reluctant to go through the work of opening their data without evidence for why open data would be in their own best interest.[1100] And open data is very much vulnerable to shifting political attitudes. While the UK became the world's open data leader by 2015,[1101] open data advocates feared that Brexit in 2016 would threaten Britain's growing open data culture. They feared that austerity measures could make government agencies stop spending the money required to publish and maintain open datasets; never mind the fact that the political drama around Brexit could have distracted from the open data push.[1102]

Level	Format
★	Make your data available on the web (in any format)
★★	Make it available as structured data (for example, Microsoft Excel instead of image scan of a table)
★★★	Make it available in an open, non-proprietary format (for example, CSV or XML instead of Microsoft Excel)
★★★★	In addition to using open formats, use Uniform Resource Locators (URLs) to identify things using open standards and recommendations from W3C, so that other people can point at your stuff
★★★★★	In addition to using open formats and using URLs to identify things, link your data to other people's data to provide context

Sir Tim Berners-Lee, the creator of the internet, suggested that there are five levels of open data, as shown in this chart. Governments should aspire to reach the highest possible level. Source: UK Parliament[1103]

There are some legitimate policy debates around open data, as well. Governments can't just publish everything; they need to ensure that the data they publish doesn't compromise privacy or national security.[1104] Sometimes, data releases could unintentionally be used to hurt citizens. For instance, the Help America Vote Act of 2002 required all 50 states and DC to maintain a central database of all registered voters,[1105] which contains information including voters' names, ages, and addresses.[1106] Many states started selling this data to residents;[1107] political candidates[1108] and researchers[1109] found this information particularly valuable. But Neel, one of our authors of this book, ran a study that found that criminals could combine public voter rolls with Airbnb listing information to figure out the exact names and addresses of millions of Airbnb hosts.[1110] In other words, governments probably shouldn't be releasing voter lists so casually.

As you can see, open data has tremendous potential, and governments have

good reason to expand the range of data they release. But policymakers also need to work with companies and citizens to address issues of privacy and security.[1111]

How could companies be held liable for data breaches?

When companies make mistakes that harm people, they're usually held accountable. When BP's *Deepwater Horizon* oil rig exploded in the Gulf of Mexico in 2010, causing mass devastation to the nearby environment, it had to pay $18.7 billion in penalties to the US government.[1112] After the American company Enron collapsed due to fraud, it had to pay $7.2 billion in settlements to shareholders who lost money.[1113]

Companies have started facing a new threat: data breaches. For instance, hackers leaked the names, email addresses, birthdays, and telephone numbers of 500 million Yahoo users in 2016.[1114] And in 2017, hackers attacked the American credit bureau Equifax, stealing the Social Security numbers of 143 million users — more than half of the adult population in the US.[1115]

The problem? Unlike BP or Enron, companies who suffer data breaches don't often get punished, and affected consumers don't usually get compensated. For instance, after the health insurance giant Anthem was hacked for the information of 80 million accounts, customers filed a class-action lawsuit but got under $1 apiece.[1116] As one frustrated pundit put it after the Equifax breach:

> I don't doubt that companies regret these things, but I don't think they care that much either. To them it means just a few days of bad press and at most a fine that amounts to a minuscule portion of their profits. With penalties like that, why would companies bother to make things better?[1117]

Experts are calling for companies to be held more liable for data breaches,[1118] and that's beginning to happen — in a few countries at least. In 2016, the EU created a landmark law called the General Data Protection Regulation.[1119] Under this new law, companies who are breached will have to pay fines of up to 20 million Euros or 4% of their annual revenue,

whichever is more.[1120] The UK passed a similar law called the Data Protection Act, which requires that companies keep your data "safe and secure" and "for no longer than is absolutely necessary."[1121] The US, meanwhile, has much lighter data protection and privacy laws.[1122] While Congress, has made some pro-data protection rules, it hasn't gone very far. For instance, in 2014 Congress proposed the Data Breach and Notification Act, which would require companies to notify customers after a breach, offer free credit monitoring to customers affected by a breach, and report large breaches to the government.[1123] But the bill never even made it to a vote. [1124] It's a start, though.

Data protection laws vary significantly between countries, and especially between the US and EU. Experts have called for "transatlantic data charters," where American and European regulators would set common policies for how companies should store, share, and protect their data.[1125] Unfortunately, past US-EU talks on this topic have gotten bogged down by widespread disagreements.[1126] But if both sides of the Atlantic can finally agree, international companies will be spared the confusion and hassle that comes with having to obey multiple, often conflicting, data protection laws.[1127]

As data protection laws spread, some insurance companies are starting to offer data breach insurance.[1128] Like with normal health and auto insurance, companies would pay a small amount every year, and in exchange the insurer would cover the costs if a devastating data breach happens.[1129]

Let's go back to the original question: how could companies be held liable for data breaches? Well, policymakers could allow — or even enforce — strict penalties like the ones seen in Europe; they could also require some form of data insurance for companies that hold sensitive data. But until then, American consumers' data continues to be at risk. All this should show you that data policy is one of the most important and most interesting areas of public policy, and our elected representatives need to take action.

Chapter 12: Trends Going Forward

Congratulations! By this point, you've learned how to think like a technologist. You understand topics ranging from the cloud to big data to internet security. You can explain how today's most popular technology works, and you have a strong understanding of the technology industry.

That's great, but it's not enough. You can't only know about the past and the present. The world of technology is always changing, so to keep up, you need to learn about current trends and predictions of where the tech world will go in the future.

So, in this final chapter, we'll explore some of the most important trends and break down some of the biggest concepts. We'll start by looking at technologies that would have seemed like science fiction in the 20th century: cars that can drive themselves, robots that can hold conversations with you, and software that can make fake audio and video good enough to fool humans. While we're at it, we'll explain popular buzzwords like "machine learning," "artificial intelligence," "neural networks," and "natural language processing." You might have heard technologists, pundits, or entrepreneurs raving about these technologies — we'll help you understand what they're talking about and why it matters.

Along the way, we'll tackle some of the age-old questions about technology, which are becoming more and more relevant as computers get ever smarter. Can computers think like people? And, most important of all, can they replace us?

Finally, we'll investigate the future of the tech industry. Will the tech titan Amazon become worth 1 trillion dollars, or will it get broken up? And what does that mean for the world?

We'll answer all these big questions and more in this chapter. Ready for one last round? Let's go.

How do self-driving cars work?

Google started a buzz when it began testing prototypes of its self-driving cars on the streets of Mountain View, California in 2015.[1130] People have been excited about self-driving cars, with one expert arguing that they could cut accident rates by 90%.[1131] Others have feared that the self-driving car industry could destroy entire industries, like America's trucking industry, which employs 3.5 million drivers.[1132] Because of all this potential impact, people all over the world want to know: how exactly do these cars work? And when (if ever) will they hit the streets worldwide? Let's take a look under the hood.

No humans necessary

Let's start by exploring how a car can drive itself. Self-driving cars use a combination of sensors attached to the car, a computer in the trunk, and a company's cloud servers.[1133]

First, the car needs to know where in the world it is. For this, the car uses an onboard GPS to figure out its rough location.[1134] The GPS isn't always perfectly accurate, though, so the car uses an "inertial navigation system" to get a more fine-grained idea of where it is as it's moving.[1135] The car has internal sensors similar to speedometers and compasses; these sensors tell how fast the car is moving and in what direction.[1136] The car can then estimate where it's gone after a certain amount of time has elapsed. Errors in these sensors can add up,[1137] so the car might use map data to calibrate its position.[1138]

Once the car knows where it is, it needs to understand what's going on around it, including other objects (both moving and stationary) and street directions (like lane markers or stop signs).[1139] This understanding begins with hyper-detailed maps of the area. These aren't your garden-variety Google Maps, though; these maps are precise to the inch and include features like the height of every curb and the position of every traffic sign.[1140] These maps are so important, in fact, that a war over high-precision map data has

been brewing among carmakers: BMW, Daimler, and Audi spent $3.1 billion to acquire a 3D mapping company called HERE in 2015.[1141] As you can imagine, Google's expertise with mapping and Street View has given it a huge head start in building hyper-detailed models of streets — a huge task, given that there are 4 million miles of road in America.[1142]

The maps help the car understand core features of the roadway like curbs and lane markings.[1143] The other difficult part is understanding the other objects on the road: pedestrians, cars, bikes, traffic cones, you name it. Fortunately, self-driving cars come armed with a variety of sensors that help it out. A spinning laser mounted on the top of the car, called the LIDAR, helps the car build a 360º model of its surroundings. Radar sensors help the car figure out how far it is from other objects. These objects help the car understand what objects are around it, but they can't help the car tell objects apart; a traffic cone and a parked car would "look" the same. To help with that, self-driving cars use cameras to identify objects based on their color and shape; cameras also pitch in to help the car guess how far it is from obstacles.[1144] The onboard computer helps the car combine this information into a 3D model of its surroundings.[1145] This model creates "boxes" representing pedestrians, cars, and bikes, and it also includes "fences" to show where the car might need to slow down or stop.[1146]

A self-driving car prototype made by Google's affiliate Waymo. Notice the spinning LIDAR device and camera on top. Source: Wikimedia[1147]

The 3D model is great, but it doesn't factor in objects' motion. To do that, the car has to predict where objects are going based on what it already knows.[1148] For instance, it could predict that a car that has been decelerating for a few seconds is likely to keep slowing down. But while the carmakers can encode some basic predictions, like green means go, they can't possibly embed every single rule, so instead the car just learns based on what it sees.[1149] For instance, self-driving cars could start noticing that, when bicyclists extend their left arm, they turn left 90% of the time. So the next time the car sees a bicyclist to its right extending their left arm, the car could slow down and let the bicyclist pass. In other words, the car has just learned to avoid left-turning bicyclists![1150] This technique is called *machine learning*; at its simplest, machine learning is just the art of making predictions based on observed patterns.[1151]

The final step is for the car to make a driving strategy. Based on its current speed and position, the car makes a large set of possible actions, or *short-range plans*, for how it could get closer to its destination: changing lanes, making a turn, accelerating and so on. Then it removes plans that would bring it too close to an obstacle, and it ranks the remaining plans on the basis of safety and speed. Once the car chooses the optimal plan, it sends those instructions to the wheels, brake, and "gas pedal" to make the car move. All of this computation happens within 50 milliseconds.[1152]

The road ahead

So when will we be getting self-driving cars? They aren't quite ready for mainstream use yet, but self-driving car companies are busy testing out their cars. Test cars are on the road in Pittsburgh,[1153] San Francisco,[1154] and Austin.[1155] The testing has been extensive: Google's self-driving affiliate Waymo said its cars had driven 3 million miles on city streets by 2016, and the cars logged a billion miles in simulations in that year alone.[1156] Waymo even built an entire fake city in California to test its cars out.[1157]

There are a wide range of projections for when self-driving cars will hit mass availability. Google said it wanted autonomous cars out by 2018,[1158] and Nissan projected it would release self-driving cars by 2020.[1159] Other

forecasters are more pessimistic, saying self-driving cars won't become mainstream till 2030.[1160]

Don't forget that many cars already include some self-driving features. Tesla's Model S car unveiled a self-driving "Autopilot" mode in 2015.[1161] Many other cars include features that rely on some self-driving technologies: self-parking, blind-spot detectors, collision avoidance systems, and drifting warnings, to name a few.[1162] But totally self-driving cars, it seems, are a bit farther away.

Speed bumps

The technology behind self-driving cars is tough, but the regulatory issues are just as difficult. Self-driving car companies have been blocked by the government in a few situations. For instance, Uber tried to test its self-driving cars in San Francisco in 2016, but city regulators shut them down within a day for not having the right permit.[1163] But other commentators complained that the government didn't have *enough* regulation on self-driving cars.[1164] Fortunately for autonomous car fans, the government released its first rulebook on self-driving cars in 2016, finally setting some standardized laws that ended the regulatory "chaos."[1165] These laws updated vehicle standards to no longer assume there was a human driver, clarified the difference between semi- and fully-autonomous vehicles, and set a "universal baseline technological and physical standard" that the cars must meet.[1166]

Another issue is that of hacking. In 2015, a journalist found that hackers could remotely take control of his (not-autonomous) Jeep,[1167] raising fears that hackers could do something similar to a self-driving car.[1168] Even if self-driving cars themselves are perfectly secure, clever hackers could find other ways to attack. For instance, one research group claimed that, by putting a small sticker on a stop sign, they could fool a self-driving car into not recognizing the sign and thus not stopping.[1169]

Perhaps the hardest problem to solve, though, is one of computational ethics. The classic example is how cars should handle harm to humans. What should a self-driving car do when it has to choose between potentially injuring the

driver or a pedestrian?[1170] If self-driving car company programs its cars to make a decision, is the car programmed to kill?[1171] To bring transparency to these ethical dilemmas, philosophers and technologists have called for "algorithmic transparency:" the idea that self-driving cars' algorithms be made public.[1172]

Despite these speed bumps, self-driving cars are likely to become more and more mainstream in the coming years. As we mentioned, self-driving cars will be great for consumer safety and convenience. But don't forget that there could be losers: in a world of self-driving cars, millions of people who drive for a livelihood could be out of a job.[1173] That leads us to a bigger question: in a world of automation, who else's job will be at risk?

Are robots going to take our jobs?

Manufacturing robots have already put thousands of industrial workers out of a job, leading to an uptick in poverty.[1174] A report issued in 2015 was even more grim: it predicted that automation would kill over 4.6 million office and administrative jobs by 2020.[1175] In other words, both skilled and unskilled workers seem to be in trouble. It seems that robots will inevitably take our jobs.

Or will they?

The economics of tech and labor

Economists group technologies into two categories: labor-enabling and labor-replacing. Labor-enabling technologies help workers be more productive. For example, consider PCs and the internet — they've made it far easier to write essays, find information, or talk to coworkers. Then there are labor-replacing technologies, like the self-driving cars and industrial robots we mentioned before. These opposing forces are in a constant tug-of-war.[1176]

The results might be unexpected. For instance, think about the ATM, which became popular in the 1970s and made many customers no longer need to talk to a teller inside a bank's branch office. Many assumed that this would eliminate the teller job altogether. Right? Wrong.[1177]

Thanks to the ATM, banks needed fewer human tellers in their branches. But this made branches cheaper to operate, which led to banks opening more branches. And that, in turn, led banks to employ more tellers. The upshot? The number of tellers in the US grew from 300,000 to 600,000 from 1970 to 2010.[1178] In other words, the ATM actually *created* teller jobs instead of replacing them.

So what does this mean for us in the age of artificial intelligence and robots?

The case for and against job theft

There's pretty strong evidence that automation will take away lots of jobs. A 2013 Oxford story found that half of all American jobs were at risk of automation by 2033.[1179] People with lower skill levels would be particularly hurt. President Obama's Chief Economic Adviser found that 83% of jobs paying under $20 an hour were at risk of automation, versus just 4% of jobs making over $40 an hour.[1180] Furthermore, 44% of jobs requiring less than a high school education were likely to be automated, compared to just 1% of jobs requiring a bachelor's degree.[1181] In other words: robots could take our jobs, and it'd especially hurt the least educated and most vulnerable.
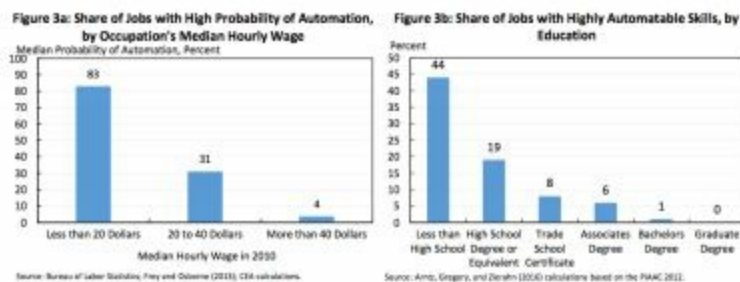
A 2016 report showed that people with lower-paying jobs, less skills, and less education were more at risk of losing their jobs to automation. Source: Council of Economic Advisors[1182]

But there's data to indicate that robots *aren't* taking our jobs, as well. Throughout the mid-2010s, American unemployment was low (less than 5% in 2017), workers were staying at their jobs longer, and wages were slightly rising.[1183] That hardly indicates that robots are massively stealing jobs. More generally, automation could move people away from doing more manual tasks to doing more tasks that require the human mind. For instance, manufacturing plants envision having fewer assembly-line workers — but more engineers, coders, and managers.[1184] Technology has created entire industries, like IT and software development.[1185] Automation wouldn't just create science, technology, engineering, and math (STEM) jobs, though: self-driving cars will still need mechanics and marketers, for instance.[1186]

So what's the verdict? No one's sure, and you can tell because pundits are adamant about both sides — sometimes hilariously so. For instance, one writer penned a New York Times piece saying, "The Long-Term Jobs Killer

Is Not China. It's Automation."[1187] But another pundit was quoted saying, "[T]he answer is very clearly not automation, it's China."[1188]

Haves and have-nots

We mentioned before that highly-skilled workers will have a lot to gain from automation, while low-skilled workers will have everything to lose.[1189] In other words, the poor would get poorer while the rich would get richer.

One solution is in education. There will be plenty of jobs available but, unless something changes, there won't be enough skilled workers to fill them. For instance, in 2015 Deloitte estimated that manufacturing would add 3.5 million jobs by 2025 thanks to automation — but 2 million of those would go unfilled due to a lack of skilled workers.[1190] Proposals to combat this include apprenticeships to help people pick up skills on the job; investment in vocational education at community colleges; and promoting STEM education in high school and college.[1191]

There have been some more radical solutions. Elon Musk projected that automation could send unemployment up to 30-40% (again, no one agrees on the impact of automation), so he proposed a "universal basic income." Under this scheme, governments would send every resident a check, which he said would fight poverty and protect the economy from certain collapse. "Universal basic income" would be funded by a government tax on robots. [1192]

As it happens, Bill Gates has long had a proposal to tax robots — or rather, to tax the companies that employ robots. Proponents say the revenue could fund jobs that humans are uniquely good at, like childcare.[1193]

All this brings us back to our original question: are robots going to take our jobs? The evidence seems mixed, but it seems clear that robots will really help some people and really harm others. So what can we do about it? The best answer seems to be to invest more in people — to make employees better trained to do the high-tech jobs of the future. Paradoxically, in an era where computers are taking over the world, maybe humans will be more

important than ever.

How does Siri work?

Ever since Apple launched Siri in 2011,[1194] millions of people have come to rely on intelligent personal assistants like Siri, Google Assistant, Amazon's Alexa, or Microsoft's Cortana.[1195] Whether you need to see today's weather, get driving directions, or send a text, intelligent personal assistants can help you solve almost any problem — and sometimes even hold a conversation to boot.[1196] But your phone doesn't have a brain. Instead, Siri has a form of "artificial intelligence"[1197] — but what does this mean, and how does it work?

Natural language processing

To figure out Siri works, let's follow an example from start to finish. Say you want pictures of kittens, so you say *cat* to Siri. Making sense of your sounds takes a lot of computational power (as we'll see shortly), so to avoid overloading your phone, Siri sends the audio of your speech to Apple's powerful servers. (This explains why Siri doesn't work if you aren't connected to the internet.)[1198]

Once Apple's servers have your speech file, they try to turn your sounds into words. First, Apple breaks down what you said — which, phonetically, sounds like "kat" — into its individual sounds: "k," "a," and "t." Then, Apple turns to a database that tracks how thousands of English speakers pronounce various words. Using this database, Apple would notice that the combination of the "k," "a," and "t" sounds usually corresponds with the word *cat*. And so, they'd infer that you meant *cat*.[1199] It might not seem like much, but they just turned an audio file into text!

Then, Siri tries to make sense of the words you said. If it notices words like "temperature" or "rain," Siri might tell your phone to open the weather app. If it notices a math question, it might open the mathematical search engine WolframAlpha. Otherwise, Siri could just run a web search on Bing.[1200]

This whole procedure of turning speech into sounds, words, and ideas is

called *natural language processing*, or NLP.[1201]

If Siri needs to say anything back to you, Apple converts its text to speech. This uses the same pronunciation database we mentioned earlier, just in reverse.[1202] Finally, Apple's servers send the processed information back to your iPhone or Mac,[1203] and Siri will speak.

Can Siri think?

In the 2013 film *Her*, a man falls in love with his intelligent personal assistant.[1204] That raises the question: if apps like Siri can answer questions and hold conversations with us, does that mean they can think? Computer scientists have been debating this for generations, but we'll give a quick overview.

To answer the question of whether computers can think, the famous computer scientist Alan Turing put forward a thought experiment called the Turing Test in 1950. In this test, a person asks questions to either a human or a computer; the person isn't told who they're talking to. If the computer can trick the person into thinking that they're talking to another human, the computer passes the test.[1205]
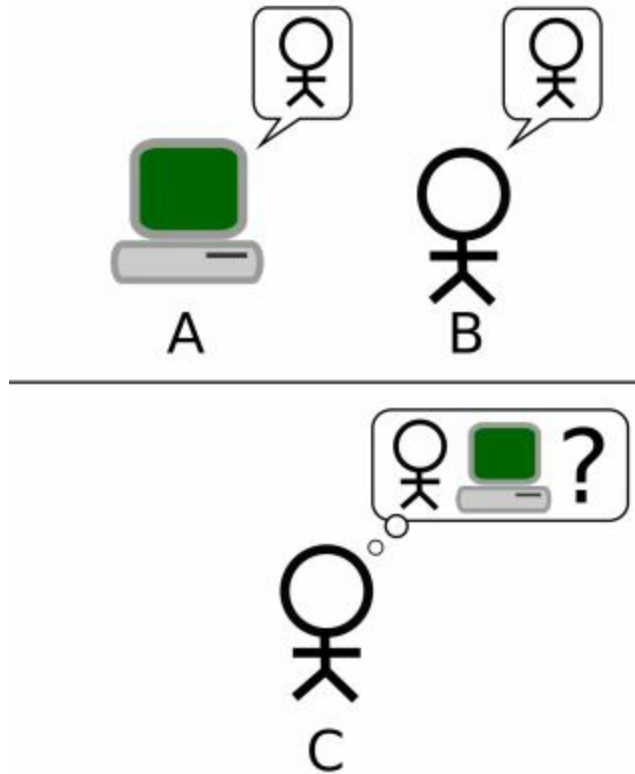
The Turing Test checks if a computer (A) can trick a person asking questions (C) into thinking they're talking to a human (B). Source: Wikipedia[1206]

In 2016, a chatbot finally passed the Turing test, but technologists were generally skeptical, saying this didn't indicate that computers could actually think like humans.[1207] Computer scientists classify most of the artificial intelligence we use today, like Siri and the chatbot we mentioned, as "weak artificial intelligence": something that's only good at specialized tasks.[1208] Philosophers say that weak AI can only *simulate* how humans think, instead of actually thinking.[1209]

Meanwhile, artificial intelligence that could think as well as a human at a wide variety of tasks would be called "strong artificial intelligence."[1210] When Stephen Hawking talked about doomsday scenarios like the "singularity," in which computers would evolve faster than humans and spell "the end of the human race," he was referring to strong AI.[1211] But some philosophers think that strong AI will never happen.[1212]

So, can Siri think? Not really. She can automate tasks, but truly thinking like a human seems far away — for now, at least.[1213]

How could you make video and audio "fake news"?

In 2017, a Canadian company called Lyrebird published audio of Donald Trump, Barack Obama, and Hillary Clinton reading their Tweets aloud.[1214] There was just one problem: none of them had actually read their Tweets — the audio was faked![1215]

Thanks to a new technology, you can create convincing but fake video and audio in a fraction of the time it would take you to manually imitate it.[1216] In this era of fake news, many people have stopped believing news they hear online, relying on video or audio to confirm that something really happened. But if video and audio can also be faked, we wouldn't have anything left to trust.[1217] So how can you make fake video and audio footage?

This mysterious technology is called *generative adversarial networks*, or GANs. GANs are a special version of a technique called *neural networks*. [1218] So before we explain how GANs work, let's look at neural networks.

Neural networks

Your brain learns things by experimenting, getting feedback, and adjusting. [1219] For instance, say you're new to baking and want to bake a cake. You throw together a random mix of flour, sugar, eggs, butter, and other ingredients, toss the batter in the oven for a random amount of time, and see how it turns out. A friend tastes the cake and gives your comments: too sweet, undercooked, needs more chocolate. You slightly adjust your recipe to address the comments, and while your friend might be happier, they still have comments. Repeat this process, and eventually you'll have tweaked your approach enough to become a master cake baker — without ever picking up a cookbook. You learn this way because your brain contains a "neural network:"[1220] a collection of connected cells called neurons that talk to each other.[1221]

To make computers more powerful, computer scientists have tried to simulate

your brain's neural network inside a computer; it's called an "artificial neural network," but many technologists (somewhat confusingly) just call it a "neural network."[1222] Like the cake example, an artificial neural network keeps track of many variables and assigns each variable a "weight": the amount of butter, the time to bake, or the oven temperature, to name a few. [1223] As you give the artificial neural network feedback, it tweaks the weights to get closer to the right answer, much like you adjusted your cake recipe based on your friend's feedback.[1224]

Neural networks are incredibly powerful: they can autocorrect text on your phone, catch spam emails, translate languages, or read your handwriting, among many other things.[1225] Neural networks are great at recognizing things, but they aren't designed to generate new stuff, like fake audio and video.[1226] For that, let's turn to an even stronger variation of neural networks.

Generative adversarial networks

In a "generative adversarial network," or GAN, you create two neural networks and make them face off. The "generator" network tries to make something fake, and the "discriminator" guesses whether or not the generator's creation is real or not.[1227] The networks get into a sort of arms race, with the generator trying to make more convincing forgeries and the discriminator trying to get better at policing fakes.[1228] The networks learn from each other, constantly improving, until the generator is churning out incredibly convincing fake things.[1229]

As an example, imagine you want to make a generative adversarial network that creates a fake video of a woman walking through a door. You create the generator and discriminator network. Originally, neither network has any idea what it's doing, so the generator might make a video of a woman walking straight upward, and the discriminator won't know that it's fake. So you step in and show the discriminator a real video of a woman walking through a door. From the video, the discriminator learns that people walk forward, not upward, and it learns to reject videos of women walking upward. The generator quickly learns that videos of women walking upward get rejected,

so it might try to make videos of women walking forward to try and trick the discriminator. This back-and-forth continues until the generator can make convincing fake videos.[1230]

So, what would we do if we started seeing faked videos of presidential candidates giving inflammatory speeches?[1231] No clue — but at least we'd know how the fakers made the videos.

Could Amazon be the first trillion-dollar company?

In September 2017, Apple was the world's most valuable company, with a market capitalization (or total value of all shares) of $834 billion. Amazon was fifth at $470 billion.[1232] But in 2016 and 2017, a flock of analysts predicted that Amazon would soon become the world's first $1 billion company. One analyst at Barclays said it was a virtual certainty.[1233] An investment bank director named Mark Mahaney thought Amazon would hit $1 trillion 2021,[1234] and NYU professor Scott Galloway was even more confident, predicting that Amazon would reach the milestone in 2020.[1235]

The investors were certainly on to something, since Amazon's stock price almost quadrupled between 2013 and 2017.[1236] But as of 2017, Amazon wasn't even halfway to $1 trillion — so what made investors so optimistic? And what does this prediction mean for the future of Amazon and the tech industry? Let's dive in.
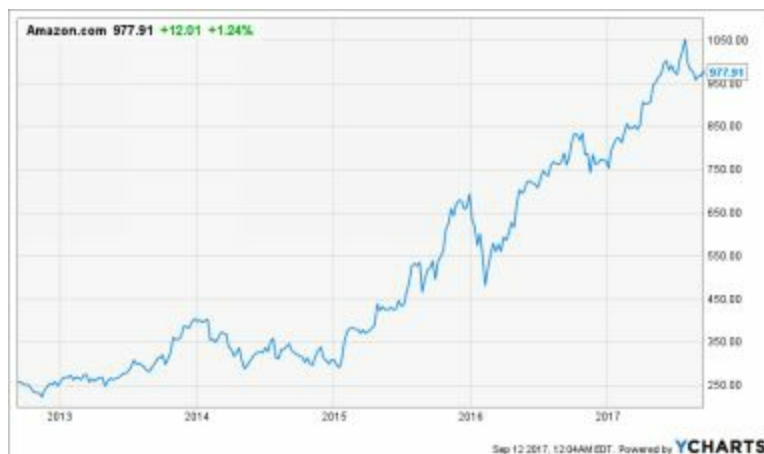
Amazon's stock price has been growing explosively since 2013. Graph made in September 2017. Source: YCharts[1237]

Sector-by-sector dominance

Much of Amazon's dominance comes from its strength in a huge range of industries. Besides retail, Amazon is involved in hardware, media, gaming,

book publishing, clothing, cloud computing, and grocery.[1238] And that's not even all of it. But to explain how Amazon is well positioned to become the first $1 trillion company, we'll explore Amazon's remarkable power across several industries.

We'll start with retail, Amazon's bread-and-butter. Amazon pulled in $107 billion in retail sales in 2015, dwarfing Walmart's $13.7 billion in the same timeframe.[1239] Amazon is the world's largest online retailer, hands down.[1240] And there's every reason to believe that this domination will continue to grow. For one, Amazon is eating brick-and-mortar retailers for breakfast[1241] at a time when these stores are shuttering at record paces: 8,000 retail stores closed in 2017, compared to 4,000 in recession-stricken 2008.[1242] Since Amazon doesn't rely on any brick-and-mortar stores, it can grow as fast as it wants for free; meanwhile, even mighty Walmart needs to spend $37 million to open a new store.[1243] Amazon's massive scale and low costs help it undercut any retailer it wants, driving many out of business.[1244]

Amazon is taking a larger and larger slice of the online retail market too.[1245] Its delivery infrastructure is second to none.[1246] Acquiring Whole Foods's 400 stores gave Amazon 400 more places to ship food from, which boosted Amazon's delivery infrastructure even further.[1247] Amazon is becoming synonymous with shopping for many Americans,[1248] to the point where even Google and Facebook have reason to be worried. In 2016, 55% of American shoppers began their online search at Amazon, up from 44% a year before; search engines' share dropped from 34% to 28%.[1249] In short, Amazon dominates online and offline retail, and evidence suggests this trend will grow.

Amazon's other star sector is the cloud.[1250] In 2017, Amazon Web Services dominated: it had 34% market share, while its biggest rival — Microsoft's Azure — was a distant third, with just 11%.[1251] And AWS is a huge asset for Amazon: its revenue soared 55% in 2016,[1252] and it brings the majority of Amazon's profits.[1253] In other words, if Amazon ever needs cash, AWS will provide plenty of it.

With Amazon's purchase of Whole Foods, they entered the $700 billion

grocery market.[1254] According to Scott Galloway, this sector was "ripe for disruption."[1255] Amazon entered the grocery world with a splash, chopping prices at Whole Foods by up to 43% as soon as it bought the chain.[1256] Thanks to its endless cash supply and strong logistics, many experts believe that Amazon will take over the grocery business the same way it took over retail.[1257]

The last sector we'll cover, and a bit of a dark horse, is business-to-business sales, or B2B. B2B is a $8 trillion market,[1258] and one research group predicted that online B2B sales would be twice as big as Amazon's normal business-to-consumer, or B2C, sales.[1259] Amazon's 2015 launch of Amazon Business, a B2B platform selling everything from bulk food to janitorial supplies, gives Amazon a strong foothold in this market.[1260]

It looks like the Everything Store is set for fabulous growth. But it might not end happily ever after.

Antitrust action?

After Amazon bought Whole Foods in 2017, many commenters started asking if Amazon had finally become monopolistic, and if so, what the government should do about it.[1261] Do they have a strong argument?

First, let's review the laundry list of complaints Amazon about anti-competitive behavior. Amazon has become notorious for fiercely undercutting competitors, driving them out of business and preventing new competitors from entering the market.[1262] With the Whole Foods Purchase, Amazon has been attacked for blocking any future grocery delivery startups from entering the market at all.[1263] And even when new retailers gain a foothold, Amazon tries to purchase them. For instance, in the 2000s Amazon snapped up Diapers.com and the shoe store Zappos.com, both of which were the biggest online retailers in their respective categories.[1264]

However, American antitrust laws seem ill-prepared to take on Amazon, primarily because these laws are designed to prevent head-to-head competitors from merging, like when the US blocked the ISP giants Comcast

and Time Warner Cable from merging in 2015.[1265] Instead, Whole Foods wasn't much of a competitor to Amazon. But regulators could take the approach of saying that, through a series of acquisitions, Amazon has acquired so much market power that it forces suppliers to sell at too-low prices and unfairly undercut its competition.[1266]

So, will an antitrust case be brought against Amazon, and would it do anything to the tech giant? Will Amazon coast to a trillion dollars, or will it face stiff competition? We can't say, but we're sure some interesting battles are going to play out in the coming years.

Conclusion

That's a wrap for *Swipe to Unlock*. Give yourself a pat on the back: you've learned an incredible amount about technology and business strategy behind it. The next time you hear an entrepreneur talk about their "cloud-based SaaS app" or rave about their "machine learning big data platform," you'll be able to understand them — and maybe even strike up a conversation. When you hear hot topics like "ransomware" or "net neutrality" on the news, you'll be able to think critically and cut through the buzzwords. And if you're ever working with engineers or businesspeople in the tech industry, you'll be able to ask the important questions: *What APIs are you using? What's the monetization strategy? What have your A/B tests found?*

Of course, everyone forgets. That's why we've defined dozens of important technology and business terms — including some of the ones we talked about above — in the glossary. The glossary even has some information we didn't get time to cover, like explanations of some popular programming languages and business terms.

What's next

If you'd like to learn more about the topics we covered in *Swipe to Unlock* or stay in touch to learn about book-related news, visit our website at swipetounlock.com!
If you're looking for a non-technical role in the tech industry, our website has plenty of resources to help you out: books we recommend, useful articles, and information about entry-level jobs at companies like Google, Facebook, and Microsoft. Check it out at swipetounlock.com/resources.

If you want to chat with us, you'll also find our contact information at swipetounlock.com. We're excited to hear from you!

Thank you!

We hope you've enjoyed *Swipe to Unlock* and that what you've learned here is useful for your life and career. Writing this book has been a ton of fun for

us, so we're glad that you joined us for the ride. If you found *Swipe to Unlock* useful, we hope you'll recommend it to your friends or consider writing a review on Amazon.

Thank you for reading, and until next time, all the best!

— Neel, Adi, and Parth

Acknowledgements

Very soon after we started writing *Swipe to Unlock*, we realized that we couldn't do it alone — it takes a village, as they say. Here, we'd like to thank all our friends and family who provided their support, feedback, and inspiration as we were writing this book.

Neel

Adi

Parth

Glossary

So how do you build a website? Just ask a software engineer, and they'll tell you: open a GitHub repo; build out a backend in Python or Ruby on Rails; serve up some HTML, CSS, and JavaScript; make some RESTful APIs; tweak the UI/UX; and ship an MVP to AWS. Oh, and get a CDN while you're at it.

Huh?

The world of software has a seemingly crazy amount of jargon and buzzwords. But here, we're going to break down some of the most common terms so you can talk like a techie without feeling like you need a foreign language class.

Programming languages

All software is written using code, much like food is made according to a recipe. And just like you can write recipes in English, Bengali, or Turkish, you can write software in programming languages like Ruby, Python, or C. Each programming language has its own strengths and weaknesses, and each one is used in particular situations. Here's a glimpse into some of the most popular languages.

Assembly

Computers only think in 1's and 0's, and assembly language is just a slightly prettier version of 1's and 0's. Programmers rarely write in assembly language, since it's too much effort; they'll usually write in a "higher-level language" that computers convert into assembly and then run. (Every other language in this section is a higher-level, or more "abstract", language.) It's like driving a car: instead of trying to directly set the speed of each wheel, you just use the steering wheel and pedals. This is far easier, and besides, you'd probably have no idea how to set the wheel speeds just right.

C/C++

Some of the oldest programming languages, and still among the most popular. They run really fast but are more difficult to write, so developers trying to get maximum performance (like those writing graphics-heavy games, physics simulators, web servers, or operating systems) often use C and C++.

C#

A popular language built by Microsoft, often used to write desktop apps.

CSS

A web development language that works with HTML, used to make websites look pretty. CSS lets you change a webpage's colors, fonts, background, and alignment, and it helps you specify where the various buttons, headers, images, etc. on a webpage should go.

Go

A language built by Google, often used to write web servers.

HTML

The language used to write webpages. You can create links, images, headers, buttons, and many other elements of webpages using HTML. Each of these elements is called a "tag" (e.g., a tag called <img> represents an image.)

Java

One of the world's most popular languages, Java is used to write Android apps, web servers, and desktop apps.

JavaScript

The language used to make webpages interactive. Every web app you use, from Facebook Messenger to Spotify to Google Maps, uses JavaScript. Nowadays, developers are also using JavaScript to build web servers and desktop apps.

PHP

A language used in the backend of websites. Facebook.com is written using a custom "dialect" of PHP.[1267]

Python

A popular, easy-to-learn language that's common in introductory CS courses. It's also popular for data science and writing web servers.

R

A data analysis language, which lets you graph, summarize, and interpret huge amounts of data.

Ruby

Similar to Python, Ruby is popular for writing web apps. Ruby on Rails, a framework for building websites, is one of the most popular tools to use Ruby.

SQL

A popular language for working with databases. Like Excel, it lets you work with tables, rows, and columns, as well as specifying far more complex analyses, called *queries*.

Swift

Apple's language used for writing iPhone, iPad, and often Mac apps.

Data

We humans like storing information in Excel files or Word docs. Computers, however, prefer storing data in simple text files. Here are a few popular ways to store data in a "machine-readable" format.

CSV
 Comma-separated values: a way to store data in lightweight tables, similar to an Excel file but much simpler. These files have the ".csv" ending.

JSON
 A popular data storage format, often used by web apps. It's more free-form than CSV, allowing data objects that are nested inside *other* data object — like a "person" object would contain "name" and "age" data.

XML
 Another text-based data storage format. Like HTML, it stores and organizes data using tags, but like JSON, it allows nesting.

Software development

Like any professionals, software developers have their favorite terms and buzzwords. Let's break them down.

A/B tests

Running experiments to decide which features to put into a product, usually a web-based one. You show some users one variation of a feature, and other users a different variation. For instance, you could show half your users a red button and the other half a blue button. Then you look at various metrics, like number of sales or number of clicks, to decide which variation is better, and you roll out the winning variation to all users. Product managers and developers love A/B testing, since it helps them scientifically determine how to improve their software.

Agile

A software development paradigm that emphasizes short, alternating bursts of writing software and getting feedback from users. For example, instead of taking months or years to release one huge final product, an Agile team would prioritize quickly releasing a "minimum viable product," or a simple prototype. Then it would get feedback from users to "iterate on" and improve the prototype, repeating this process many times until it is happy with the result.

Angular

Google's web development framework, often used to build web apps. Several popular websites, like Tesla, Nasdaq, and The Weather Channel, use Angular.[1268]

Backend

The "behind-the-scenes" part of an app or website that users don't see. The backend handles and stores data and, for websites, prepares the web pages that are eventually shown to the user. An analogy: in a restaurant, the cooks in the kitchen are the "backend", since they prepare the food that customers enjoy, even if the customers never see them.

Beta

A preliminary version of software, often released to testers to get user feedback before the final product launches.

Big data

Working with huge amounts of data to extract interesting insights. There's no specific definition of how big is "big", but if a dataset is too huge to fit on a single normal-sized computer, there's a good chance that it's "big."[1269]

Blockchain

The technology behind Bitcoin. Blockchain allows for decentralized transactions; imagine you could hail an Uber without having to use the Uber app, or you could send someone a message without a company like Facebook or your cell phone provider getting in between. With blockchain, everyone shares a record of every past interaction, so you don't need a central authority. With Bitcoin, every user has a list of every past sale, so no one person or company "owns" Bitcoin. This also protects against fraud, since everyone knows if one person is trying to pull something shady.

Bootstrap

A popular toolkit for designing websites, Bootstrap is basically a giant CSS file that contains nicely-designed layouts, fonts, colors, and other styling options. Many websites use Bootstrap as a starting point for their styling; it's a very powerful website template.

Caching

Storing information in a particular place on a computer so you can access it more quickly. It's like storing your favorite pizza place's phone number in your contacts so you don't have to Google it every time — it makes recalling the information faster.

Cookie

Small notes that websites store on your browser to remember your customizations. For instance, an e-commerce site could store your cart, preferred language, or username in cookies. Cookies are also the basis for targeted advertisements: websites can pass around your location and other personal information via cookies to figure out what you like and hence what ads to show you.

Database

A giant table used to store information; like a superpowered Excel file. For instance, Facebook might store info about all its users in a database, with a separate row for each user and columns for name, birthday,

hometown, etc.

Docker

A way for developers to package up everything an app needs to run in a "container," which anyone can run on any supported machine. It's convenient because you don't have to worry about having the right system configuration; the same container will run the exact same way everywhere. The alternative is to boot up a whole new operating system to run each app, but Docker is much more efficient.

Flat design

A minimalistic design trend, where you remove unnecessary shiny colors, shadows, animations, and other details, reducing the app to simple colors, geometric shapes, and grids. A few examples are Microsoft's Metro UI (the tiled design used in Windows 8 and 10)[1270] and Apple's flattening of iOS in version 7.[1271] (Visit the footnoted links for pictures!)

Frontend

The user-facing part of a website or app. The frontend includes all the buttons, pages, and pictures that users interact with. It takes information from the user, sends it to the backend, and updates what the users see accordingly. It's like in a restaurant: the waiters are the "frontend", since they take diners' requests to the cooks (the backend) and serve the diners the completed food.

GitHub

A website that hosts millions of open-source software projects. Anyone can see and build on others code here. Code is organized into repositories, or "repos"; people can "fork" these repos to make their own versions of the code; and developers can suggest changes to repos using "pull requests."

Hackathon

A coding competition where developers team up to build cool, creative software in short sprints, often from 12 to 72 hours. Hackathons often feature prizes, tech company recruiters, free swag like t-shirts and stickers, and late-night food.

Hadoop

A free "big data" software package for storing and analyzing huge amounts of data — we're talking terabytes and petabytes.

jQuery

One of the most famous web development libraries, it's a JavaScript tool that makes interactive websites much easier to build.

Library

A reusable chunk of code that one developer publishes online for other developers to use. For instance, D3 is a famous library that lets JavaScript developers make interactive graphs, charts, and maps with just a few lines of code. *Also known as package or module.*

Linux

A free, open-source family of operating systems; alternatives to Windows and macOS. Many of the world's biggest supercomputers, as well as most web servers, run Linux. Android is built on Linux, too.

Material design

Google's design theme, used for Android and many Google apps. It features bright colors, square "cards" of information, and sliding animations. It's similar to flat design, but it has some shadows, gradients, and 3D elements that flat design wouldn't have.[1272]

Minification

A technique that developers use to compress their code files by removing any unnecessary bits of text. *Also known as uglification.*

Mockup

After wireframing and prototyping, designers make mockups, which are high-quality drawings that specify exactly which fonts, colors, pictures, spacing, etc. the developers building the app should use. Mockups help designers ensure every detail is perfect and get feedback before the app is actually coded. According to UXPin, "Wireframes are the skeleton. Prototypes demonstrate the behavior. Mockups are the skin."[1273]

Node.js

A JavaScript framework for building web apps.

Open-source

A philosophy for building software where anyone can see, copy, and improve the code behind an app. (It's as if a restaurant let you see the recipes behind its dishes.) Many popular apps and platforms are open source, like Linux, Android, Firefox, and WordPress.[1274] Many programming languages and web servers are also open-source.[1275]

Persona

Example people that designers create to summarize the types of users in their market. Personas have names, backstories, and personalities.[1276] For example, LinkedIn's personas could be Sanjana the Student, Ricky the Recruiter, or Jackie the Job-Hunter.

Prototype

An early version of an app or website that lets app makers test their ideas with users. Prototypes can be as complex as simple clickable websites or as simple as stacks of sticky notes.

React

Facebook's web development framework, often used to build web apps. Websites like Facebook, Instagram, Spotify, The New York Times, Twitter Mobile, and many others use React.[1277]

Responsive web design

Making websites work well on all screen sizes — phones, tablets, laptops, etc. For instance, the New York Times might show several columns of text on bigger screens (and the print paper), but just one column on smaller screens.

Ruby on Rails

A framework for building web apps using Ruby. Airbnb, Twitch, and Square are just a few sites built with Ruby on Rails.[1278] *Also known as RoR or Rails.*

Scrum

An offshoot of Agile, where software development teams release new features every few weeks, organizing their work into "sprints." They often have daily 15-minute "stand-up" meetings so everyone knows what everyone else is doing and so that vital information is shared across the whole team.

Server

Computers that power websites and many apps. Servers tend not to have a standard graphical interface (like a monitor) and are instead used solely for their computational might.

Stack

The suite of technologies that an app or website is built with. This includes the app's choice of frontend tools, backend tools, and database. As an analogy, a car's "stack" could include a particular kind of upholstery, engine, tires, and headlights, among other things.

Terminal

A text-based interface available on computers that developers use to build software. Even if you're not writing code, the terminal is handy for complex customization, and a few apps can only be run from the command line, not from the point-and-click interface we're used to. *Also known as command line, shell, or Bash.*

Unix

A family of operating systems, including Linux and macOS.

Wireframe

A simple way to draw the "skeleton" of an app or website,[1279] like how you make an outline before writing an essay. You just use lines on paper: buttons and images become boxes, sidebars become rectangles, text becomes squiggly lines, and so on. Wireframes help figure out where page elements should go before anything gets coded.[1280]

Technology's alphabet soup

Acronyms might just be the most frustrating part of software jargon. Here are a couple of the most common ones.

AJAX

A method for one website to access information from another using an API. Uses JavaScript.

API

Application Programming Interface: A way for one app to get information from another app, or make another app do something. For instance, Twitter has an API that lets another app post Tweets on someone's behalf, and ESPN has an API that lets you grab the latest sports scores.

AWS

Amazon Web Services: a platform that lets you store data or run apps in the cloud.

CDN

Content Delivery Network: a way for websites to serve images, CSS files, and other "static" assets faster by using a separate dedicated website. These dedicated CDN websites are specialized for holding files instead of running code, and they have many servers scattered around the world, so anyone can get the files much faster than normal.

CPU

Central Processing Unit: the "brain" of a computer or phone, which runs the operating system and apps.

FTP

A protocol for sending files to and from web servers.

GPU

Graphics Processing Unit: a special part of a computer optimized for drawing graphics. If you ever hear the term "hardware-accelerated animations", that's using the GPU.

HTTP

HyperText Transfer Protocol: a protocol used to view webpages on the internet. By "protocol", we mean a set of rules for how information

should be transferred.

HTTPS

HyperText Transfer Protocol Secure: an encrypted version of HTTP, which is used for secure online communications like banking, payments, email, and logging into websites.

IaaS

Infrastructure-as-a-Service: tools that let you rent out another company's server space to run your app. One example is Amazon Web Services. [1281]

IDE

Integrated Development Environment: a specialized app that makes it easy for developers to build particular kinds of apps. Eclipse, for instance, is an IDE for Java and Android. It's like how chefs have their own specialized kitchens with particular tools and ingredients.

I/O

Input/Output: often used in the context of reading and writing files.

IP

Internet Protocol: a protocol for moving "packets" of information from one computer to another over the internet. Works closely with TCP. HTTP is built on top of TCP and IP. [1282]

MVC

Model-View-Controller: A way of organizing code, which often builds on Object-Oriented Programming. Many web or app development frameworks use MVC.

MVP

Minimum Viable Product: in Agile, an early-stage prototype used for early testing. For instance, an MVP of Snapchat could just be an SMS app that only sent pictures — it's just a simple version to see if people like the idea.

NLP

Natural Language Processing: a form of artificial intelligence that deals with understanding human languages.

NoSQL

A way of constructing databases, an alternative to (you guessed it) SQL. NoSQL emphasizes more free-form interaction with data rather than just working with rows and columns, which SQL does.

OOP

Object Oriented Programming: a way of structuring code so it's easier to understand, reuse, and build on. You represent everything as an object, from interface elements like *Button* or *Picture* to concepts like *Customer* or *Dog*. For instance, Snapchat could have objects like *User*, *Snap*, *Group*, *Sticker*, *Story*, or *CameraButton*. Each object has its own associated information and actions; for instance, a *Dog* could know its name and know how to bark.

PaaS

Platform-as-a-Service: tools that run an app for you; you just need to send them your code.[1283] Between IaaS and SaaS in terms of complexity.

RAM

Random-Access Memory: a computer's "short-term" memory, which apps use to store temporary information like which browser tabs you have open. The more RAM your device has, generally, the faster it is.

REST

A popular type of API. APIs of this type are called RESTful.

ROM

Read-Only Memory: information that's burned onto hardware and usually can't be changed. Computers store the code needed to start the computer in ROM. *Also known as firmware.*

SaaS

Software-as-a-Service: software that's delivered over the internet, meaning you'll often use it in your web browser. Google Docs is a classic example. You'll often need to pay for SaaS apps on a monthly or yearly basis instead of paying to download the app upfront.

SDK

Software Development Kit: a pack of tools that help developers build apps for a particular platform, such as Android or Google Maps.

SEO

Search Engine Optimization: changing your website so it shows up higher in Google search results. For instance, including the right keywords in your page's title or headings.

SHA

A popular cryptography algorithm used for encoding and decoding

secure communications. There are multiple versions of SHA; as of 2017, the most modern one is SHA-3.[1284]

TCP

Transmission Control Protocol: a protocol for breaking information into smaller chunks, so you can send it over the internet more easily.

TLD

A "domain name ending", like .com, .org, or .gov. Each country has its own TLD, called a "ccTLD": France has .fr, Mexico has .mx, India has .in, and so on.

TLS

Transport Layer Security: a method of encrypting information sent over the internet so hackers can't snoop on communications.

UI

User Interface: a type of design focusing on making apps and websites look good. Deals with colors, fonts, layout, etc. Often paired with UX.

URL

A webpage's address such as https://maps.google.com or https://en.wikipedia.org/wiki/Llama.

UX

User Experience: a type of design focusing on making apps and websites easy to use. Deals with how to arrange parts of a website and webpage. Often paired with UI.

Business side

Not to be outdone by the software developers, tech companies' businesspeople — think marketers and strategists — have their own favorite jargon.

B2B

Business-to-business: companies that normally sell to other businesses instead of to average people like you or us. Some famous B2B tech companies are IBM, which sells cloud computing services to businesses, and Accenture, which provides technical consulting.[1285]

B2C

Business-to-consumer: companies that sell to consumers; in other words, you could buy their stuff from stores or websites. For instance, Fitbit, Nike, and Ford are B2C. Some companies could be both B2B and B2C. For instance, Coca-Cola sells soda to shoppers and also to universities, hotels, and restaurants.[1286] And Microsoft sells Office to both consumers and large businesses.

Bounce rate

How often visitors to your app or website leave without doing anything meaningful, such as clicking a link. A high bounce rate might suggest that visitors aren't interested in what the website has to offer.

Call-to-action (CTA)

A button or link that prompts visitors to take some action, like "Join our mailing list" or "Register for our free conference."[1287]

Churn rate

The percent of users that a company loses over a particular timespan. For instance, if 1000 people signed up for Office 365 but only 750 renewed their subscription the next year, the churn rate would be 25%.

Click-through rate (CTR)

The number of people who clicked on an ad divided by the number of people who saw it and had the option to click on it; in other words, the likelihood that an average person would click on the ad. It's way to measure how successful an ad was.

Conversion

Whenever a user does something that the business wants; the precise action can depend on the company's goals. Conversions could include joining the mailing list, signing up for an account, or buying an item.

Customer Relationship Management (CRM)

Software that a company uses to track its relationships with customers and business partners. Companies can track emails, meeting notes, and other data with CRM software.[1288]

Funnel

A metaphor for how the pool of potential customers shrinks before they make a particular "conversion," like buying a product. For instance, an e-commerce website might get 1000 visitors, but only 500 would search for something, 100 would put something in their cart, and 50 would make a purchase.

Key Performance Indicator (KPI)

A metric that companies use for tracking success of products, teams, or employees. For instance, YouTube's KPIs could be number of users, number of videos, or number of watches, among others.

Landing page

A small webpage targeted at a particular demographic; it'll often offer visitors something useful like an eBook or mailing list in exchange for their contact information. In other words, it's a targeted way to acquire leads.[1289]

Lead

Someone who's shown interest in using a service or buying a product. Marketers try to turn strangers into leads and leads into customers, a process called "inbound marketing."[1290]

Lifetime Value (LTV)

How much money a customer will bring you, directly or indirectly, over the duration of your relationship with them. For instance, if a college bookstore thinks that students will spend $500 a year on textbooks over 4 years of school, each student's lifetime value would be $2000. Generally, companies will never spend more than a customer's lifetime value on customer acquisition cost.[1291]

Market penetration

How much of a target market a product or industry actually reaches. For instance, there are about 30 million teenagers in the US,[1292] and if a

teen-focused social network had 6 million teenaged users, it'd have 20% penetration of the teenager market.

Market segmentation

Breaking down a huge, diverse market into smaller, more specific ones. For instance, a company could segment its market by gender, location, interests (also known as "psychographics"), and income (part of so-called "behavioral" segmentation).[1293]

Pay-Per-Click (PPC)

A common type of internet ad, such as the ones seen on Google, that charge you a few cents every time someone clicks on your ad.

Net Promoter Score (NPS)

A metric that measures customer satisfaction. Customers are asked to rate a product or service on a scale from 0 (they hate it) to 10 (they love it).[1294]

Return on Investment (ROI)

The ratio of a project's profit to its cost.[1295] For instance, if you spent $2000 on an ad campaign and sold $2600 of extra software, your ROI would be 30%. ROI could also be a synonym for "bang for your buck."

Small- and Medium-Sized Businesses (SMBs)

Generally, businesses with under 1000 employees.[1296]

Value Proposition

A short statement that explains why consumers would find it useful. For instance, in 2015 the e-book website Scribd used the value proposition "Read like you own every book in the world."[1297]

Roles at tech companies

Tech companies hire "normal" kinds of professionals, like marketers, CEOs, and HR representatives. But software is made differently than most physical goods, so tech companies have special kinds of roles. Here's a quick glimpse inside the software industry.

Backend engineers
> Software engineers that handle databases and web servers. For instance, Facebook's backend engineers write the code that lets Facebook's supercomputers store billions of photos and handle billions of daily visitors. *See also software engineer.*

Data scientist
> They analyze the company's data (on customers, sales, usage, etc.) to inform the company's business strategy and products.

Designer
> They make apps and websites beautiful and functional, and they also design stuff like logos, colors, and branding.

Frontend engineers
> Software engineers who build the customer-facing apps and websites. For instance, Facebook's frontend engineers make the Facebook website and apps look and work well. *See also software engineer.*

Product Manager (PM)
> PMs sit at the intersection of business, design, and engineers. Based on what the customers and business need, they decide what products (apps, features, or even hardware) to make and what features the products need to have, then work with engineers to make the products happen. Think of them as the conductors of the orchestra: they help all the various parts work together to make a great piece of music (or software, in this case).

Product Marketing Manager (PMM)
> A slightly more marketing-focused version of PMs, they're more focused on launching and marketing products instead of building them.

Quality Assurance engineers (QA)
> These people rigorously test software and hardware to hunt down bugs and ensure the software is robust.

Software engineer

People who write code and build out software. *Also known as SWE, software developer, or dev.*

Notes

There's so much to know about technology and the business strategy behind it, and in the book we only scratched the surface. So below are links to every single source we used during our research. If a particular fact or opinion piques your interest, we encourage you to read the source and dive deeper into the material!

[1]Chapter 1

https://www.wired.com/2014/06/ai-healthcare/

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