Contents

Preface ix
Torie Bosch

Introduction 1
Ellen Ullman

1 The First Line of Code 13
Elena Botella

2 Monte Carlo Algorithms: Random Numbers in Computing from the H-Bomb to Today 19
Benjamin Pope

3 Jean Sammet and the Code That Runs the World 25
Claire L. Evans

4 Spacewar: Collaborative Coding and the Rise of Gaming Culture 31
Arthur Daemmrich

5 BASIC and the Illusion of Coding Empowerment 38
Joy Lisi Rankin

6 The First Email: The Code That Connected Us Online 44
Margaret O’Mara

7 The Police Beat Algorithm: The Code That Launched Computational Policing and Modern Racial Profiling 49
Charlton McIlwain

8 “Apollo 11, Do Bailout” 56
Ellen R. Stofan and Nick Partridge
VI / CONTENTS

9 The Most Famous Comment in Unix History: “You Are Not Expected to Understand This” 63
David Cassel

10 The Accidental Felon 69
Katie Hafner

11 Internet Relay Chat: From Fish-Slap to LOL 75
Susan C. Herring

12 Hyperlink: The Idea That Led to Another, and Another, and Another 81
Brian McCullough

13 JPEG: The Unsung Hero in the Digital Revolution 86
Hany Farid

14 The Viral Internet Image You’ve Never Seen 91
Lily Hay Newman

15 The Pop-Up Ad: The Code That Made the Internet Worse 96
Ethan Zuckerman

16 Wear This Code, Go to Jail 102
James Grimmelmann

17 Needles in the World’s Biggest Haystack: The Algorithm That Ranked the Internet 108
John MacCormick

18 A Failure to Interoperate: The Lost Mars Climate Orbiter 113
Charles Duan
19  The Code That Launched a Million Cat Videos  119
    Lowen Liu

20  Nakamoto’s Prophecy: Bitcoin and the Revolution in Trust  124
    Quinn DuPont

21  The Curse of the Awesome Button  131
    Will Oremus

22  The Bug No One Was Responsible For—Until Everyone Was  139
    Josephine Wolff

23  The Volkswagen Emissions Scandal: How Digital Systems Can Be Used to Cheat  145
    Lee Vinsel

24  The Code That Brought a Language Online  151
    Syeda Gulshan Ferdous Jana

25  Telegram: The Platform That Became “the Internet” in Iran  156
    Mahsa Alimardani and Afsaneh Rigot

26  Encoding Gender  162
    Meredith Broussard

    Acknowledgments  169

    Notes  171

    List of Contributors  189

    Index  195
You need the willingness to fail all the time.

Those words guided me throughout all the years when I worked to become a decent programmer, as they no doubt guided countless others. That one sentence reminded us that coding is a life in which failure will be your constant shadow. Bugs, crashes, halts, glitches, hacks: programmers who want to survive in the profession (like anyone hoping to create a new thing on earth) must come to a begrudging acceptance of failure as a confounding helper, an agent of destruction you wish you could evade, but never can.

The words were spoken by John Backus, who led the group that created the FORTRAN programming language, fully released in 1957. FORTRAN (short for Formula Translator) was the first language that allowed programmers to write code that was not directly tied to any one computing environment. It was a frustrating project that lurched from failure to failure. Backus went on to say:

You have to generate many ideas and then you have to work very hard only to discover that they don’t work. And you keep doing that over and over until you find one that does work.

He also told us:

If you are not failing a lot, you are probably not being as creative as you could be—you aren’t stretching your imagination.
Software companies try to avoid serious failures with procedures, rules, reviews. But programs are works of the imagination that must then make the hazardous crossing into the structured world of code. The attempts to avoid failure will also fail.

All code has flaws, inevitably. Human thought is wonderfully chaotic; it allows us to hold incompatible beliefs, be interrupted, function in a world we do not fully understand. So much of what we know is inscribed in the body, the product of evolution, instinctive, not readily accessible to the rational mind, what Daniel Kahneman has described as fast thinking (System 1). Meanwhile, code-writing (as opposed to the creative work of code-design) requires fully conscious and rational thought, Kahneman’s “slow thinking” (System 2), a level of focused attention that is impossible to sustain over time.

I have a friend who was once in charge of testing at a startup that was frantic to go public. The IPO was delayed for months on end because of the relentless appearance of new serious bugs. The higher-ups demanded to know, “When will all the bugs be found?” It was a ridiculous question, because the testing was being done even while new code was being written. Meanwhile, “fixes” to already discovered bugs were in the business of creating a whole new pile of bugs. In any case, no one can predict when the last bugs will be found, because the only correct answer is, “Never.”

Many bugs are blind spots in the code. The designer and programmer try to protect the system by looking for conditions that will break things: they will not find them all. Most often, software teams are rushed. They have to create systems quickly. Programmers don’t have time to lean back, think of other things, let the background of the mind speak. A prime source of bugs is absurd scheduling.

Other bugs are like physical vulnerabilities inscribed in the DNA. These bugs sit quietly until some environmental factor (in humans, things like ageing, chemicals, medications) suddenly activates the flaw, and we get sick. In the case of computing, the
technical environment is complex and constantly changing. Programs interact with modules not foreseen in the original design; with new operating systems and changed ones, variations in chips, network configurations, protocols, device drivers; beset by documentation that cannot keep up with the changes. What worked one day doesn’t work the next, and the programmer’s constant question is, “What changed?” Well, lots of things. Which one (or ones) did the damage? That way lies madness.

The deepest weaknesses are revealed when a digital creation is designed for expert users in a collegial environment, and then opened to a wider pool.

Dennis Ritchie and his team developed the C language, which, along with Unix, was part of a research project conducted inside the storied Bell Labs technology incubator. The language gave the team’s programmers a great deal of freedom, including direct access to the contents of memory, something systems normally do not allow, in order to protect the integrity of the coding environment. That level of freedom was fine as long as their work remained a research project. According to Brian Kernighan, who coauthored the book that introduced C to the world, Ritchie did not anticipate that the operating system and language would become “as big as they did.” Yet they did indeed become big. Programmers’ access to memory then escaped into the wild: programs acquired the dangerous ability to invade and manipulate the memory space of another program (mostly by accident), and that invaded program can invade another’s (and so on), enabling a world of perplexing bugs.

Then there is the Internet itself, derived from the ARPANET, which was created as a platform in which a limited group of researchers could converse openly about scientific subjects. Security was not assumed to be needed. And so arrived the hackable digital universe.

I once had the good fortune of working for a hacker. This goes back to the time when “hacker” was an honorific, as it still is
among talented hardware and software engineers. It refers to a type of crusty programmer who can chop through code with a combination of grim determination and giddy enthusiasm. The goal, above all, is to uncover the flaws that induce the failures, then (somehow or other) devise the fix that will make things work. Their solutions are often “ugly,” in coder parlance (aka kludges), the product of down-and-dirty plumbing. But no matter. Maybe lovely, elegant programs and systems can come later. Or not.

“Hacker” has acquired a less admirable meaning, of course, having acquired the taint of what we used to call “crackers,” as in safe crackers, people not allowed to get at what’s in the safe but who get in anyway. It is a chaotic world involving everyone from cryptocurrency tinkerers to bank thieves; from hackers working for hostile nation states to ones stealing data for espionage and ransom; to those seen as ethical hackers, who want to reveal the wrongdoings of anyone or anything in power; to loners looking for notoriety; to pranksters, jokers, naughty boys of all ages, breaking in just to see if they are clever enough to do it. (It’s fun to make porn appear in Zoom meetings, isn’t it?)

There are the workaday hacks, the constant reports of code vulnerabilities. Peter G. Neumann, the revered computer science researcher, moderates “The Risks Digest,” which is updated weekly, sometimes as often as every few days. The “Crypto-Gram Newsletter,” written by noted security analyst Bruce Schneier, is released monthly. As individual programmers and software makers struggle against the onslaught of flaws in their own code, they are meanwhile bombarded by the hacks that rain down upon the digital planet, nearly invisible, like the solar wind.

Then come the hackers who break into the code meant to defend against hackers: code to protect code becomes a victim. NASA stored reports of vulnerabilities they received from friendly hackers, and then the store itself was hacked. Software written by the company CodeCov, which is widely used to test for bugs and code vulnerabilities, was broken into by Russian
hackers, giving them a window into the very code to be protected. In a recently revealed 10-year-old hack, Chinese spies broke into RSA’s cryptosystem. The company is a corporate security giant whose customers include “tens of millions of users in government and military agencies, defense contractors, and countless corporations around the world,” according to wired.com. The break-in allowed “hackers to instantly bypass [RSA’s] security system anywhere in the world.”

The fate of humanity hangs in the balance. Nicole Perlroth’s book *This Is How They Tell Me the World Ends: The Cyberweapons Arms Race* describes how the Internet—buggy and hackable—has become a potent military tool. It has the dark power to ignite global war: by accident, or by design.

Now I will return to the “good” use of hacker, because I want to preserve its historical meaning among the general public and give the original hackers their due: an army of sometimes disheveled geniuses who were wary of rules and formalities, non-conformist in their thinking, somehow both brilliant and practical at the same time, who could reach in, rummage around, and figure out what to do. A member of Backus’s FORTRAN team called their group “the hackers of those days.”

A now-famous hack saved the Apollo 13 mission from disaster. A now-famous hack saved the Apollo 13 mission from disaster. Before the mission could achieve a moon landing as planned, an oxygen tank exploded in the command module. The three astronauts had to take refuge in the lunar module, which was designed to carry only two astronauts. To reduce the build-up of carbon dioxide, they retrieved an additional canister of lithium hydroxide pellets (a carbon dioxide scrubber) from the command module. But there arose the sort of problem that plagues complex projects: components designed and built separately. One canister had a round connector, the other a square one, the proverbial square peg in a round hole. A remedy had to be found—quickly—or all three men would die of asphyxiation.
NASA engineers on the ground raced to find a solution. They threw together bits of stuff that were on the spacecraft—plastic bags, covers ripped from manuals, duct tape, cardboard, anything—and devised a bridge between the mismatched connectors. It was one of those “ugly” fixes. As the Apollo 13 astronaut James Lovell later described it: “Hose. Duct tape and an old sock.”

Daniel Kaminsky, a famed cybersecurity expert, created another legendary, down-and-dirty hack. In 2008, he discovered a security hole in the Internet’s Domain Name System (DNS), which converts website URLs to specific IP addresses. Kaminsky saw how easy it was for knowledgeable bad actors to redirect the user not to the intended destination, but to a world of fake sites—a “bank,” a “credit card company,” an “email login”—and therefore collect the user’s IDs and passwords. He alerted others and, along with Paul Vixie, coded an emergency patch.

Kaminsky, who will forever have a place of honor among the greats of the hacker community, died on April 23, 2021. His obituary in the New York Times called him “the savior of the Internet.” He was the first to sound the alarm and respond to the threat. Yet, given what we know about the relationship between coding and error, it is no surprise to learn that the patch was far from perfect. After the “fix” was installed, there were 6:00 a.m. calls from Finnish certificate authorities saying their security procedures were broken. Some DNS servers stopped working correctly. And there were some pretty harsh words from Kaminsky’s peers in the security community. Years later, in a talk at the 2016 Black Hat hacker conference, Kaminsky referred to his patch as “that DNS mess.” Vixie, a longtime steward of the DNS, described the code they cobbled together in terms yet more ugly than Apollo’s old sock: he compared it to dog excrement. In the way of hacker expediency, he called it the best dog excrement “we could have come up with.”

Each of the programs, systems, and concepts discussed in this book had to go through the test of trial-by-error. The essays in
this book explore a wide range of topics. Several offer a deeper look at technologies familiar to the general public: the coming of Email, hyperlinking, JPEG image files, the Facebook Like. Some discuss historical landmarks that ought to be known more widely: women's contributions to early computing; the creation and endurance of COBOL, the first language in general use for business software; the coming of BASIC, the wonderful beginner's language.

Two essays explore deeper concepts in computing: data encryption, and the Markov Chain Monte-Carlo concept (MCMC), a foundational mathematical method used to understand distributions in data and arrive at probabilities.

Computing can bring happiness, as three essays show. There is pleasure (and pain) in learning to write code; in the fun brought into the world by Spacewar!, the first distributed video game; and in the advent of the Roomba, which, in addition to cleaning floors, also gave hours of delirious pleasure to innumerable cats.

Two essays discuss contributions to computing that I see as being derived from the idea of “the wisdom of the crowd”: the Facebook Like button and page ranking. The premise is that numbers in and of themselves say something about the worth of whatever is being liked, from websites to Instagram postings to dance crazes on TikTok: more likes equals more eyeballs equals “better.” The underlying theory is based on the belief that, given a very large universe of participants, a truth will emerge.

The coming of the “smart mob” has been a decidedly mixed blessing. Twenty-five years ago, I had an informal talk with Larry Page about Google’s search engine as it worked at the time. I said I was concerned that the order in which results were listed, based as it was on the number of links into a given page, was a species of the rich getting richer. Larry, ever thoughtful, sat quietly, considering his reply. Finally he said, “I worried about that too, but I realized there was nothing I could do about it.”

What he meant was that there was nothing he could do algorithmically. Given the immense universe of knowledge, a human
curator would have faced an impossible task; code has to be the curator. Google’s search engine has improved vastly over time, its criteria for ranking becoming ever more sophisticated. And search engines, most modeled on Google’s, have brought astounding advances in how human beings can understand the world. Yet search engines have also ushered in the age of “most popular,” “trending,” “bests,” and posts that users hope will “go viral.” This amplification of responses can empower the public and create a world of fun. They also reveal the hazards of assigning wisdom to the crowd: results prejudiced by the cultural majority, an arms race between the search algorithm and sites wanting to promote themselves, conspiracy theories, hordes of influencers stoking likes and clicks, truly fake news.

Then there are the programs we wish had not survived the assault by bugs. One essay examines so-called predictive policing, which pretends to predict where crime will take place in the future. Like all AI algorithms, it is based on databases laced with bad information, on methods that are rife with bias.

On a lighter note, there is another maybe-we-never-wished-for code invention: the pop-up ad. The essay here, by the programmer who authored it, describes his remorse, the regret he feels about loosing the pop-up upon the world.

A book about code must necessarily address the subjects that are integral to the creation of software: error and failure. “The Lost Mars Climate Orbiter” describes a failure that, 28 years after Apollo 13, echoes the earlier mission’s mistake: system parts created separately. One team used the American measurement system, the other the English Imperial system. The repetition of this type of error shows how pervasive are the hazards in complex systems, where one group of engineers cannot possibly create the whole, and disparate parts must somehow be knit together, and flawlessly.

“Heartbleed” describes a bug deep in the internals of the Internet that caused havoc for millions of devices. A hacker ex-
exploited weaknesses in open-source software and vulnerabilities in the C language, as mentioned above, which gave programmers direct access to the contents of memory. Like so many errors, the problem lay dormant, everything apparently working, until something in the environment changed: the arrival of a hacker with malicious intent.

Another essay discusses the Morris Worm, the first to be distributed via the Internet. Robert Tappan Morris, then a graduate student at Cornell, wrote the invasive code as an intellectual project, as a test of the Internet’s weaknesses. However, a mistake in his code instructed the worm to keep reproducing itself, whether or not a system had already been infected. Then he inadvertently released the worm into the wild. A senior engineer who worked on the emergency caused by the worm, Colm MacCárthaigh, later said, “It felt like the Internet was on fire.” Morris never intended to cause the vast damage he did. In this sense, his worm was a bug inside a hack.

A particularly pernicious use of errant code was deployed by Volkswagen to falsely lower the readings of pollution levels caused by their diesel engines: an intentional bug, an error created for corporate gain.

And then we come to the day-to-day, unglamorous but vital chore performed by all good programmers: adding comments to their code. Comments are an invaluable tool; they describe sections of the program that are tricky, not immediately obvious or readable. Comments are acts of generosity, help for the unknown colleagues who will work on the code over time, in the hope that they will keep a system working.

Sometimes the “future” programmer will be the original author of the code, and the comment is a gift to oneself, since it is all but impossible for individuals to recall all the complex details in the software they have written. A bug is an opportunist that waits at the gate of any change to the body of running code; a comment is a weapon that, a priori, takes up the battle against software entropy.
I am just old enough to remember the desperate attempts by the United States to match the Soviet Union’s great achievement, Sputnik, the first earth-orbiting satellite. NASA’s launches were broadcast on television, some live. We saw one rocket after another exploding spectacularly on the pad; or collapsing in a ball of fire after lifting-off a mere few feet; or managing to rise into the sky only to burst into flames at the first stage of separation. Those failures are engraved in the memories of those who watched the attempts: the great anguish inherent in technological achievement, and, per Backus, the imperative to try again.

Decades later, after scores of intervening successes—including a human’s trip to the moon and projects that sent explorer satellites to the edge of our solar system and beyond—NASA launched the mission to send the Perseverance Rover to Mars. The launch took place on July 30, 2020. On February 18, 2021, nearly six months later, Perseverance landed on Mars.

The landing was streamed live thanks to NASA’s commitment to inform the public, even if a mission might fail. What riveted my attention was a pane on the left side of the screen. It highlighted each stage as the mission unfolded, modules for launch, separations, cruise balance, etc. Between each module was a step that began with the word “Interface,” as in: Module A, Interface to module B, Module B, Interface to Module C, Module C, and so on. You could see the tension in the faces of the women and men staring into their monitoring screens. I held my breath along with them.

There is no more hazardous place in a complex project than the handshake between one section and the next. In this interregnum lurks all the potential misunderstandings between separate groups of developers, as we saw with the lost Mars orbiter and the near catastrophe of Apollo 13. The illuminated word “Interface” always seemed to linger for far too long. I wondered if this latest generation had learned the lessons of their forebears, who knew the danger zones. In the case of a
breakdown, did these young engineers have the hackers’ skills to scrounge around and repair a ripped seam? This Mars Rover project seemed impossibly complicated, riddled with opportunities for disaster. I watched in a mood of both exaltation and horror.

Time went by. The display followed the steps in the project: one module, interface, next module, interface, and the next. Finally we came to the astounding unfurling of the parachute that gently lowered Perseverance to the surface. And it was done.

And yet.

There is no such thing as the last bug.

The problem appeared in the initial test of the small helicopter, Ingenuity, which had arrived on Mars attached to the underbelly of Perseverance, like a baby kangaroo in the pouch of the mother ship. Ingenuity was to attempt to fly in the thin atmosphere of Mars, to pioneer an age of powered, controlled flight—engineered by humans—on a planet other than earth.

The first try failed. The helicopter’s start-up activities took longer than expected, and its computer shut down the motors. The engineers overseeing the mission identified a potential workaround and devised a patch. Yet, knowing that touching existing code is an excellent opportunity to break it, they wisely did not install it. Instead, they adjusted the commands they would send to the craft.31

Here was a repair that was sent not through the Internet but across 130 million miles of space.32 Engineers had to wait two anxious earth days to find out if their changes would work.33 On April 19, 2021, Ingenuity rose 10 feet into the Martian atmosphere as planned, hovered briefly, banked, turned, and landed at its takeoff point.34

More flights followed. Failure had led to success. This was a bug-fix for our time, another hack for the ages.
A page number in *italics* refers to an illustration.

Adelman, Leonard, 104

advertising: to support user-generated content, 96–97, 98, 99; targeted, 93–95, 99, 136

Ahmed, Nasir, 88

Aldrin, Buzz, 56

AltaVista, 108, 109

Amazon, and Heartbleed, 139, 143–44

amplitude of oscillations, 87, 88

Analytical Engine, 15–16

Android phones, and Heartbleed, 140

Angle, Colin, 119, 121–23

AOL, 48

API (Application Programming Interface), 157

Apollo 10, 62

Apollo 11, 56–62, 61

Apollo 13, 5–6

Apollo Guidance Computer (AGC), 56–62, 61

Apple: HyperCard for Macintosh, 82; targeted marketing and, 94

Armstrong, Neil, 56, 60

ARPANET, 3, 45–47, 67, 69, 73

ASCII, 165

Association for Computing Machinery (ACM), 29–30, 163

Asteroids video game, 36

Atabey, Zemi Yukiyú, 167

Atari, 34, 35–36

audio compression, 89

Babbage, Charles, 15–16

Back, Adam, 102, 107

Backus, John, 1, 5, 10

Bangla language blog community, 151–55

Banu Musa brothers, 18

BASIC, 40–43

batch processing, 38–39, 44

Bell Labs: C language developed at, 3; Unix comment and, 64; Unix created at, 3, 65, 66

Bergin, Tim, 28–29

Berners-Lee, Tim, 82, 83, 84–85

Bernstein, Daniel, 105–6

binary representation: of all code, 18; of data, 18, 165; of gender, 162–68

Bitcoin: blockchain and, 126, 127–28; Nakamoto and, 124–26, 125, 127, 129–30; new values and, 129–30; privacy and, 126; trust and, 125–27

Black people: framed as responsible for crime, 50–51, 53–54, 55; prevalent in early computing, 41–42. See also communities of color; race; racism

blacklist, 85, 107, 126, 127–29

Blockstream, 107

Bohnet, David, 99

Boltzmann factor, 21

Boole, Charles, 165

Boolean values, 165

Boolean variables, 166–67

Bosworth, Andrew, 131, 133–34, 135

bots, on Iran’s Telegram, 157, 158

Bouchon, Basile, 13–15, 15, 16, 17–18

Boyle, Willard, 88

Brin, Sergey, 108, 110, 111, 112

Brooks, Rodney, 121

bugs, 2–3; Morris worm based on, 70

Busch, Michael, 38, 40

Bush, Vannevar, 81–82

Bushnell, Nolan, 34

C, memory management in, 3, 141–42

Callahan, Ezra, 131, 134, 138

Cambridge Analytica scandal, 99

cars, computerization of, 147–48
Cascading Style Sheets (CSS), 91
cat videos, 7, 119–20, 122, 123
Census Bureau, US: punch cards used in 1890, 17; UNIVAC used in 1951, 162
channels: on Internet Relay Chat, 75; on Telegram, 157–58
Chappelle, Dave, 119
charge-coupled device (CCD), 88
chat, 75–80
check engine light, 148
Chiappetta, Mark, 121
Chrome, third-party cookies in, 95
cisgender heteronormativity, 166–67
civil rights movement, 49, 50, 59
Clean Air Act Amendments of 1970, 146–47
click, and hyperlink concept, 83, 84
climate change, and blockchain, 129
Clinton administration, and telephone encryption, 106
Clipper, 106
COBOL, 29, 30, 37, 40–41
CODASYL, 26, 30
code: binary representation of, 18; definition of, 13, 16–17. See also software
CodeCov, 4–5
Codenomicon, 140
code vulnerabilities, 4–5; Heartbleed, 139–44, 141
coding empowerment, illusion of, 41–43
comet trajectory, 22–23, 23
command line, 83
comments, 63–68
communities of color: surveillance of, 49, 53, 55. See also Black people; race; racism
Compatible Time-Sharing System (CTSS), 44–45
compilers, 26, 30; rewritten for Roomba, 121; run-time compiler trick, 32–33
compression schemes, 86–88; JPEG standard, 86, 88–90, 90
CompuServe, 47
Computer History Museum, 36, 67
crime: Black people framed as responsible for, 50–51, 53–54, 55; proposed computational solutions to, 51–55, 54
crowdsourcing, 7, 8, 110
cryptoeconomics, 129
Cuervo, Soleio, 135
cypherpunks, 103, 106, 124
Dabney, Ted, 34
Dartmouth College Time-Sharing System, 39–40, 41, 42
data: analyzed with MCMC algorithm, 22–24; binary representation of, 18, 165; types of, 165
databases: gender in, 162–68; LGBTQIA+ identities in, 163; types of variables in, 165–66
decentralized finance (DeFi), 127
DeCSS, 107
Defender video game, 36
Digg, 134
Digital Equipment Corporation (DEC), 32, 34, 36
digital images, 86–90, 90
Dijkstra, Edsger W., 29
Discrete Cosine Transform (DCT), 88, 89, 90
Dorner, Steve, 47–48
dot-com boom, 48
DuckDuckGo, Email Protection feature, 94
Discrete Time System (DTS), 44–45
Dorner, Steve, 47–48
dot-com boom, 48
DuckDuckGo, Email Protection feature, 94
Durov, Nikolai, 156–57
Durov, Pavel, 156–57
DVDs, encryption of, 107
Edwards, Dan, 32–33
eigenvalue problem, 111
elegant code, 4, 167
Elizabeth II, 47
Email, 44–48; interoperability and, 117; origin of @ notation in, 46; tracking pixels in, 91–92, 92, 93, 94
emojis, 79–80
encryption: Heartbleed vulnerability and, 139–40, 142; Iran’s Internet and, 158; RSA algorithm for, 102–7.
See also Internet security
Engelbart, Douglas, 82
ENIAC, 19, 29
Environmental Protection Agency, 146, 147, 148
equation of state, 20–22
Ethereum, 128
Eudora, 47–48
Evans, Claire L., 42
Ewing, Jack, 148
export-control laws, 102–4, 106–7
Facebook: death threats toward Bangladeshi bloggers on, 155; gender identity and, 164; like button on, 85, 93–94, 131–38, 132; and news feed algorithm, 134, 135, 136, 137; open-source software and, 143–44; populist politicians and, 137–38; virtual performative on, 79
Facebook Beacon, 134
Facebook Pixel, 94
facial recognition, 55
failure, 1–2
fast and slow thinking, 2
Faulkner, Roger, 67–68
Ferguson, Jonathan, 162
file format incompatibility, 117
financial crisis of 2008, 124, 130
Forelle, M. C., 149
forensic analysis of images, 86, 90
forks, and Iranian Internet, 157, 160
FORTRAN, 1, 5, 40–41
Fourier, Jean-Baptiste Joseph, 87
Fourier transform, 89
freedom of expression: in Bangladesh, 154, 155; on Iran’s Telegram channels, 157–58
frequency of oscillations, 87–88; JPEG standard and, 89–90
Friendfeed, 134
Galaxy Game arcade game, 34
game theory, and public goods, 129
gaming culture, 31–37
Gass, Saul I., 52, 54
Gasser, Urs, 117
gender binary in databases, 162–68
gender identity: and government documents, 168; vs. legal sex, 167.
See also White men, and access to computing; women
genderqueer identification, 167
General Motors, emissions deceit by, 148
Gen Z, and Bitcoin, 130
GeoCities, 97, 99
global economic crisis of 2008, 124, 130
Gmail, setting to block external images, 94
Google: “Don’t be evil” motto of, 135; invisible cross-app tracking on, 95; open-source software and, 143–44; and PageRank algorithm, 108–12, 109; ranking issues on, 7–8; reverse-engineered hyperlinking and, 85; social media in Bangladesh and, 155; and surveillance capitalism, 100; third-party cookies in Chrome and, 95
governance, and blockchain, 129
GPU (graphics card), 17
Graetz, Martin, 31, 33
graphical user interface, 82–83
Greenspan, Alan, 124
hackers, 3–5
*Hacker's Dictionary*, 65, 66–67
hacks, good use of, 3–4, 5–6, 11
Haider, Hasin, 152
Hastings, W. K., 22
Hawes, Mary K., 27
Heartbleed vulnerability, 139–44, 141
Hicks, Mark, 162
Higinbotham, William, 37
Holberton, Betty, 29
Hollerith, Herman, 17, 18
Hopper, Grace, 26–29, 42
HTML: Cascading Style Sheets and, 91; interoperability and, 85; as not Turing complete, 17
hydrogen bomb, 19–20
HyperCard, 82
hyperlinks, 81–85
hypertext, 82

IBM: buying Lotus for $3.5 billion, 48; COBOL development and, 28, 29; first manned US space mission and, 52; focus on problem-solving at, 49–50; FORTRAN and, 40; growth of after Second World War, 27; Hollerith's 1889 system and, 17; MIT and, 32; open-source software and, 143–44
images, digital, 86–90, 90
imagination, 1–2
inequality, and blockchain, 129
Instagram, 137
Internet: audio, images, and video on, 88; commercialization of, 47; evolution from ARPANET of, 3, 69; interoperability and, 117; in Iran, 156–61, 159; as military tool, 5; need for hyperlinks on, 83–84; tracking pixels on, 91–95, 92. See also targeted advertising
Internet Relay Chat (IRC), 75–80
Internet security: emergency DNS patch in 2008, 6; and hacking of security companies, 4–5; Iran's Telegram and, 158; Morris worm and, 69–74, 71; multibillion-dollar industry for, 74. See also encryption interoperability, 116–18; development of programming language for, 27–29; hyperlinks and, 85; shift away from, 117–18
invisible GIFs. See tracking pixels
iOS15, and Email web bugs, 94
Iran, Internet in, 156–61, 159
iRobot, 119, 120, 122
Jacquard, Joseph Marie, 14
Jacquard Loom, 14–15, 17
January 6 invasion of US Capitol, 99
Johnson, Lyndon, 50, 52
Johnson, Steve, 65–66
Jones, Joe, 120, 121, 122
JPEG compression standard, 86, 88–90, 90
Junger, Peter, 105
Kahneman, Daniel, 2
Kaminsky, Daniel, 6
Karhunen-Loeve transform (KLT), 88
Kelty, Christopher M., 65
Kemeny, John, 39, 42, 43
Kennedy, John F., 56, 61
Kernighan, Brian, 3
Keys, Os, 166
Khamenei, Ali, 156
Kint, Jason, 92
kludges, 4
Kotok, Alan, 32
Kurtz, Tom, 38, 39, 43
Landsteiner, Norbert, 36
law enforcement technologies, 55
LGBTQIA+ people: and database design, 163–64, 166–68; in Iran, 159–60
Licklider, J.C.R., 45–46
like button, 131–38, 132; counter of, 134, 138; flaws of, 137–38; as a link, 85; tracking pixel and, 93–94
link, software concept of, 81–82
link rot, 85
Linux, expletives in source code of, 67
Lions, John, 64–65
listserv, 45
LOL: as early computer slang, 58; emoji for, 79; in Internet Relay Chat, 75, 77, 78, 79
loops, precursors of, 18
Los Alamos nuclear weapons program, 19–20
Lotus Notes, 47–48
Lovelace, Ada, 15–16
Lovell, James, 6
Lycos, 108, 109
MacCárthaigh, Colm, 139, 140
machine code, 27
MAIL command, 44, 45, 46, 48
mainframe computers: batch processing for, 38–39, 44; for calculation, not correspondence, 44; of Dartmouth time-sharing system, 38–40
maintenance, ignored in our culture, 29
Mandiberg, Michael, 84
MANIAC, 21
marketing on the Internet. See targeted advertising
Mark I computer, 26
Markov Chain Monte Carlo (MCMC), 21–24
Mars Climate Orbiter, 113–16, 114, 117
Mars Global Surveyor, 115
Masswerk, 36
McCarthy, John, 32, 44
McGeachie, John, 38, 40
Mehta, Neel, 140
Metropolis, Nick, 21
Metropolis algorithm, 21
Microsoft: open-source software and, 143–44; Windows XP’s lines of code, 63; Word for Windows, 67, 117
Millennial generation, and Bitcoin, 130
Minsky, Marvin, 32
Minskytron hyperspace signature, 33, 35, 36
Missile Command video game, 36
Mitchell, Jaime, 168
Monte Carlo method, 19, 20, 21–24
Morgenstern, Jared, 136
Morris, Bob, 70
Morris, Noel, 45
Morris, Robert Tappan, 69–74
Morris worm, 69–74, 71
Moussouris, Katie, 93
movie industry, and decryption of DVDs, 107
MP3, 89
MPEG, 89
multitasking, of running programs, 64
music, encoded, 18
Muskie, Edmund, 146
MySpace, 131, 135
Nader, Ralph, 146
Nakamoto, Satoshi, 124–26, 125, 127, 129–30
Napoleon Bonaparte, 14
Nelsen, Arvid, 42
Nelson, Ted, 81, 82
Neumann, Peter G., 4, 69
*The New Hacker’s Dictionary*, 65, 67; original version of, 66–67
Nixon, Richard, 146
norming, 53
Northcutt, Poppy, 56
nuclear weapons program, 19–20
Okelola, Ola, 133
open-source software: for Bangla text entry, 152; Bitcoin and, 126; Heartbleed vulnerability and, 139–44, 141; institutional support for, 141, 143–44
OpenSSL software library, 139–40, 141, 142, 144
operating systems, lines of code in, 63
Ozzie, Ray, 47
Page, Larry, 7, 108, 110, 111, 112
PageRank algorithm, 108–12, 109
Palfrey, John, 117
PDP-1, 32–34, 36
PDP-11, 34
200 / INDEX

Pearlman, Leah, 131, 133, 134, 135, 136, 138
Perlroth, Nicole, 5
Perseverance Rover, 10–11
phase of oscillations, 87
Piner, Steven, 33
Pines, Jonathan, 136
Pitts, Bill, 34
player pianos, 18
Police Beat Algorithm, 49–55, 54
police brutality, 50–51
Pong, 35
populist politicians, 137–38
pop-up ads, 96–101, 97
pornography: appearing in Zoom meetings, 4; censored in Iran, 158
privacy: Facebook like button and, 134; Iranian authorities and, 157; motive for Bitcoin and, 126; tracking pixels and, 92–93, 94–95
profiling, for police, 52, 53
programming languages: BASIC, 40–43; binary data and, 165–66; C, 3, 141–42; COBOL, 29, 30, 37, 40–41; FORTRAN, 1, 5, 40–41; origin of, 26–30; Turing complete, 17
Project Xanadu, 81, 82
proxy services, and Iranian censorship, 160
public-key algorithms, 104–5
punch cards, 14, 16, 17, 18, 38–39
race: computing access and, 43; gaming culture and, 37. See also Black people; communities of color
racism: Police Beat Algorithm and, 55; uprisings against, 50–51, 52
random surfing algorithm, 109, 111
RankDex, 112
Raymond, Eric S., 67
regulations, circumvented with computers, 149–50
Ritchie, Dennis, 3, 65–66, 66
Rivest, Ron, 104–5
Roomba, 7, 119–23, 122
Rosenbluth, Arianna, 19, 21, 23–24
Rosenbluth, Marshall, 19, 20–21, 24
Rosenstein, Justin, 131, 133
RSA encryption algorithm, 102, 104–5
RSA security company, 5
RSA T-shirt, 102–3, 103, 106–7
Ruckelshaus, William, 147
run-time compiler trick, 32–33
Russell, Steven, 31, 32, 34, 36
Russian interference in 2016 US election, 99
same-sex marriage, 164
Sammet, Jean, 25–30, 42
Samson, Peter, 33, 36
Schneier, Bruce, 4
Scott, David, 57
search engines: benefits and hazards of, 8; dynamic query-dependent scores in, 112; before Google, 108–9, 112. See also Google
Secure Sockets Layer (SSL), 140
Shamir, Adi, 104–5
Shetterly, Margot Lee, 42
Silver, Nate, 23
Simmel, Georg, 127
Smith, George, 88
Smith, Richard M., 92
Snuffle, 105, 106
social media: alternative models for, 100–101; in Bangladesh, 151–55; current dysfunctions of, 99; hyperlinks and, 85; Internet Relay Chat and, 75, 78, 79; replacement of Email communications by, 48; Telegram application in Iran, 156–61. See also Facebook
software: for Apollo Guidance Computer, 56–62, 61; to cheat emissions tests, 145–46, 149; copyright for, 37, 107, 149; export laws and, 102–4, 107; hardwired, 58, 62; interoperable, 27, 116–17; long-term use of, 37; as protected speech, 106–7. See also code; open-source software software crisis, 27
Soltani, Ashkan, 93, 95
“Somewhere in . . . ” social media company, 151–52, 155
Space Invaders arcade game, 35
Spacewar, 31–37, 35
SSL (Secure Sockets Layer), 140
surveillance: advertising and, 95, 98, 99; by Iranian authorities, 156; police algorithms and, 49, 53, 55
surveillance capitalism, 98, 99–100
Syzygy Engineering, 34

Tanaka, Brian, 64
targeted advertising: giving users more control over, 94–95; like button and, 93–94, 136; pop-up ads and, 99; tracking pixels and, 93–94, 95
Tech Model Railroad Club (TMRC), 32, 33
Telegram application in Iran, 156–61
Teller, Augusta, 21
Teller, Edward, 19–21
Tennis for Two, 37
Thomas, Arun, 64
Thompson, Ken, 66
3D-printed firearms, 107
Tierney, Gertrude, 29
TikTok, 137
time-sharing systems: at Dartmouth College, 39–40, 41, 42; early mail programs on, 44–45; one-click multitasking derived from, 64
Tomlinson, Ray, 46
“town crier” worm, 73
tracking pixels, 91–95, 92
transparency report, 155
transparent 1 × 1 pixels, 91–95, 92
Transport Layer Security (TLS), 140
Tripod.com, 96–97, 99
trout-slap, 75–76, 79, 80
trust: in Bangla blog community, 153–54; Bitcoin and, 125–27; blockchain and, 127–29
Tuck, Hugh, 34
Turing, Alan, 15–16
Turing completeness, 16–17
Turing Test, 16
Twitter: as imitator of Facebook, 137; virtual performatives on, 79–80
TX-0, 32
Ulam, Stanislaw, 20, 23
UNIVAC, 26, 162
universal machine, 16–17
Unix: comments in, 63–68; creators of, 3, 65, 66; Morris worm and, 70; time-sharing systems in, 63–64; unavailable source code for, 64–65
Usher, Abbot Payson, 14
vampire worm, 73
Van Vleck, Tom, 45
variables in a program, 165–66
Vezza, Albert, 45–46
Viber, 158
video compression, 89
Vimeo, 134
virtual performatives, 76–80
virtual private networks, 158, 160
Vixie, Paul, 6
Volkswagen emissions scandal, 145–50
von Neumann, John, 20
Wable, Akhil, 131, 134
Watson, Thomas J., 49–50
Watts uprisings, 50–51, 52
web bugs, 91–95, 92
Weber, Max, 127
weighting, 53
WhatsApp, 158, 160
White, Kenneth, 94
White men, and access to computing, 41, 42–43
Whitnah, Tom, 133, 136
Wiitanen, Wayne, 31
Wikileaks, frozen accounts of, 126
Willis, Robert, 14
wisdom of the crowd, 7, 8, 110
women: computing in high schools and, 43; gaming culture and, 37; as pioneers in computer science, 24, 25–30; prevalence of in early computing, 41–42
INDEX

word processing: PDP-1 program in 1960s, 33; Word for Windows, 67, 117
World Wide Web, 82, 83–84
worms, 73; Morris worm, 69–74, 71

Y2gay, 164
Y2K crisis, 30, 164

“You are not expected to understand this,” 64–68

YouTube, 87, 101, 123

You are not expected to understand this,” 64–68

Zuboff, Shoshana, 98, 99–100

Zuckerberg, Mark, 99, 134, 135

Yost, Jeffrey R., 29