

TUBES

A JOURNEY

TO THE

CENTER

OF THE

INTERNET

ANDREW BLUM

ecco

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It is not down in any map; true places never are.

—HERMAN MELVILLE

*Somehow I knew that the notional space behind all of the
computer screens would be one single universe.*

—WILLIAM GIBSON

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Prologue

On a bitterly cold day a few winters ago, the Internet stopped working. Not the whole Internet, only the section that resides in a dusty clump beside my living room couch. There's a black cable modem with five green lights, a blue telephone adapter the size of a hardcover book, and a white wireless router with a single illuminated eye. On good days they all blink happily at one another, satisfied with the signals coming through the wall. But on that day their blinking was labored. Web pages loaded in fits and starts, and my phone—of the “voice over IP” variety, which sends calls over the Internet—made everyone sound like a scuba diver. If there were little men inside these boxes, then it was as if they had suddenly become prone to naps. The switch itself had fallen asleep.

The repairman arrived the next morning, full of assurances. He attached an electronic whistle—it looked like a penlight—to the living room end of the cable, and then began to trace its path, searching for clues. I followed him, first outside to the street,

then down into the basement and through a hatch to the backyard. A rusty switch box was caught in a web of black cables and bolted to a brick wall. Disconnecting them one at a time, he screwed a tiny speaker into each one until he found the one that whistled: audible proof of a continuous path between here and there.

Then his eyes lifted ominously to the sky. A squirrel scampered along a wire toward a battleship gray enclosure affixed like a birdhouse to a pole. Anemic urban vines wrapped around it. Animals chew on the rubber coating, the repairman explained. Short of rewiring the whole backyard there was nothing he could do. "But it might get better on its own," he said, and it did. But the crude physicality of the situation astonished me. Here was the Internet, the most powerful information network ever conceived! Capable of instantaneous communication with anyplace on earth! Instigator of revolutions! Constant companion, messenger of love, fountain of riches and beloved distraction. Stymied by the buckteeth of a Brooklyn squirrel.

I like gadgets. I will happily discuss the Internet as a culture and a medium. My mother-in-law calls me for tech support. But I confess that the substance of the thing—a "thing" that squirrels can nibble at—had escaped me. I may have been plugged in, but the tangible realities of the plug were a mystery to me. The green lights on the box in my living room signaled that "the Internet"—a singular unnuanced whole—was, to put it simply, *on*. I was connected, yes; but connected to what? I'd read a few articles about big factory-sized data centers filled with hard drives, invariably someplace far away. I'd unplugged and plugged back in my share of broken cable modems behind the couch. But

beyond that, my map of the Internet was blank—as blank as the Ocean Sea was to Columbus.

That disconnect, if I can use that word, startled me. The Internet is the single biggest technological construction of our daily existence. It is vivid and alive on the screens all around us, as boisterous as a bustling human city. Two billion people use the Internet, in some form, every day. Yet physically speaking, it is utterly disembodied, a featureless expanse: all ether, no net. In the F. Scott Fitzgerald story "My Lost City," the protagonist climbs to the top of the Empire State Building and recognizes, crestfallen, that his city had limits. "And with the awful realization that New York was a city after all and not a universe, the whole shining edifice that he had reared in his imagination came crashing to the ground." I realized that my Internet had limits too. Yet, oddly, they weren't abstract limits but physical ones. My Internet was in pieces—literally. It had parts and places. It was even more like a city than I had thought.

The squirrel outage was annoying, but the sudden appearance of the Internet's texture was thrilling. I've always been acutely attuned to my immediate surroundings, to the world around me. I tend to remember places the way a musician does tunes or a chef, flavors. It's not merely that I like to travel (although I do), but more that the physical world is a source of constant, sometimes overwhelming, preoccupation. I have a strong "sense of place," as some people describe it. I like to notice the widths of the sidewalks in cities and the quality of light in different latitudes. My memories are almost always keyed to specific places. As a writer, that's often led me to the subject of architecture, but it's never been the buildings themselves that interest me most, rather the

places the buildings create—the sum total of construction, culture, and memory; the world we inhabit.

But the Internet has always been a necessary exception to this habit, a special case. Sitting at my desk in front of a computer screen all day, and then getting up at the end of the day and habitually looking at the other, smaller screen I carry in my pocket, I accepted that the world inside them was distinct from the sensory world all around me—as if the screens' glass were not transparent but opaque, a solid border between dimensions. To be online was to be disembodied, reduced to eyes and fingertips. There wasn't much to do about it. There was the virtual world and the physical world, cyberspace and real places, and never the two shall meet.

But as if in a fairy tale, the squirrel cracked open the door to a previously invisible realm behind the screen, a world of wires and the spaces in between. The chewed cable suggested that there could be a way of stitching the Internet and the real world together again into a single place. What if the Internet wasn't an invisible elsewhere, but actually a *somewhere*? Because this much I knew: the wire in the backyard led to another wire, and another behind that—beyond to a whole world of wires. The Internet wasn't actually a *cloud*; only a willful delusion could convince anyone of that. Nor was it substantially *wireless*. The Internet couldn't just be everywhere. But then where was it? If I followed the wire, where would it lead? What would that place look like? Who would I find? Why were they there? I decided to visit the Internet.

When in 2006 Senator Ted Stevens of Alaska described the Internet as “a series of tubes,” it was easy to ridicule him. He seemed hopelessly, foolishly trapped in the old way of knowing the world, while the rest of us had skipped merrily into the future. Worse, he was supposed to know better. As chair of the US Senate's Commerce, Science, and Transportation Committee, Stevens had oversight for the telecommunications industry. But there he was behind the lectern of the Hart Building on Capitol Hill, explaining that “the Internet is not something that you just dump something on. It's not a big truck, it's a series of tubes, and if you don't understand those tubes can be filled, and if they're filled when you put your message in and it gets in line it's going to be delayed—by anyone that puts into that tube enormous amounts of material . . . *Enormous* amounts of material!” The *New York Times* fretted over the senator's cluelessness. Late-night comics showed side-by-side pictures of dump trucks and steel tubes. DJs mixed mash-ups of his speech. I made fun of him to my wife.

Yet I have now spent the better part of two years on the trail of the Internet's physical infrastructure, following that wire from the backyard. I have confirmed with my own eyes that the Internet is many things, in many places. But one thing it most certainly is, nearly everywhere, is, in fact, a series of tubes. There are tubes beneath the ocean that connect London and New York. Tubes that connect Google and Facebook. There are buildings filled with tubes, and hundreds of thousands of miles of roads and railroad tracks, beside which lie buried tubes. Everything

you do online travels through a tube. Inside those tubes (by and large) are glass fibers. Inside those fibers is light. Encoded in that light is, increasingly, *us*.

I suppose that all sounds improbable and mysterious. When the Internet first took off, in the mid-1990s, we tended to think of it as a specific kind of place, like a village. But since then those old geographic metaphors have fallen out of favor. We no longer visit "cyberspace" (except to wage war). All the "information superhighway" signs have been taken down. Instead, we think of the Internet as a silky web in which every place is equally accessible to every other place. Our connections online are instantaneous and complete—except when they're not. A website might be "down" or our home connection might be wonky, but it's rare that you can't get to one part of the Internet from another—so rare that the Internet doesn't appear to have any parts at all.

The preferred image of the Internet is instead a sort of nebulous electronic solar system, a cosmic "cloud." I have a shelf filled with books about the Internet and they all have nearly the same picture on the cover: a blob of softly glowing lines of light, as mysterious as the Milky Way—or the human brain. Indeed, thinking of the Internet as a physical thing has fallen so far out of fashion that we're more likely to view it as an extension of our own minds than a machine. "The cyborg future is here," proclaimed the technology writer Clive Thompson in 2007. "Almost without noticing it, we've outsourced important peripheral brain functions to the silicon around us."

I know what that feels like, but I'm left wondering about all that "silicon around us." Clearly Thompson means our computers and smartphones and e-readers and whatever other devices

we hold at arm's length. But it must also include the network behind them—and where's that? I'd feel better about outsourcing my life to machines if I could at least know where they were, who controls them, and who put them there. From climate change to food shortages to trash to poverty, the great global scourges of modern life are always made worse by not knowing. Yet we treat the Internet as if it were a fantasy.

The Silicon Valley philosopher Kevin Kelly, faced with this chasm between the physical here and the missing virtual there, became curious if there might be a way to think of them together again. On his blog he solicited hand sketches of the "maps people have in their minds when they enter the Internet." The goal of this "Internet Mapping Project," as he described it, was to attempt to create a "folk cartography" that "might be useful for some semiotician or anthropologist." Sure enough, one stepped forward out of the ether two days later—a psychologist and professor of media at the University of Buenos Aires named Mara Vanina Osés. She analyzed more than fifty of the drawings Kelly collected to create a taxonomy of the ways people imagined the Internet: as a mesh, a ring, or a star; as a cloud or a radial like the sun; with themselves at the center, on the bottom, the right or the left. These mental maps mostly divide into two camps: chaotic expressions of a spidery infinity, like Jackson Pollock paintings; or an image of the Internet-as-village, drawn like a town in a children's book. They are perceptive, revealing plenty of self-consciousness about the way we live on the network. What strikes me, though, is that in no case do the machines of the Internet actually appear. "All that silicon" is nowhere to be found. We seem to have exchanged thousands of years of mental car-

tography, a collective ordering of the earth going back to Homer, for a smooth, placeless world. The network's physical reality is less than real—it's irrelevant. What Kelly's folk cartography portrayed most vividly was that the Internet is a landscape of the mind.

This book chronicles my effort at turning that imagined place into a real one. It is an account of the physical world. The Internet may seem to be everywhere—and in many ways it is—but it is also very clearly in some places more than others. The single whole is an illusion. The Internet has crossroads and superhighways, large monuments and quiet chapels. Our everyday experience of the Internet obscures that geography, flattening it and speeding it up beyond any recognition. To counter that, and to see the Internet as a coherent physical place all its own, I've had to tinker with my conventional picture of the world. At times this book's attention oscillates between a single machine and an entire continent, and at other times I simultaneously consider the tiny nano scale of optical switches and the global scale of transoceanic cables. I often engage with the most minute of timetables, acknowledging that an online journey of milliseconds contains multitudes. But it is a journey nonetheless.

This is a book about real places on the map: their sounds and smells, their storied pasts, their physical details, and the people who live there. To stitch together two halves of a broken world—to put the physical and the virtual back in the same place—I've stopped looking at web "sites" and "addresses" and instead sought out real sites and addresses, and the humming machines they house. I've stepped away from my keyboard, and with it the mirror-world of Google, Wikipedia, and blogs, and

boarded planes and trains. I've driven on empty stretches of highway and to the edges of continents. In visiting the Internet, I've tried to strip away my individual experience of it—as that thing manifest on the screen—to reveal its underlying mass. My search for "the Internet" has therefore been a search for reality, or really a specific breed of reality: the hard truths of geography.

The Internet has a seemingly infinite number of edges, but a shockingly small number of centers. At its surface, this book recounts my journey to those centers, to the Internet's most important places. I visited those giant data warehouses, but many other types of places as well: the labyrinthine digital agoras where networks meet, the undersea cables that connect continents, and the signal-haunted buildings where glass fibers fill copper tubes built for the telegraph. Unless you're one of the small tribe of network engineers who often served as my guides, this is certainly not the Internet you know. But it is most definitely the Internet you use. If you have received an email or loaded a web page already today—indeed, if you are receiving an email or loading a web page (or a book) *right now*—I can guarantee that you are touching these very real places. I can admit that the Internet is a strange landscape, but I insist that it is a landscape nonetheless—a "netscape," I'd call it, if that word weren't already taken. For all the breathless talk of the supreme placelessness of our new digital age, when you pull back the curtain, the networks of the Internet are as fixed in real, physical places as any railroad or telephone system ever was.

In basest terms, the Internet is made of pulses of light. Those pulses might seem miraculous, but they're not magic. They are produced by powerful lasers contained in steel boxes housed

(predominantly) in unmarked buildings. The lasers exist. The boxes exist. The buildings exist. The Internet *exists*—it has a physical reality, an essential infrastructure, a “hard bottom,” as Henry David Thoreau said of Walden Pond. In undertaking this journey and writing this book, I’ve tried to wash away the technological alluvium of contemporary life in order to see—fresh in the sunlight—the physical essence of our digital world.

1

The Map

On the January day I arrived in Milwaukee, it was so cold that the streets themselves had blanched white. The city was born in 1846 out of three competing settlements at the edge of a broad harbor on the western shore of Lake Michigan. Four years after its founding, the Milwaukee & Waukesha Railroad linked the lake with the hinterland, and the rich wheat fields of the Midwest with the growing populations of the east. Before long, Milwaukeeans weren’t only moving materials but processing them, making beer from hops, leather from cows, and flour from wheat. With the growing success of this industry—and the help of an influx of German immigrants—those first processing plants encouraged the growth of a broad range of precision manufacturing. The heart of the activity was the Menomonee Valley, a miasmic swamp that was steadily filled in to accommodate

what was soon a coal-choked industrial powerhouse. "Industrially, Milwaukee is known across the face of the earth," the 1941 *WPA Guide to Wisconsin* rhapsodized. "Out of the city's vast machine shops come products that range from turbines weighing 1,200,000 pounds to parts so minute as to be assembled only with the aid of magnifying glasses. Milwaukee steam shovels dug the Panama Canal; Milwaukee turbines harnessed Niagara Falls; Milwaukee tractors are in the fields of most of the world's agricultural regions; herring-bone gears made in Milwaukee operate mines in Africa and Mexico, sugar mills in South America, and rolling mills in Japan, India, and Australia." Milwaukee had become the center of a far-reaching industrial colossus—known everywhere as "the machine shop of the world."

It didn't last forever. After World War II, the fixed steel lines of the railroads gave way to the more flexible movement of rubber tires over new roads. The hard networks became softer. And the Menomonee Valley started a steady decline, paralleling that of the nation's manufacturing more broadly. The United States became a country that produced ideas more than things. The "machine shop of the world" became the buckle of the Rust Belt. Milwaukee's factories were left abandoned—and then, only more recently, turned into condominiums.

But Milwaukee's industry didn't disappear entirely. It quietly holds on today, having moved out of the city and into the suburbs, like so much of American urban life. Early one morning I followed its path, driving from a downtown hotel on a deserted street to a new industrial neighborhood in the northwest corner of the city. I passed a McDonald's, a Denny's, an Olive Garden, and an IHOP, then took a left at a Honda dealer. High-

tension power lines loomed overhead, and I bumped across a railroad spur that led the dozen miles back to the Menomonee Valley. Along a series of smooth, wide suburban streets was a concentration of industry that would have made William Harley and Arthur Davidson proud. In one building, they made beer cans; another, ball bearings. There were factories for car keys, airplane parts, structural steel, resistors, carbon brushes, mascot costumes, and industrial signs—that said things like WHEEL CHOCKS REQUIRED FOR LOADING AND UNLOADING. My destination was the tidy tan building across the road, with the giant "KN" painted on the side.

Kubin-Nicholson got its start in 1926, silk-screening movie posters from a print shop on Milwaukee's South First Street. In time, it branched out to signs for butchers, grocers, and department stores, before focusing on tobacco ads, printed in Milwaukee and pasted on billboards across the entire Midwest. Kubin-Nicholson was the "printers of the humongous." Its current press—as big as a school bus—sat within a cavernous hall. Its installation had taken a team of German engineers four months, flying home every other weekend to see their families. It was a rare beast, with fewer than twenty like it across the United States. And, on that morning, a frustratingly silent one.

The black ink was on the fritz. A call had been placed to the tech support people in Europe, who were able to log into the machine remotely to try to diagnose the problem. I watched from inside a glass-walled customer lounge, as the pressman peered into its innards, a cordless phone wedged in the crook of his neck, a long screwdriver in his hand. Beside me was Markus Krisetya, who had flown in from Washington to supervise the job on

the press that day. He wanted to make sure the ink was precisely calibrated, so that just the right quantity of each color was distributed across the poster-sized paper. It wasn't the kind of thing that could be done over email. No digital scan would properly capture the nuance. FedEx would be far too slow for the back-and-forth, trial and error, required for the final settings. Krisetya accepted it as one of those things that still had to be done in person, a fact made even more surprising by what was being printed: a map of the Internet.

Krisetya was its cartographer. Each year, his colleagues at TeleGeography, a Washington, DC-based market research firm, polled telecommunications companies around the world for the latest information about the capacity of their data lines, their busiest routes, and their plans for expansion. TeleGeography's cartographers don't use any fancy algorithms or proprietary data analysis software. They worked an old-fashioned process of calling industry contacts and gaining their trust, then choosing just the right moment to make a few leaps of conjecture. Most of that effort goes toward a big annual report known as *Global Internet Geography*, or *GIG*, sold to the telecommunications industry for \$5,495 a pop. But some of the key pieces of data are shunted into a series of maps of Krisetya's creation. One diagrammed the Internet's backbone architecture, the key links between cities. Another illustrated the quantities of network traffic, boiling trillions of moving bits down to a series of thick and thin lines. A third—the map on the press that morning in Milwaukee—showed the world's undersea communications cables, the physical connections between continents. All were representations of the spaces in between, the strands of connection that we typi-

cally ignore. The countries and continents were afterthoughts; their action was in the emptiness of the oceans. Yet these maps were also representations of physical things: actual cables, filled with strands of glass, themselves filled with light—amazing human constructions, of the kind a Milwaukeean would be proud.

Krisetya paid homage with his own sense of craft. When each map design was complete, he electronically transferred the file here to Milwaukee, then followed it himself. He'd stay at whatever downtown business hotel had a special, then head out here first thing in the morning, bringing nothing but a small gym bag, and his eyes. He knew big machines like this one. After college in the United States, he returned to his native Indonesia to work as a database systems engineer, mostly for the mining industry. Young, slight, with an easy manner, happy to fit in anywhere, eager for adventure, he'd show up at a remote encampment deep in the jungles, ready to tinker with their mainframes. As a boy, he'd drawn fantastical maps of *Dungeons & Dragons* realms, cribbed from bootlegged photocopied versions of the rulebooks that had somehow made their way to his home city of Salatiga. "I loved drawing stories on paper, and referencing distance in that strange manner," he told me, looking out at the silent press. "That's what got my fascination with maps started." It was only when he returned to the United States to study international relations in graduate school that his future wife, a geography student, encouraged him to take a cartography class taught by Mark Monmonier, author of the cult favorite *How to Lie with Maps*. The sly joke of the title is that maps never just show places; they express and reinforce interests. When TeleGeography offered Krisetya a job in 1999, he already knew the question: Maps

project an image of the world—but what did that mean for the Internet?

With help from the tech support people in Germany, the pressman finally coaxed the giant machine to life, and its vibrations shook the door frames—*un-cha, un-cha, un-cha*. “I hear paper!” Krisetya cheered. A test print had been lain out on a large easel lit with klieg lights, like an operating table. Krisetya pulled off his thick-framed glasses and placed a magnifying loupe to his eye. I stood just over his shoulder, squinting at the bright lights, struggling to take in the world this map portrayed.

It was a Mercator projection, with the continents drawn in heavy black and the international boundaries etched, like afterthoughts, by thin scores. Rigid red and yellow lines striped the Atlantic and Pacific, jagged around the southern continents, and converged in key places: north and south of New York City, in the southwest of England, the straits near Taiwan, and the Red Sea—so tightly there that they formed a single thick mark. Each line represented a single cable, mere inches in diameter but thousands of miles in length. If you lifted one up from the ocean floor and sliced it crosswise, you’d find a hard plastic jacket surrounding an inner core of steel-encased strands of glass, each the width of a human hair and glowing faintly with red light. On the map it looked huge; on the ocean floor it would be a garden hose beneath the drifting sediment. It seemed to collapse the electronic global village upon the magnetic globe itself.

Krisetya examined every inch of the test print, pointing out imperfections. The pressman responded by moving levers up and down on a huge control panel, like the soundboard at a rock concert. Every few minutes, the giant press would spool up and

spit out a few copies of the newest version. Krisetya would then go back over it again, inch by inch until finally, he put down his magnifier and nodded quietly. The pressman affixed a neon orange sticker to the map, and Krisetya signed it with a black marker, like an artist. This was the gold master, the definitive and original representation of the earth’s underwater telecommunications landscape, circa 2010.

The networked world claims to be frictionless—to allow for things to be anywhere. Transferring the map’s electronic file to Milwaukee was as effortless as sending an email. Yet the map itself wasn’t a JPEG, PDF, or scalable Google map, but something fixed and lasting—printed on a synthetic paper called Yupo, updated once a year, sold for \$250, packaged in cardboard tubes, and shipped around the world. TeleGeography’s map of the physical infrastructure of the Internet was itself of the physical world. It may have represented the Internet, but inevitably it came from somewhere—specifically, North Eighty-Seventh Street in Milwaukee, a place that knew a little something about how the world was made.

To go in search of the physical Internet was to go in search of the gaps between the fluid and fixed. To ask, what could happen *anywhere*? And, what had to happen *here*? I didn’t know this at the time, but in one of many strange ironies involved in visiting the Internet, over the next year and a half I would see TeleGeography’s maps hanging on the walls of Internet buildings around the world—in Miami, Amsterdam, Lisbon, London, and elsewhere. Wedged into their plastic office-supply store frames, they were fixtures of those places, as much a part of the atmosphere as the brown cardboard shipping boxes piled up in the corners,

or the surveillance cameras poking out from the walls. The maps were themselves like the dyes that trace fluid dynamics, their mere presence highlighting the currents and eddies of the physical Internet.

When the squirrel chewed through the wire in my backyard in Brooklyn, I had only the slightest inkling of how the Internet all fit together. I assumed my cable company must have a central hub somewhere—maybe out on Long Island, where its corporate headquarters was? But after that I could only imagine that the paths went everywhere, the bits scattering like Ping-Pong balls bouncing through dozens if not hundreds of tubes—more than could be counted, which was basically the same as saying none at all. I'd heard about an Internet "backbone," but the details were sketchy, and if it were truly a big deal, I figured I would have heard more. At the least, it would have occasionally become clogged or broken, bought or sold. As for international links, the undersea cables seemed mythic, like something out of Jules Verne. The Internet—other than as it appeared on my ever-present screen—was more conceptual than actual. The only concrete piece I had a clear image of were those big data centers, photographs of which I'd seen in magazines. They always looked the same: linoleum floors, thick bundles of cables, and blinking lights. The power of the images came not from their individuality, but from their uniformity. They implied an infinity of other machines standing invisibly behind them. As I understood it (but mostly didn't), those were the parts of the Internet. So what was I looking for?

I became an armchair traveler, querying network engineers with the same set of questions: How did the network fit together? What should I see? Where should I go? I started working up an itinerary, a list of cities and countries, of monuments and centers. But in the process I quickly stumbled on a more fundamental question about the network of networks: What was a network, anyway? I had one at home. Verizon had one too. So did banks, schools, and pretty much everyone else, some reaching across buildings, others across cities, and a few across the entire world. Sitting at my desk, I thought they all seemed to coexist, in relative peace and prosperity. Out there in the world, how did they all physically fit together?

Once I got my nerve up to ask the question at all, the whole thing started to make more sense. It turns out that the Internet has a kind of depth. Multiple networks run through the same wires, even though they are owned and operated by independent organizations—perhaps a university and a telephone carrier, say, or a telephone carrier contracted to a university. The networks *carry* networks. One company might own the actual fiber-optic cables, while another operates the light signals pulsing over that fiber, and a third owns (or more likely rents) the bandwidth encoded in that light. China Telecom, for example, operates a robust North American network—not as a result of driving bulldozers across the continent, but by leasing strands of existing fiber, or even just wavelengths of light within a shared fiber.

This geographic and physical overlapping was crucial to understanding where and what the Internet was. But it meant I had to get over the old, and really misleading, metaphor of the "information highway." It wasn't really that the network is a "highway"

busy with “cars” carrying data. I had to acknowledge the extra layer of ownership in there: the network is more like the trucks on a highway than the highway itself. That allows for the likelihood that many individual networks—“autonomous systems,” in Internet parlance—run over the same wires, their information-laden electrons or photons jostling across the countryside, like packs of eighteen-wheelers on the highway.

In that case, the networks that compose the Internet could be imagined as existing in three overlapping realms: logically, meaning the magical and (for most of us) opaque way the electronic signals travel; physically, meaning the machines and wires those signals run through; and geographically, meaning the places those signals reach. The logical realm inevitably requires quite a lot of specialized knowledge to get at; most of us leave that to the coders and engineers. But the second two realms—the physical and geographic—are fully a part of our familiar world. They are accessible to the senses. But they are mostly hidden from view. In fact, trying to see them disturbed the way I imagined the interstices of the physical and electronic worlds.

It was striking to me that I had no trouble thinking of a physical network of something, like a railroad or a city; after all, it shares the physical world in which we exist as humans, and which we learned as children to navigate. Similarly, anyone who spends time using a computer is at least comfortable with the idea of the “logical” world, even if we don’t often call it that. We sign in to our home or office networks, to an email service, bank, or social network—logical networks all, which encompass our attention for hours on end. Yet we can’t for the life of us grasp that narrow seam between the physical and the logical.

Here was the rarely acknowledged chasm in our understanding of the world—a sort of twenty-first-century original sin. The Internet is everywhere; the Internet is nowhere. But indubitably, as invisible as the logical might seem, its physical counterpart is always there.

I wasn’t prepared for what that meant on the ground. Photographs of the Internet were always close-ups. There was no context, no neighborhood, no history. The places seemed interchangeable. I understood there were these layers, but it wasn’t clear to me how they would appear in front of my face. The logical distinctions were, by definition, invisible. So then what was I going to see? And what was I really looking for?

A few days before I left for Milwaukee, I was emailing with a network engineer who’d been helping me with the basics of how the Internet fit together. He was a Wisconsin native, as it turned out. “If you’re going to be in Milwaukee anyway, there is one spot you *must* hit,” he wrote. There was an old building downtown “chock full of Internet.” And he knew a guy who could show me around. “Have you seen *Goonies*?” he asked. “Bring your nice camera.” After approving the test prints at Kubin-Nicholson, Krisetya usually spent the afternoon at the art museum before catching a flight home. But he was eager to come along. So we headed downtown to meet a stranger in a sandwich shop who was supposed to show us Milwaukee’s Internet.

On his website, Jon Auer listed among his favorite books *Router Security Strategies* and *How to Win Friends & Influence People*. His Flickr page consisted mostly of photos of telecom-

munications equipment. In person, he had pink cheeks and metal-rimmed glasses, and on that frigid Wisconsin winter day he wore a hooded sweatshirt with no coat, and he carried a camouflage-patterned messenger bag. He fit the stereotype of a geek, but whatever social liability that might once have been, it had transformed into unadorned passion—and yielded a good job, running the network of a company that provides Internet access to towns across southeastern Wisconsin, mostly places too distant or too sleepy to attract the interest of the big telephone and cable operators. At lunch, he spoke almost in a whisper, conveying the impression that what we were about to do was slightly illicit, but not to worry. This was his turf, his backwoods. He had all the keys—and where he didn't, he knew the combination to the locks. He wrapped up his sandwich and led us out the back door of the shop, directly into the lobby of the building that turned out to be the center of Milwaukee's Internet.

Built in 1901 by a prominent Milwaukee businessman and once home to the Milwaukee Athletic Club, this building's days as a prestigious address were clearly long over. If in recent years the city had succeeded in revitalizing its downtown, that liveliness did not extend to this sad place. A sleepy-eyed guard sat listlessly behind a worn-out desk in the empty lobby. Auer nodded in her direction and led us down a narrow tiled passageway to the basement. Fluorescent lights buzzed dimly. There were dusty stacks of file boxes and precarious heaps of abandoned office furniture. The ceiling was totally obscured by a tangle of pipes and wires, twisted around one another like mangrove roots. They came in all sizes: wide steel conduits the diameter of dinner plates, orange plastic ducts like vacuum cleaner hoses, and the occasional

single dangling black thread—the hackwork of a rushed network engineer. Auer shook his head at it, disapprovingly. I was struck with a more mundane thought: *look at all those tubes!* Inside of them were fiber-optic cables, glass strands with information encoded in pulses of light. In one direction, they went through the foundation wall and underneath the street, heading toward the highway—mostly to Chicago, Auer said. In the other direction, they crossed the basement ceiling to an old utility chase and upstairs to the offices-turned-equipment rooms of the dozen or so Internet companies that had colonized the building, feeding first off this fiber, and then off one another, one attracting the next, steadily displacing the cut-rate law firms and yellowed dentists' offices. Some were Internet service providers, like Auer's, that connected people in the surrounding area; others operated small data centers, which hosted the websites of local businesses on hard drives upstairs. Auer pointed out a steel box tucked into a dark corner, its LED lights blinking away. This was the main access point for Milwaukee's municipal data network, connecting libraries, schools, and government offices. Without it, thousands of civil servants would bang their computer mice against the desk in frustration. "All this talk about Homeland Security, but look what someone could do in here with a chainsaw," Auer said. Krisetya and I snapped pictures, the camera flashes blowing out the basement's dark crevices. We were spelunkers in a cave of wires.

Upstairs, the empty hallways smelled of mildew. We passed vacant offices, their doors cracked open. Auer's space looked like it belonged to a private eye in a film noir. The three small rooms had linoleum floors and worn-out Venetian blinds. The

double-hung windows were thrown wide open to the winter, the cheapest way to keep the machines cool. The only evidence of the building's former opulence was a remnant scrap of mosaic floor tile, shattered in a corner like a broken mug. Auer's piece of the Internet was set unceremoniously on a raised platform: two man-sized steel racks, filled with a half-dozen machines, snug in a nest of cables. The key piece of equipment was a black Cisco 6500 Series router, the size of a few stacked pizza boxes, its chassis tattooed with bar-coded inventory labels and poked through by blinking green LEDs.

For the twenty-five thousand customers who relied on Auer's company to connect to "the Internet," this machine was the on-ramp. Its job was to read the destination of a packet of data and send it along one of two paths. The first path went upstairs to an equipment room belonging to Cogent, a wholesale Internet provider that serviced cities from San Francisco to Kiev. A yellow wire passed through a utility shaft, came through a wall, and plugged into Cogent's equipment, itself connected to electronic colleagues in Chicago and Minneapolis. This building was Cogent's only "point of presence" in all of Wisconsin, the only place Cogent's express train stopped; that's why Auer's company was here, and all the others. The second cable went to Time Warner, whose wholesale Internet division provided an additional connection—a backup, plugging Auer's piece of the Internet into all the rest.

Taken as a whole, the building seemed a labyrinth, packed with a hundred years of twisted cables and broken dreams. Yet in its particularity, this part of the Internet—Auer's part—was strikingly legible; it wasn't an endless city at all but a simple fork in the road. I asked Auer what happened after here, and he

shrugged. "I care about where we can talk to Cogent or Time Warner, which means this building. Once it's here it's really out of my hands." For about twenty-five thousand Wisconsinites, this was the source. Their Internet went this way and it went that way: two yellow cables leading, eventually, to the world. Every journey—physical and virtual—begins with a single step.

A few weeks later I went to Washington to visit TeleGeography's offices, for a better sense of how Krisetya drew a clear map of the Internet's mushy layer cake. But the night before I left, New York was hit by a blizzard, and I emailed Krisetya to let him know I'd be arriving later than expected. As the train moved south across New Jersey the snow began to dwindle, so that by the time we pulled into Washington the blanket of white I had left in New York had given way to clear gray sky and dry sidewalks. It was as if over the course of the ride the veil that had descended upon the landscape had just as quickly been lifted. Arriving in DC, I opened my laptop in the center of Union Station's great neoclassical hall to log into a café's wireless network and send off an email to California. A few minutes later, standing on the Metro platform, I thumbed a message to my wife saying that, despite New York being shut down by the snow, I had made it to Washington (and we'll see about getting back).

I share all these quotidian details of travel because on that day my senses were unusually attuned to the networks that surrounded me, both visible and invisible. Maybe it was the way the snow had drawn a new outline around the world's familiar shapes, while slowing my progress past them. Or maybe it was

just the early morning hour and the fact that I had maps on the brain. But as the train was sliding across the elbow of New Jersey, ducking out of the storm, I could imagine the emails following (albeit faster) along the same path. I had recently learned that many of the fiber-optic routes between New York and Washington were laid along the railroad tracks, and I could begin to imagine the route my email to California had taken: it might have shot back the way I'd come, to New York, before heading cross-country, or it could have continued farther west to Ashburn, Virginia, where there was an especially significant network crossroads. The exact route of that email didn't matter; what did was that the Internet no longer seemed infinite. The invisible world was revealing itself.

In a neighborhood of staid lobbyists and wood-paneled law firms, TeleGeography's K Street office stands out for its lime-green walls, exposed ceilings, and translucent cubicle dividers. The front door pivoted creatively on its center point. Maps lined the walls, of course. On one, Spain had been adorned with a Groucho Marx mustache, a remnant of a recent holiday party. Krisetya welcomed me into his office, the desk piled high with books about information design. When he joined TeleGeography in 1999, he was put right to work on the company's first big report, *Hubs + Spokes: A TeleGeography Internet Reader*. It was groundbreaking. Before, there were geographic maps showing the networks operated by individual corporations or government agencies, and there were "logical" diagrams of the whole Internet, like a subway map. Neither gave a strong sense of how the Internet adhered and diverged from the real-world geography of cities and countries. What places were *more* connected? Where were the hubs?

Krisetya began looking at new ways of portraying that combination of the geopolitical and networked worlds. He blended the outlines of the continents with diagrams of the networks, "always layering something abstract on top of something that's familiar, always looking to give it more meaning." Other kinds of maps had long struggled with the same issues—like airline routes or subways. In both cases, the end points were more important than the paths themselves. They always had to balance the workings of the system internally with the external world it connected. London's Tube map might be the height of the genre: a geographical fiction that pushes and pulls at real-world creations, leaving in its wake a kind of alternate city that's become as real as the true one.

On his maps, Krisetya portrayed this by showing the most heavily trafficked routes between cities, such as between New York and London, with the thickest lines—not because there were necessarily more cables there (or some single, superthick cable) but because that was the route across which the most data flowed. This was an insight that dated back to that first report. "If you look inside the Internet cloud a fairly distinct hub-and-spoke structure begins to emerge at both an operational (networking) and physical (geopolitical) level," it explained. The Internet's structure "is based upon a core of meshed connectivity between world cities on coastal shores—Silicon Valley, New York and Washington, DC; London, Paris, Amsterdam and Frankfurt; Tokyo and Seoul." And it still is.

Today's version—the one TeleGeography calls the *GIG*—is the bible for big telecommunications companies. The key to its approach is still to look at Internet traffic as concentrated between

powerful cities. TeleGeography breaks down the nebulous cloud into a clear system of point-to-point communications, of segments. Contrary to its ostensible fluidity, the geography of the Internet reflects the geography of the earth; it adheres to the borders of nations and the edges of continents. "That's the nugget of our approach," Krisetya explained to me in his office, sounding like a college tutor. "We always put much more emphasis on the actual geography than the connections in between. In the beginning, that's what we were more familiar with. When the Internet was still very much abstract, we knew where the two end points were, even if we didn't understand how this was all being built."

That had a certain clarity. The world is real; London is London, New York is New York, and the two usually had a lot to say to each other. But I was still hung up on what seemed a simple question: What, physically speaking, *were* all those lines? And where precisely did they run? If TeleGeography properly understood the Internet as being "point to point," what and where were the points?

For their part, TeleGeography's analysts don't go out into the world with a GPS and a sketchpad. They don't attach sensors to the Internet to measure the speed of the bits passing by, like a water meter. Their process is quite low tech: they distribute a simple questionnaire to telecom executives, requesting information about their networks in exchange for the promise to keep it confidential and to share the aggregated information with them. And then TeleGeography asks the Internet itself.

To see how, Krisetya dropped me off at the tidy desk of Bonnie Crouch, the young analyst responsible for gathering and interpreting TeleGeography's data on Asia. The diplomatic work of wran-

gling and cajoling the information from the telecom carriers was finished, and the responses loaded into TeleGeography's database. Crouch's job was to confirm what the carriers said, based on the Internet's actual traffic patterns. Cartographers talk about "ground truth": the in-person measurements used to check the accuracy of the "remote sensing"—which in contemporary mapmaking usually means aerial or satellite photographs. TeleGeography had its own way of checking the "ground truth" of the Internet.

When I enter an address into my browser, a thousand tiny processes are set in motion. But in the most fundamental terms, I'm asking a computer far away to send information to a computer close by, the one in front of me. Browsing the web, that typically means a short command—"send me that blog post!"—is volleyed back with a far larger trove, the blog post itself. Behind the URL—say, www.mapgeeks.com—is a self-addressed envelope with the instructions that connect any two computers. Every piece, or "packet," of data traveling across the Internet is labeled with its destination, known as an "IP" address. Those addresses are grouped into the equivalent of postal codes, called "prefixes," given out by an international governing body, the Internet Assigned Numbers Authority. But the routes themselves aren't assigned by anyone at all. Instead, each router announces the existence of all the computers and all the other routers "behind" it, as if posting a sign saying THIS SECTION OF THE INTERNET OVER HERE. Those announcements are then passed around from router to router, like a good piece of gossip. For example, Jon Auer's router in Milwaukee is the doorway to his twenty-five thousand customers, grouped into just four prefixes. It announces its presence to the two neighboring routers, belonging

to Cogent and Time Warner. Those two neighboring routers make a note of it, and then pass the word on to their neighbors—and so on, until every router on the Internet knows who's behind whom. The complete aggregate list of destinations is known as the "routing table." At the end of 2010 it had nearly four hundred thousand entries and was growing steadily. The whole thing is typically stored in the router's internal memory, while a compact flash card, like the kind used by digital cameras, keeps the operating code. Auer buys his on sale at the local drugstore.

Two things surprised me about this. The first is that every IP address is by definition public knowledge; to be on the Internet is to want to be found. The second is that the announcement of each route is based wholly on trust. The Internet Assigned Numbers Authority gives out the prefixes, but anyone can put up a sign pointing the way. And sometimes that does go horribly wrong. In one well-known incident in February 2008, the Pakistani government instructed all Pakistani Internet providers to block YouTube, because of a video it deemed offensive. But an engineer at Pakistan Telecom, receiving the memo at his desk, misconfigured his router, and rather than removing the announced path to YouTube, he announced it himself—in effect declaring that he *was* YouTube. Within two and a half minutes, the "hijacked" route was passed to routers across the Internet, leading anyone looking for YouTube to knock on Pakistan Telecom's door. Needless to say, YouTube wasn't in there. For most of the world, YouTube wasn't available at all for nearly two hours, at which point the mess was sorted out.

It sounds preposterously loose and informal. But it strikes at the core of the Internet's fundamental openness. There's a cer-

tain amount of vulnerability involved with being a network on the Internet. When two networks connect, they have to trust each other—which also means trusting everyone the other one trusts. Internet networks are promiscuous, but their promiscuity is out in the open. It's free love. Jon Postel, the longtime administrator of the Internet Assigned Numbers Authority, put this into a koan, a golden rule for network engineers: "Be conservative in what you send, be liberal in what you accept."

For TeleGeography this means everything is out in the open, for those who know how to see it. The company uses a program called Traceroute, originally written in 1988 by a computer scientist at the Lawrence Berkeley National Laboratory. He had gotten fed up, as he put it in a mailing list message to his colleagues, trying to figure out "where the !?#! are the packets going?" and worked up a simple program that traced their paths. Enter in an IP address and Traceroute will feed back a list of the routers traversed to reach it, and the time (in milliseconds) elapsed in the journey between each one. TeleGeography then takes it one step further. It carefully selects fifteen locations around the world, looking especially for "dead-end" places with only a few paths out to the rest of the Internet—Denmark's Faroe Islands, for example. It then searches for websites there hosting a copy of the Traceroute program (often a university computer science department), and directs those fifteen Traceroute hosts to query more than twenty-five hundred "destinations," websites carefully chosen because they could reasonably be expected to actually live on a hard drive in the place where they say they live. Jagiellonian University in Poland, for example, is unlikely to host its website in, say, Nebraska. That meant TeleGeography in Washington was

asking a computer science department in Denmark to show how it was connected to a university in Poland. It was like a spotlight in Scandinavia shining on twenty-five hundred different places around the world, and reporting back on the unique reflections. TeleGeography's trick was finding real-world corners and dead ends, thereby minimizing the number of possible paths.

Added all together, the fifteen hosts TeleGeography selected query twenty-five hundred destinations yielding more than twenty thousand journeys across the Internet—and, inherently, around the earth. Quite a few of these journeys are never completed; the traces conk out, lost in the ether. The whole set takes several days, not because TeleGeography has a slow computer, or even a slow Internet connection. Rather, those days represent the aggregate duration of all those thousands of trips, milliseconds piled upon milliseconds in which the explorer packets are crisscrossing the earth. And I don't mean "crisscrossing" idly. These paths are by no means random or imaginary. Each packet—a clump of math, in the form of electrical signals or pulses of light—moves along very specific physical pathways. The whole point of each traceroute is to identify that specificity, that singular record of a journey. Theoretically you could divide up the task of querying each traceroute among multiple computers, but there's no way to rush the traces themselves, no more than you can rush the speed of light. The time the packets take on their journey is the time they take. Each recorded journey is like a series of tiny postcards from around the globe. TeleGeography then layers the tens of thousands of them as if they were strands of papier-mâché, until the patterns emerge.

Crouch and the other analysts then parse the routes by hand.

"Any particular country of interest?" she asked me, with the geographic expansiveness I was quickly learning to love about Internet people. I told her to pick whichever she knew best, and she chose Japan—dodging the ambiguity of China's networks. On her screen, a long list of jumbled letters and numbers, like a phone book without the names, scrolled down. Each grouping represented the results of a single trace—from the Faroes to Hokkaido, for example. Each individual line represented a single router: a lonely machine in a cold room, studiously forwarding packets. Over time the codes had become familiar to Crouch, like London's streets are to a cabdriver. "You begin to get a feel for how companies name their routers," she said. "Like that one's going from SYD to HKG—the airport codes for Sydney to Hong Kong. And the carrier did tell us it's running that route, so we don't need to worry about it." Her goal in reading these lists was to confirm that the carriers are operating the routes they say they are, and, with a more subjective eye, to make a judgment about the amount of traffic on that route. "Our research gives us all the pieces of the puzzle: the bandwidth, the Internet capacity, some of the pricing information. The gaps in between we can fill in with some reasonable accuracy."

It occurred to me that Crouch was part of the small global fraternity that knows the geography of the Internet the way most people know their hometowns. Her boss, a Texan named Alan Maudlin who improbably led TeleGeography's analyst team from his home in Bratislava, possessed one of the best mental maps of the physical infrastructure of the Internet. I'd spoken with him before coming. "I don't need to look at a map," he told me over Skype. "I have in my mind, and I can almost note, which cables

connect everywhere in the world.” Rather than maps of the Internet, his study in Slovakia was decorated with antique maps of Texas. “I suppose it is kind of like the *Matrix*, where you can see the code. I don’t even have to think about it anymore. I can just see where it’s going. I know what city the router is in, and where the packet’s going. It’s the weirdest thing. But it’s easy to just fly through it all, once you know what to look for.”

Yet what’s so striking to me—and so often overlooked—is that each router is inherently *present*. Each router is a singular way-point, a physical box, in a real place, on a packet’s journey across this real earth. Two billion people use the Internet from every country on earth; airplanes have Wi-Fi; astronauts browse the web from space. The question “Where is the Internet?” should seem meaningless, because *where isn’t it?* And yet, standing over Crouch’s shoulder, watching her identify the coded name of individual machines in a city on the other side of the world, the Internet didn’t seem infinite at all. It seemed like a necklace strung around the earth. Forming what pattern? Did it look like the route maps in the back of an airline magazine? Or was it more chaotic, like a bowl of spaghetti or the London Underground? Before, I’d imagined the Internet as something organic, beyond human design, like an ant colony or a mountain range. But now its designers seemed present, not an innumerable crowd but a tidy contact list on a laptop in Washington. So who were they then? Why did they lay their networks there? Where did it all begin?

2

A Network of Networks

I wanted to know where the Internet started, but the question turned out to be more complicated than I’d imagined. For an invention that dominates our daily lives—acknowledged as an epoch-making transformative force across global society—the Internet’s history is surprisingly underwritten.

The serious book-length histories all seem to have been published in 1999, as if the Internet were finished then—as if the Internet were finished now. But more than that timing, they each seem to have their own heroes, milestones, and beginnings. The Internet’s history, like the network, was itself distributed. As one historian of historians put it (writing in 1998), “the Internet lacks a central founding figure—a Thomas Edison or a Samuel F. B. Morse.” I should have known things wouldn’t be so clear-cut when the author of *Inventing the Internet*, widely considered the

most authoritative among them, began by suggesting that "the history of the Internet holds a number of surprises and confounds some common assumptions." I felt like a guy wandering around a party he wasn't invited to, asking who the host was, and nobody knew. Or maybe there wasn't a host at all? Maybe the problem was more philosophical than that? The Internet had a chicken-and-egg thing going on: If the Internet is a network of networks, then it takes two networks to make an Internet, so how could one have been the first?

Needless to say, all this did not inspire confidence. I had set out in search of the real, the concrete, the verifiable, but I was greeted at the door by the historiographic equivalent of a comments thread. My question had to be narrower, more rooted in time and place. It was about the object. "Not ideas about the thing but the thing itself," as Wallace Stevens wrote. Not, where did the Internet begin? But, where was its first box? And that, at least, was clear.

In the summer of 1969, a machine called an interface message processor, or IMP, was installed at the University of California-Los Angeles, under the supervision of a young professor named Leonard Kleinrock. He's still there, a little less young, but with a boyish smile and a website that seemed to encourage visitors. "You'll want to meet me in my office," he replied when I emailed. "The original site of the IMP is just down the hall." We made arrangements. But it wasn't until I settled into my cramped seat on the plane to Los Angeles, surrounded by tired consultants in wrinkled shirts and aspiring starlets in sunglasses, that the full implications of my journey sank in: I was going to visit the Internet, flying three thousand miles on a pilgrimage to a half-

imagined place. And what did I expect to find? What, truly, was I looking for?

I suppose all pilgrims feel that way at some point. We are optimistic creatures. In Judaism, the Temple Mount in Jerusalem is the place from which the whole world expanded, the place closest to God, and the most important place of prayer. For Muslims, the small cube building in Mecca known as the Kaaba is the holiest place, so dominant in the psychic geography of the devout that they face it to pray five times a day, wherever they are in the world, even flying across the ocean on an airplane. Every cult, group, team, gang, society, guild—whatever—has its significant place, marked with memory and meaning. And most of us also have our own individual places: a hometown, stadium, church, beach, or mountain that looms epically above our lives.

Yet this significance is always in a way personal, even if millions collectively share it. Philosophers like to point out that "place" is as much within us as without us. You can demarcate a place on a map, pinpoint its latitude and longitude with global positioning satellites, and kick the very real dirt of its very real ground. But that's inevitably going to be only half its story. The other half of the story comes from us, from the stories we tell about a place and our experience of it. As the philosopher Edward Casey writes, "Stripping away cultural or linguistic accretions, we shall never find a pure place lying underneath." All we shall find instead are "continuous and changing qualifications of particular places." When we travel, we fix a place's meaning in our minds. It is in the eyes of a pilgrim that a holy site becomes holiest. And in being there, he affirms not only the place's significance but also his own. Our physical place helps us better know

our psychic place—our identity. But did that hold true for me, on the path to the Internet? I longed to see its most significant places, but were its places really places at all? And if they were, was the Internet close enough to religion—a way of understanding the world—that seeing those places would be meaningful?

The question got more complicated the next morning in Los Angeles. I woke up at dawn, my body clock still set to New York, in an enormous hotel near the airport, with a mirrored glass façade and a view of the runway. I stood in front of the window watching a line of jets land on top of their shadows. Inside, nearly every surface had a little folded cardboard sign that indicated the branded touches that made the room conform to the hotel chain's international standards: the "Suite Dreams®" bed, the "Serenity Bath Collection™," the "Signature Service." Nothing was singular or local; everything came from far away, at the direction of a global corporation. The novelist Walter Kirn calls this "Airworld"—these nonplaces of airports and their surroundings. I tried to get a little postmodern kick out of it all and summon my inner Ryan Bingham, the protagonist of Kirn's novel *Up in the Air* (played by George Clooney in the movie) who only feels at home here in this homogeneous, if admittedly comfortable, world—even if "cities don't stick in my head the way they used to." But I was hollow. On my way to the Internet I was already climbing a steep slope toward the singular and the local. It was frustrating to find the ostensibly real places blurring into each other as well. I had come to Los Angeles to try to bring the network back into the world—but instead, the world seemed to have succumbed to the logic of the network.

But I shouldn't have worried. At UCLA that afternoon, the moment of the Internet's physical birth came vividly into focus, rooted in a very specific place. On the quiet Saturday afternoon of the Labor Day weekend in 1969, a small crowd of computer science graduate students had gathered in the courtyard of Boelter Hall with a bottle of champagne. Standing in the same spot, I conjured the scene. The occasion was the arrival of their grand and expensive new gadget, coming that day from Boston by air freight: a modified and military-hardened version of a Honeywell DDP-516 minicomputer—"mini," at the time, meaning a machine that weighed nine hundred pounds and cost \$80,000, the equivalent of nearly \$500,000 today. It was traveling from the Cambridge, Massachusetts, engineering firm of Bolt, Beranek and Newman, possessor of a \$1 million Department of Defense contract to build an experimental computer network, known as the ARPANET. Among Bolt's many customizations was a new name for the machine: the Interface Message Processor. The particular one then wending its way up the hill to the UCLA campus was the very first: IMP #1.

The graduate students were mostly my parents' age, born in the last days of World War II—proto-baby boomers, in their midtwenties at the time—and I can blur in some family photos of the era. It was the summer of Woodstock and men on the moon, and even computer scientists wore their hair shaggy and their pants legs wide. One probably had a button with the word *RESIST* on it next to a question mark, the scientific notation for electrical resistance and a popular antiwar symbol for engineers. They all knew that their funding, \$200,000 to UCLA alone sup-

porting forty grad students and staff, came from the Department of Defense. But they also all knew that what they were building wasn't a weapon.

The ARPANET project was managed by the Department of Defense's Advanced Research Projects Agency (ARPA), founded in the wake of Sputnik's launch to support scientific research, esoteric stuff far out on the technological frontier. ARPANET certainly qualified. There had been few attempts to connect computers at continental-scaled distances, let alone create an interconnected network of them. If somewhere deep in the Pentagon a four-star general had the grim notion that the nascent ARPANET might evolve into a communications network that could survive a nuclear war—a popular myth about the origins of the Internet—this group was insulated from it. And anyway, they ignored it. They were consumed by the technical challenges arriving inside that moving van, by new wives and babies, and by the infinite possibilities of computer communications. Consumed, that is, by peaceful intentions.

Boelter Hall was new and shiny then, like much of Los Angeles itself. Built in the early 1960s to house the rapidly expanding engineering department, its stripped modernist lines were the height of architectural fashion, suitable to the cutting-edge work going on inside—not unlike the new biomolecular science building that now towers over it next door. These days Boelter is a bit rough around the edges, with worn-out sunshades over the windows and rusting steel balcony railings facing a courtyard of full-grown eucalyptus trees. The IMP's welcoming party would have stood here beneath them in the shade, on a hot Southern California day. Long before cell phones, they would have guessed at the

timing of the truck's progress from the airport. A forklift waited nearby, ready to lift the massive machine up into the building. Did they sip their champagne from Styrofoam cups? Snap pictures with one of the inexpensive new Japanese cameras that had recently begun to be imported? (If so, they're long lost.) The excitement of the occasion would have been unmistakable, even if the full historic implications were not: this was the first piece of the Internet.

But while the grad students were celebrating outside, their professor was stuck upstairs, alone in the large office he had recently expanded in a fit of empire building, shuffling papers on a Saturday afternoon. This I can picture precisely, because when I walked in forty-one years later, Leonard Kleinrock was still sitting there, sprightly at seventy-five, wearing a starched pink shirt, black slacks, and a BlackBerry clipped to a polished leather belt. His face was tanned and his hair was full. A brand-new laptop was open on his desk and he was yelling into a speakerphone: "It's not catching!"

On the other end, the disembodied voice of a tech support person responded slowly and patiently. *Click here. Now click there. Type this in.* Kleinrock looked over the top of his reading glasses and waved me toward a chair. Then he clicked. And clicked again.

Now try, the voice said.

He winced. "It says I'm not connected to the Internet. That's what it says!" Then he laughed so hard his shoulders shook.

Kleinrock is the father of the Internet—or rather, *a* father, as success has many. In 1961, while a graduate student at MIT, he published the first paper on "packet switching," the idea that

data could be transmitted efficiently in small chunks rather than a continuous stream—one of the key notions behind the Internet. The idea was already in the air. A professor at the British National Physical Laboratory named Donald Davies had, unbeknownst to Kleinrock, been independently refining similar concepts, as had Paul Baran, a researcher at the RAND Corporation in Los Angeles. Baran's work, begun in 1960 at the request of the US Air Force, was explicitly aimed at designing a network that could survive a nuclear attack. Davies, working in an academic setting, merely wanted to improve England's communications system. By the mid-1960s—by which time Kleinrock was at UCLA, on his way toward tenure—their ideas were circulating among the small global community of computer scientists, hashed out at conferences and on office chalkboards. But they were only ideas. No one had yet fit the pieces of the puzzle together into a working network. The fundamental challenge these network pioneers faced—and the one that remains at the heart of the Internet's DNA—was designing not just a network but a network of networks. They weren't only trying to get two or three or even a thousand computers talking, but two or three or a thousand different kinds of computers, grouped in all sort of ways, spread far and wide. This metalevel challenge was known as "Internetworking."

It took the Department of Defense to bring teeth to it. In 1967, a young computer scientist named Larry Roberts—Kleinrock's MIT office mate—was recruited to ARPA specifically to develop an experimental nationwide computer network. The next July, he sent out a detailed request for proposals to 140 different technology companies to build what he at first called the "ARPA net." It

would begin at four universities, all in the west: UCLA, Stanford Research Institute, the University of Utah, and the University of California–Santa Barbara. The geographic bias wasn't an accident. Connecting university computers together was a threatening idea—each school would inherently have to share its prized, and already overused, machine. The East Coast schools tended to be more conservative, or at least less susceptible to Roberts's ability to influence them with his control over their ARPA funding. California already had a burgeoning technology culture and big universities, but the nascent ARPANET's West Coast beginnings had as much to do with a cultural appetite for new ideas.

Under Kleinrock's direction, UCLA would have the added task of hosting the Network Measurement Center, responsible for studying the performance of this new creation. The reason for that was as much personal as professional: not only was Kleinrock the reigning expert in network theory but Roberts trusted his old friend. If Bolt, Beranek and Newman's job was to build the network, Kleinrock's would be to break it, to test the limits of its performance. It also meant that UCLA would receive that first IMP, to be installed between the computer science department's big, shared computer, called a Sigma-7, and the specially modified phone lines to the other universities that AT&T had readied for when there eventually was a network. For its first month in California, IMP #1 stood alone in the world, an island awaiting its first link.

"Do you want to see it?" Kleinrock asked, jumping excitedly from his chair. He led me across the hall to a small conference room, not fifteen feet from his desk. "This is it—a beautiful machine! A really magnificent machine!" The IMP looked—like all

famous things—exactly like it does in photographs: refrigerator-sized, beige, steel, with buttons on the front, like a file cabinet dressed up as R2-D2. He opened and closed the cabinet and twisted some dials. “Military hardened, built out of a Honeywell DDP-516, state of the art at the time.” I said I had begun to notice that the Internet had a smell, an odd but distinctive mix of industrial-strength air conditioners and the ozone released by capacitors, and we both leaned in for a whiff. The IMP smelled like my grandfather’s basement. “That’s mildew,” Kleinrock said. “We should close the door and it’ll cook it up.”

The IMP’s current situation certainly lacked in ceremony, shoved as it was into the corner of a small conference room, with mismatched chairs and faded posters on the walls. A stack of paper coffee cups poked out of a plastic bag. “Why is it sitting here?” Kleinrock said. “Why is it not in a wonderful showcase somewhere on campus? The reason is nobody took this machine as being important. They were going to throw it out. I had to rescue it. Nobody recognized its value. I said, ‘We gotta keep this thing, it’s important!’ But you’re never a philosopher in your own country.”

But that was changing. A history graduate student at UCLA had recently clued into the historical significance of Boelter Hall and the IMP and had begun assembling archival materials. After years of pleading with the university administration, Kleinrock had finally gathered support for the construction of the Kleinrock Internet Heritage Site and Archive. It would commemorate not only the IMP itself but the historical moment. “It was amazing, this group of really smart people collected in the same time and the same place,” Kleinrock said. “It happens, it’s sort of pe-

riodic, when you get this kind of golden era.” Indeed, the group assembled in his lab that fall formed a core group of Internet hall of famers, notably Vint Cerf (now “Chief Internet Evangelist” at Google), who cowrote the Internet’s most important operational code—what is known as the TCP/IP protocol—with Steve Crocker, also Kleinrock’s student, and Jon Postel, who managed the Internet Assigned Numbers Authority for years and was a key mentor to an entire generation of network engineers.

The museum would be built in room 3420, where the IMP had been installed from Labor Day 1969 until it was decommissioned in 1982. We walked down the hall to see it. “The IMP was against this wall here,” Kleinrock said, slapping the white paint, “but the room has been reconfigured. The ceiling is new, the floor is new—we had a raised floor for air-conditioning.” We peered behind a steel storage cabinet to see if the original phone jack might still be there—the first few feet of the Internet’s first route—but it wasn’t. There was no plaque, no historic display, and there were certainly no tourists, not yet. Kleinrock’s hope was to restore the room to the way it looked in 1969, which I imagined would become something like Graceland, frozen in time, with the IMP and an old rotary telephone and photographs of men in heavy-framed glasses and with slicked-down hair. “To put a wall up here and put a doorway there is \$40,000, and we have a \$50,000 budget for this and the archivist,” Kleinrock said. “So I’m going to have to donate a lot of money, I think. It’s okay. It’s a good cause.”

As we talked, an undergraduate computer lab was in progress in the room, with students touching soldering irons to green circuit boards, their cell phones set on the desks in front of them,

while a teaching assistant barked instructions. No one even glanced at us. Kleinrock was one of the Internet's earliest masterminds, but to the nineteen-year-olds in here, whose lives were fully shaped by its presence—Internet Explorer came out before they would have learned to read—he faded into the woodwork. Almost literally. This wasn't a holy site, it was a classroom—far less of a tourist attraction than Ryan Seacrest's house, not far away. So what was I doing here?

Boelter Hall was where the Internet had once been fully containable, in stark contrast with its current sprawl. And Kleinrock was still there, embodying that history in his memory. But I could have reached him on the phone, we could have video-chatted. But I had cast my net in the waters of experience, having chosen (for example) to ignore the photograph of room 3420 that shows up in a Google image search, and instead come see it for myself. That afternoon, when I had arrived early for my appointment with Kleinrock, I sat on a ledge outside Boelter Hall eating a bag of chips, fiddling with my cell phone. My wife had just emailed a video of our baby taking her first crawling steps, a video that loaded vividly on the small screen and pulled me back, in my head, to New York. I had come to visit the first node of the Internet, but one of its most recent nodes—the one I carried in my pocket—had distracted me. If the Internet was a fluid new world distinct from the old physical world, Boelter Hall struck me as a place where the two met, forming an unusually visible seam. Except the essence I sought was diluted by the evolution of the thing that it created. Here was the shiny new device, connected everywhere; there was the ancient machine in the wood case, smelling of mildew. What, really, was the difference? The IMP

here was the real thing: not a replica or a model—or a digital image. That's why I was here: to hear the details from Kleinrock himself and note the color of the walls, but also to thumb my nose at the immediate reproducibility of everything else. The place itself couldn't be blogged and reblogged—and I confess that I was a little drunk on the irony of that. In his 1936 essay, "The Work of Art in the Age of Mechanical Reproduction," Walter Benjamin describes the fading importance of an object's "aura," its unique essence; and here I was in search of the aura of the thing that threatened to destroy the idea of "aura" once and for all.

I asked Kleinrock about this: Why isn't *essence* a word we typically talk about in the context of the Internet itself? It's more often the opposite that thrills us: the network's ease at instant reproduction, its ability to make things "viral," with the consequence of threatening not only the aura but also our desire for it—leading us to watch a concert through a smartphone screen. "For the same reason people don't know when it was created or where it started, or what the first message was," he said. "It's an interesting psychological and sociological commentary that people are not curious about it. It's like oxygen. People don't ask where oxygen comes from. I think the students today miss a lot because they don't take things apart. You can't take this apart"—he rapped his new laptop. "Where's the physical experience? Unfortunately it's gone. They have no idea how this thing works. When I was a kid building radios I knew what I was dealing with; I knew how things worked and why they worked that way." The lab then in progress in room 3420 was an exception, the one time the computer science students got their hands dirty.

I asked Kleinrock about some of the mementos lying around his office. From a small gray archival box resting on top of a file cabinet he pulled out the original log recording the moment when UCLA's IMP first connected with IMP #2, installed at Stanford Research Institute, late on the Wednesday evening of October 29, 1969. The notebook was tan, with "IMP LOG" written in sloppy marker on its cover. You can see it on Kleinrock's website, of course. "That's the most precious document on the Internet," he said. "There is someone putting together these archives now, and they shoot me every time I touch this. They're the ones who gave me this box." He opened it up and began to read the entries:

SRI called, tried debug test, but it didn't work.

Dan pushed some buttons.

"The important one is here—October twenty-ninth. I shouldn't be touching these pages, but I can't resist! There it is." In blue ballpoint pen, the words running over two lines and beside the time code 22:30, was written:

Talked to SRI host to host.

It is the sole documentary evidence of the ARPANET's first successful transmission between sites—the moment of the Internet's first breath. I nervously kept my hands in my lap. "If anybody comes to steal it, here it is!" Kleinrock said. "There's also a copy of my dissertation."

Then he turned nostalgic. "In those early days, none of us had any idea what it would become. I had a vision, and I got a lot of it right. But what I missed was the social side—that my ninety-nine-year-old mother would be on the Internet when she was alive. That part eluded me. I thought it was going to be comput-

ers talking to computers or people talking to computers. That's not what it's about. It's about you and me talking."

I reminded him that we had closed up the IMP to let the smell "cook up," and we again crossed the hall to pay our respects. Kleinrock opened the cabinet. "Here," he said. "Yeah. Mmmm. Get your nose down there." I leaned in, as if toward a flower. "Smell that? There are components here, there's rubber. This is the stuff when I was a kid I used to cannibalize old radios, with vacuum tubes, and I would smell the solder a lot, the resin." I recalled the electronics class I took as a third grader, after school. We made LEDs that blinked in a pattern. I spend my days connected to electronic machines but I'd hardly smelled it since.

"You can't record that," Kleinrock said. "Yet. One day you will."

The Internet's adolescence was protracted. From the ARPANET's birth at UCLA in 1969 until the mid-1990s, the network of networks crept slowly outward from universities and military bases to computer companies, law firms, and banks, long before it found its way to the rest of us. But in those long early years there really wasn't much of it to speak of. For a quarter century, Kleinrock and his colleagues were like explorers, staking the flag of the nascent Internet on a series of far-flung colonies, connected only tenuously with one another, and often not at all with their immediate surroundings. The Internet was thin on the ground.

The early maps of the ARPANET frequently published by Bolt, Beranek and Newman show just how thin. They look like constellation charts. In each version, an outline drawing of the

United States is overlaid with black circles indicating each IMP, linked by razor-straight lines. The ARPANET began life as the Little Dipper, scooping up a piece of California, its handle in Utah. By the summer of 1970, it had expanded east across the country to add MIT, Harvard, and Bolt's Cambridge offices. Washington didn't appear until the following fall. By September 1973, the ARPANET went international, with the establishment of a satellite link to University College London. By the end of the decade, the network's geography was fully entrenched around four regions: Silicon Valley, Los Angeles, Boston, and Washington. New York City hardly appeared at all, with only NYU winning a colony. Only a few scattered nodes dotted the middle of the United States. True to its philosophical roots as a doomsday-era communications system, the ARPANET was strikingly deurbanized and decentralized. It had no special places, no monuments. Physically speaking, there were IMPs like the one down the hall from Kleinrock's office, linked by always-on phone connections provided under special terms by AT&T. It existed in spare classrooms of university computer science departments, within outbuildings on military bases, and across the copper lines and microwave links of the existing telephone network. The ARPANET wasn't even a cloud. It was a series of isolated outposts strung together by narrow roads, like a latter-day Pony Express.

No doubt there was serious research going on, but the ARPANET's use as a communications tool retained an air of novelty. In September 1973, a conference at Sussex University, in Brighton, England, brought together computer scientists from around the world who were each developing their own government-

sponsored computer networks. Since the ARPANET was the largest, a special demonstration link was established back to the United States. It hadn't been an easy thing to arrange. A telephone line had to be activated between one of the ARPANET nodes in Virginia and a nearby satellite antenna. From there, the signal was bounced off an orbiting satellite to another earth station in Goonhilly Downs in Cornwall, then onward through a telephone link to London, and finally into Brighton. It was less a technological marvel than what engineers like to call a "kludge," a temporary and tenuous link across the ocean.

But history remembers it for more prosaic reasons. In a story that has become legend, when Kleinrock arrived home in Los Angeles from the conference, he realized he'd forgotten his electric razor in the Sussex dormitory bathroom. Logging into the ARPANET from his UCLA computer terminal, he entered the command WHERE ROBERTS, which told him if his friend Larry Roberts—a well-known workaholic and insomniac—was logged in as well. Sure enough he was, wide awake at 3:00 A.M. Using a rudimentary chat program—"clickety clickety clack," as Kleinrock describes it—the two friends made arrangements to send home the razor. That kind of communication was "a bit like being a stowaway on an aircraft carrier," as the historians Katie Hafner and Matthew Lyon describe it.

The 1970s ARPANET was US government property, linking defense researchers either within the military itself or at ARPA-funded university departments. But socially the ARPANET was a small town. The 1980 edition of the ARPANET directory is a canary-colored perfect-bound book, about the thickness of a fall fashion magazine. It lists the five-thousand-odd names of ev-

everyone on the ARPANET, with their postal addresses, the lettered code for their nodes, and their email addresses—absent the “.com” or “.edu,” which wouldn’t be invented for another few years. Kleinrock is in there, of course, with the same office address and phone number as today (although his area code, zip code, and email address have all changed). Sharing the page with him are computer scientists at MIT, University College London, and the University of Pennsylvania; a commander at the Army Communications Research and Development Command at Fort Monmouth, New Jersey; and the chief of the Strategic Studies Programming Division at Offutt Air Force Base in Nebraska—famous as the manufacturing site of the *Enola Gay*, the primary Cold War-era nuclear command center, and the place at which President Bush temporarily sought refuge on 9/11.

The ARPANET was like that: an accidental meeting place for academics and high-tech soldiers, brought together under the umbrella of computer networking. Inside the front flap of the directory is a logical map of the ARPANET, with each node labeled in tiny print and connected together with thick and thin straight lines, like an elaborate and convoluted flowchart. Every computer on the ARPANET fits easily on the page. But that intimacy wouldn’t last.

By the early 1980s, the big computer companies—like IBM, XEROX, or Digital Equipment Corporation—and large government agencies—like NASA and the Department of Energy—were running their own independent computer networks, each with its own acronym. High-energy physicists had HEPnet. Space physicists had SPAN. Magnetic fusion researchers had MFENET. A handful of European networks had also emerged,

including EUnet and EARN (the European Academic Research Network). And there were a growing number of regional academic networks, named like the twelve sons of Mr. and Mrs. Net: BARRNet, MIDnet, Westnet, NorthWestNet, SESQUINet.

The trouble was, all those networks weren’t connected. While stretching nationwide and occasionally across the ocean, they operated in effect as private highways overlaid on the public telephone system. They overlapped geographically, sometimes serving the same university campuses. And they even might have overlapped physically, sharing the very same long-distance telephone cables. But in networking terms they were “logically” distinct. They were disconnected—as separate as the sun and the moon.

That remained the case until New Year’s Day 1983 when, in a transition years in the planning, all the host computers on the ARPANET adopted the electronic rules that remain the basic building block of the Internet. In technical terms, they switched their communications protocol, or language, from NCP, or “Network Control Protocol,” to TCP/IP, or “Transmission Control Protocol/Internet Protocol.” This was the moment in the Internet’s history when the child became father to the man. The changeover, led by the engineers at Bolt, Beranek and Newman, kept dozens of system administrators tied to their desks on New Year’s Eve, struggling to make the deadline—leading one to commemorate the ordeal by making I SURVIVED THE TCP/IP TRANSITION buttons. Any node that did not comply was cut off until it did. But once the dust had settled several months later, the result was the computing equivalent of a single international language. TCP/IP went from a dominant dialect to an official lingua franca.

As the historian Janet Abbate notes, the changeover marked not just an administrative shift but a crucial conceptual one: "It was no longer enough to think about how a set of *computers* could be connected; network builders now also had to consider how different *networks* could interact." The ARPANET was no longer a walled garden with an official government directory of participants, but rather had become just one network among many, linked together into an "Internetwork."

The New Year's 1983 standardization of TCP/IP permanently fixed the Internet's distributed structure, ensuring to this day its lack of central control. Each network acts independently, or "autonomously," because TCP/IP gives it the vocabulary to *inter-*act. As the author and Columbia law school professor Tim Wu points out, this is the founding ideology of the Internet, and it has clear similarities with other decentralized systems—most notably the federal system of the United States. Because the early Internet ran on the existing wires of the telephone network, its founders were forced "to invent a protocol that took account of the existence of many networks, over which they had limited power," Wu writes. It was "a system of tolerated difference—a system that recognized and accepted the autonomy of the network's members."

But while this autonomy came about because of the infrastructure the Internet was given, it soon became the crucial force shaping the infrastructure the Internet made. Winston Churchill said about architecture that "we shape our buildings, and afterwards our buildings shape us," and the same is true of the Internet. With TCP/IP in place and new autonomous networks popping up with increasing frequency, the Internet grew

physically, but haphazardly. It took shape in ad hoc ways, like a city, with a loose structure giving way to spontaneous, organic growth. The Internet's geography and shape weren't drawn up in some central AT&T engineering office—as the telephone system was—but rather arose out of the independent actions of first hundreds, and later thousands, of networks.

With TCP/IP in place, the Internet—more or less as we know it today—had arrived, and a remarkable period of growth began. In 1982, there were only 15 networks, or "autonomous systems," on the Internet, meaning they communicated with TCP/IP; by 1986 there were more than 400. (In 2011, there were more than 35,000.) The numbers of computers on those networks ballooned even faster. In the fall of 1985, there were 2,000 computers with access to the Internet; by the end of 1987 there were 30,000, and by the end of 1989 there were 159,000. (In 2011, there were 2 billion Internet users, with their hands on even more devices.) The Internet, which had for nearly twenty years been a college town called the ARPANET, had begun to feel more like a metropolis. If before you could imagine each router as a cloister on a quiet mountaintop, the incredible growth in the number of machines meant that those routers were now piling up near one another, forming villages. Some of those villages were even beginning to reveal the vague promise of a skyline. For me, it's the most exciting moment of this early history: the Internet was becoming a place.

Toward the end of the 1980s a handful of companies began to build their own long-distance data highways, or "backbones," and city streets, or "metropolitan" networks. But strike from your mind any images of bulldozers steaming across the Penn-

sylvania countryside laying cable—although those would come soon enough. These early long-distance and local networks still worked across the existing phone lines, with specialized equipment installed on either end. By the early 1990s, the trickle became a wave, as companies like MCI, PSI, UUNet, MFS, and Sprint attracted increasing investment dollars—and used them to dig their own trenches and fill them with the new technology of fiber optics, which had been commercialized in the 1980s. The network of networks was accumulating an infrastructure of its own. It began to colonize key places around the world—indeed, the places where it still predominantly exists: suburban Virginia and Silicon Valley, California; London's Docklands district; Amsterdam, Frankfurt, and downtown Tokyo's Otemachi district. The Internet had propagated to the point of becoming visible to the naked eye, becoming a real landscape all its own. What for the first twenty years of the Internet's existence were easy to dismiss as in-between spaces—telecom closets and spare classrooms—now had character. By the mid-1990s the wave of construction became a torrent, and "broadband" became one of the most infamous bubbles in American economic history. Yet it was that spending, as overheated and economically destructive as it was, that built the Internet we use today.

In 1994, I was finishing high school, logging long hours on the family Macintosh, endlessly tying up the phone exploring the message boards and chat rooms of America Online. Then sometime that winter my father brought home a small 3.5-inch disk loaded with a new program called "Mosaic"—the first web browser. On a sunny weekend morning, sitting at the dining room table, my physics homework pushed to the side, a long telephone

cord strung across the room, we listened as the screeching tones of the modem signaled a connection with a distant computer. My mother looked disapprovingly over the top of her newspaper. On the screen, rather than the America Online menu, with its short list of choices, there was a blinking cursor inside an empty "address bar"—the ur-starting point for all our digital journeys.

But where to go? At that point, the options were limited. Few organizations had websites—only universities, a few computer companies, the National Weather Service. And how did one know where to find them? There was no Google, Yahoo!, MSN, or even Ask Jeeves. Unlike the walled enclosure of AOL, unlike any other computer I'd ever used, it felt as open-ended as the world. The sensation was distinct: it felt like travel. I wasn't alone in the thrill. That was a heady season for the Internet. Netscape released its web browser in October, as Microsoft ramped up the advertising campaign for its own "Internet Explorer." The Internet was about to go mainstream, once and for all. The roof was about to blow off.

But which roof, really? The boom would strain the Internet's existing infrastructure to the breaking point. So who would save it? How did it expand? To where? I'd heard the business stories of the dot-com boom, about how Jim Clark and Marc Andreessen founded Netscape, and Bill Gates battled to keep Internet Explorer an integral part of Microsoft's Windows operating system. But what about the networks themselves, and their places of connections? In a business that's always been obsessed with the next new thing, who was still around to tell that story?

I went back to California—only to hear about Virginia.

On a characteristically damp and gray San Francisco day, I met a network engineer named Steve Feldman at a café a few blocks from his office, in the heart of the cluster of Internet companies located south of Market Street. He looked like a high school math teacher, with khaki pants, sturdy brown walking shoes, and a big beard. His office ID hung around his neck from a lanyard embroidered with NANOG, the North American Network Operators' Group—the clubby association of engineers who manage the biggest Internet networks, and whose steering committee Feldman chairs. These days his job is to run the data network for CBS Interactive, making sure, among other things, that the latest episode of *Survivor* or the NCAA basketball game is properly streamed to your screen. (Even if he wasn't a fan himself.) But for a time in the '90s, Feldman ran the Internet's single most important place, a global crossroads improbably located in the parking garage of an office building in a suburb of Washington, DC. It was a thrilling moment in the Internet's evolution—for a while. By the end, things had gotten out of control.

We sat down between two young guys pecking away at laptops, their heads in the cloud. Our conversation must have sounded strange to them; it was all such ancient history. In 1993, Feldman—a graduate of the computer science department at Berkeley—went to work for a young networking company called MFS Datanet, which had started out laying fiber in Chicago's coal tunnels, and had more recently been building private networks linking corporate offices together, mostly piggybacking on existing phone lines. MFS wasn't providing Internet access itself, only helping companies with their internal networks, but it had

gotten good at doing so across a city—which was exactly what the handful of companies that were providing Internet access needed. They had a problem. At the time, the de facto backbone of the Internet was run by the National Science Foundation and known as NSFNET, but technically the commercial companies were prohibited from using it by the “acceptable use policy,” which in theory limited traffic to academic or educational purposes. To grow, the commercial providers had to find a way to exchange traffic across their own private roads, in order to avoid traversing that government-run highway. That meant connecting to one another—physically. But where?

Business was booming for everybody, but the whole endeavor was threatened by an absence of real estate. Where could they connect? Quite literally: Where was a cheap place with plenty of electricity where the engineers could string a cable from the router of one network to the router of another?

The Virginia suburbs west of Washington, DC, were already a hot spot for many of the early commercial Internet providers, mainly due to the concentration of military contractors and high-tech companies in the area. “It was the technology center,” Feldman told me. For a time, a few of the early Internet providers interconnected their networks inside a Sprint building in northwest Washington, but it was an imperfect solution. Sprint didn't like its competitors setting up shop inside its building (especially when Sprint didn't have a business setup to properly charge them for it). And for the Internet providers themselves—companies like UUNET, PSI, or Netcom—it was expensive to be there, because of the cost of leasing local data lines back to their own office or network POP (or “point of presence”).

MFS offered a solution: it would turn its offices into a hub. The company already had plenty of existing local data lines, which it would use to tether each of the Internet providers, like dancers around a maypole. MFS would then provide a switch, called a Catalyst 1200, that would route traffic between the networks. It wasn't merely a local road; it was a roundabout. By plugging into this hub, each network would have immediate and direct access to all the other participating networks, no highway tolls required. But for the plan to be viable a handful of the Internet providers had to commit simultaneously—or else it would be a roundabout in the middle of nowhere. A group of them made the decision over lunch one day in 1992 at the Tortilla Factory in Herndon, Virginia. At the table were Bob Collet, who ran Sprint's network; Marty Schoffstall, cofounder of PSI; and Rick Adams, founder of UUNET (who would later make hundreds of millions of dollars taking it public). Each of these networks operated independently, but they knew full well they were useless without one another. The Internet was still for hobbyists—an eccentric subset of the population, composed mostly of people who had used the network in college and wanted to keep going. (In the United States, the percentage of households with access to the Internet wasn't measured at all until 1997.) But the growth trend was clear: for the good of the Internet—really if there were to *be* a functioning nonacademic Internet at all—the networks had to act as one. MFS called its new hub a “Metropolitan Area Exchange.” To indicate its ambition to build several of them around the country, it nicknamed the hub MAE-East.

It took off immediately. “MAE-East was so popular that we were outgrowing the technology faster than we could upgrade

it,” Feldman said. When a new Internet service provider sprang into existence, its customers would mainly call in over a regular telephone line using a modem. But then the provider had to connect to the rest of the Internet (as Jon Auer did in Milwaukee). And for a time, MAE-East was it. “If you connected to MAE-East, you’d have the entire Internet at your doorstep,” Feldman said. “It was the *de facto* way into the Internet business.” Within a couple years, MAE-East was the crossroads for fully half of all the world’s Internet’s traffic. A message from London to Paris most likely went through MAE-East. A physicist in Tokyo querying a website in Stockholm went through MAE-East—on the fifth floor of 8100 Boone Boulevard in Tysons Corner, Virginia.

It was a portentous location. The intersection of the Leesburg Pike and Chain Bridge Road may have been the crossroads of the digital world, but it was also conspicuously close to the crossroads of American espionage—overhanging MAE-East with an ongoing fog of mystery, suspicion, even conspiracy.

Tysons Corner is one of the highest points in Fairfax County, at five hundred feet above sea level. During the Civil War, the Union army took advantage of its views back toward Washington and out toward the Blue Ridge Mountains, and erected a signal tower there, pillaging timber for its construction from nearby farms. A century later, at the start of the Cold War, the US Army built a radio tower on the same spot and for the same reason: to relay communications between headquarters in the capital and distant military posts. A military tower still stands on the site, a red-and-white steel skeleton looming above a busy suburban crossroads, ringed by a protective fence with a sternly worded sign prohibiting photographs. Heightening the place’s mysteri-

ousness, shortwave radio hobbyists have fingered the tower as a source of the “numbers stations”—radio broadcasts of an endless cadence of spoken digits. If the professional spook commentators are to be believed, far-flung spies tune in at specified times to receive coded communiqués from headquarters. According to Mark Stout, a historian at the International Spy Museum, the single-use codebooks the system uses are uncrackable. “You really truly cryptanalytically have no traction getting into a one-time pad system,” he says. “None at all.”

Indeed, if counterespionage were your gig, the rest of Tysons Corner might pose similar challenges. MAE-East isn’t there anymore—or rather, whatever networking equipment that still is there is no longer a significant center of the Internet—but the neighborhood remains the same. Circling the parking lots, the buildings themselves seem sealed, with perfectly flat glass façades, as if conceived by their architects to be as anonymous as they are impenetrable. The buildings are mostly unmarked, in accordance with the wishes of their low-profile tenants. When they do have signs, they reveal the identities of military contractors: Lockheed Martin, Northrop Grumman, BAE. Many were built with special rooms, known as Sensitive Compartmented Information Facilities, or “skiffs,” designed to meet government criteria for handling classified information.

The most paranoid network engineers—the “tin-foil hat guys,” as they’re known, in reference to the conviction that the only way to keep the government from reading your mind is to wear a helmet made of aluminum foil—took MAE-East’s location as proof of its malevolent government control. Why else would it

be down the road from the CIA? And if it wasn’t the CIA listening in, then it must have been the supersecret National Security Agency systematically tapping everything passing through—a claim repeated in James Bamford’s bestselling 2008 book about the NSA, *The Shadow Factory*. Even today, do any idle googling about MAE-East and the information seems oddly sketchy—written in the present tense, even though its importance is long past; marked in red on satellite photographs with its relation to a nearby CIA facility highlighted; somehow frozen in time. MAE-East remains an international woman—or an international *something*—of mystery.

Alas, it’s all a little overblown. MAE-East’s importance may have begun spontaneously, but it continued bureaucratically. In 1991, the US Congress had passed the High Performance Computing and Communication Act, better known as the “Gore Bill,” named after its original sponsor, then-senator Al Gore. It’s to this that Gore owed his purported claim of having “invented the Internet”—which isn’t as far-fetched as it sounds. *Invent* is undoubtedly the wrong word, but the push from government was crucial in getting the Internet out of its academic ghetto. Among the bill’s provisions was a piece of policy best known by its popular name: the “information superhighway.” But rather than putting shovels in the ground to build it, government policymakers catalyzed private companies to do it for them, by funding the construction of “on-ramps.” A network access point, or NAP, as they called it, would be “a high-speed network or switch to which a number of networks can be connected via routers for the purpose of traffic exchange and interoperation.” It would be

funded with federal dollars, but operated by a private company. An access point, in other words, would be a network that connects networks: a copycat MAE-East.

Feldman responded to the government request for bids with an idea for a fancy new exchange—but the National Science Foundation, which ran the process, said they'd rather just give MFS money to keep MAE-East going. Contracts were eventually awarded for four access points, run by four major telecom players: the Sprint NAP in Pennsauken, New Jersey, just across the Delaware River from Philadelphia; the Ameritech NAP in Chicago; the Pacific Bell NAP in San Francisco; and MAE-East. But Feldman likes to say there were really only three and half, "because we already existed." (And MFS would soon open MAE-West, at 55 South Market Street, in San Jose, California, to compete with the Pacific Bell NAP.) That geography was deliberate. The National Science Foundation knew that to succeed the network hubs needed to serve distinct regional markets, spread evenly across the country. Distance mattered. The original solicitation accordingly identified "California," Chicago, and New York City as "priority locations." The decision to locate the Sprint NAP in a bunker of a building in Pennsauken, ninety miles from New York, was because of the existing facility's links to the transatlantic undersea cables that landed on the New Jersey shore; it was the gateway to Europe.

The opening of the network access points also marked an important philosophical shift, one that would have ramifications for its physical structure. In a clear departure from its original roots, the Internet was no longer structured as a mesh, but rather was entirely dependent on a handful of centers. As the urban

theorist Anthony Townsend has pointed out, "The reengineering of the Internet's topology that was implemented in 1995 was the culmination of a long-term trend away from the idealized distributed network . . . envisioned in the 1960s." As the number of networks increased, their autonomy was best served by centralized meeting points.

But for Feldman the meeting point felt more like a choke point. By 1996, MAE-East was overstuffed with belching, blinking machines, and growing somewhat out of control, however profitably. The original concept had been that each network would house its own router and link into MAE-East over its data lines. A machine evocatively called a FiberMux Magnum would act like the can on one end of a string telephone, changing the signals coming over the line into a form MAE-East's router could understand. But as you might guess, FiberMux Magnums themselves take up space, and the fifth-floor suite at 8100 Boone that housed MAE-East—or you might say that *was* MAE-East—quickly filled up. The situation deteriorated further when networks discovered that they could increase their performance if they chucked the FiberMuxes and installed their actual routers at MAE-East too, in effect making it their new technical office. And it got even more crowded when they discovered performance increased again if they put their servers there as well, so that MAE-East wasn't just the transit point for data, but often its source. Web pages loaded faster for its customers, and it reduced the costs of moving the bits around. But with those changes, MAE-East had transformed from a crossroads to a depot.

It fell to Feldman to find a way to expand. The landlord at 8100 Boone had become impatient with its power-sucking ten-

ant, so soon the many-tentacled apparatus moved into a plasterboard enclosure carved out of the basement parking garage of the building across the street, at 1919 Gallows Road. Air-conditioning units surrounded the bare white walls, hard up against the underground parking spots. A generic hardware store ACCESS RESTRICTED sign marked the door. The undisputed capital of the Internet was decidedly humble, the kind of space where you'd expect to find floor-polishing machines and toilet paper stocks, not the spinal cord of a global information network. MAE-East's location in a parking garage may have seemed like something out of a spy movie—the one where an anonymous door in a dingy corridor opens up to reveal a huge, glistening, high-tech lair. But the high-tech lair was a hovel.

It drove Feldman to distraction. When he wasn't selecting and installing new equipment, managing the connections between networks, and trying to figure out what everybody needed, he was apologizing. Traffic had been doubling every year, far outpacing what the router technology could handle, not to mention the real estate. The Internet was clogged. At every meeting of the North American Network Operators' Group, Feldman would be asked to stand up in front of his colleagues and explain why the crossroads of the Internet, his crossroads, was perpetually jammed. It wasn't an easy crowd. "People in the NANOG community say what they're thinking," Feldman said. "And they don't pull punches." At one meeting, ultimately exasperated by the complaints, Feldman taped a paper bull's-eye to his chest before taking the stage. There was no getting around it: the model was broken. The Internet needed a new kind of place.

By 1997, 20 percent of American adults were using the Inter-

net—up from nearly zero a few years before. The Internet had proven its usefulness. But it was unfinished, unrealized. Some of the needed pieces were obvious: there had to be new high-capacity long-distance lines between cities; software tools that would enable "e-commerce" and online videos; and new devices that could connect to the Internet faster and more flexibly. But beneath all that was an unmet mechanical need, an unbuilt room in the Internet's basement: Where could all the networks connect? They came up with the answer down the road, in the heart of Silicon Valley—in a basement, in fact.

"A cable? To Brazil?" he asked.

"Africa," Carrilho replied.

The commuter raised his eyebrows, shook his head, and went home to dinner. For the people of this seaside village, this was a temporary disruption, a few days of bulldozers on the beach and some extra trucks in the municipal lot. By the end of the week, the manhole would be covered, and the cable to Africa would be forgotten under the sand.

Where Data Sleeps

The Dalles, Oregon, has always been a special kind of cross-roads, a place where geography has repeatedly forced the hand of infrastructure. Its odd name—it rhymes with neither "balls" nor "bells"—comes from the French word for "flagstone" and refers to the rocks in the mighty Columbia River, which narrows here before plunging through the great gap in the Cascade Range known as the Columbia River Gorge. Everything here has followed from that.

When Lewis and Clark arrived in 1805 on their exploration of the west, they found the largest Native American gathering place in the region. During the annual salmon runs, the population swelled to nearly ten thousand, about the same size as the town today. For a while the Oregon Trail ended in The Dalles, where western settlers faced the uncomfortable choice of mule-packing

around 11,249-foot-tall Mt. Hood, or braving the Columbia's rapids. The Dalles was the choke point in the path of western migration. It still is.

From my motel room the landscape looked like a battlefield between geology and industry. In the backdrop were the lumpy tan foothills of the Cascades, covered in wisps of fog on a rainy late-winter day. In the near distance was the Union Pacific rail yard, where freight trains stopped and stuttered before descending through the modern alignment that hugs the basalt cliffs of the gorge. Parallel to the tracks is Interstate 84, the first major east/west route across the mountains until Interstate 80 in California, nearly six hundred miles to the south. Truck traffic rushed by all night, heading west to Portland, or east toward Spokane, Boise, and Salt Lake. The river itself was wide and gurgly. I watched cars streaming antlike across the Dalles Bridge, just downstream from the Dalles Dam, a small piece of the vast hydroelectric system built by the Army Corps of Engineers and marketed by the Bonneville Power Administration, whose high-tension lines lace the hills. The Dalles is a key node in the power grid of the entire western United States. Most notably, it is the starting point for a 3,100-megawatt transmission path, known as the Pacific DC Intertie, which transfers hydroelectric power from the Columbia River basin to Southern California, like a massive extension cord dragged up from Los Angeles. Its plug is the Celilo Converter Station, just over the hill from my motel room. The Dalles might be a small place but you wouldn't say it's off the beaten path. It *is* the beaten path: an infrastructural confluence, where the inescapable topography of the Cascades and the Columbia River

have forced together salmon, settlers, railroads, highways, power lines, and, as it turns out, the Internet.

I had come to The Dalles because it is home to one of the Internet's most important repositories of data, as well as being the de facto capital of a whole region devoted to storing our online selves. The place struck me as a sort of Kathmandu for data centers, a foggy town at the base of a mountain that happened to be the perfect jumping-off point for an exploration of the massive buildings where our data is stored. Even better, The Dalles was mysterious and evocative enough—a natural nexus—to highlight these buildings' strange powers. A data center doesn't merely contain the hard drives that contain our data. Our data has become the mirror of our identities, the physical embodiment of our most personal facts and feelings. A data center is the storehouse of the digital soul. I liked the idea of data centers tucked away up in the mountains like wizards—or perhaps warheads. And Kathmandu felt right in another way: I was looking for enlightenment, for a new sense of my digital self.

Up until now I'd focused mainly on exchange points: the Internet's central hubs, the places where networks meet to become an Internetwork. My mind had filled with accumulated images of corrugated steel buildings, yellow fiber-optic cables, and basement vaults. But data centers presented a different challenge on this journey. They seemed to be everywhere. As I considered this, a more schematic image of the Internet came to mind, of two funnels fused at their narrow ends, like a siamese vuvuzela. The exchanges sit at the narrow spot in the middle. There aren't very many of them, but they are the choke points for the vast

majority of traffic. One funnel pulls in all of us: the billions of “eyeballs” scattered around the world. The other funnel catches the buildings where our data is stored, processed, and served. Data centers are what’s on the other end of the tubes. They’re only able to exist in faraway places thanks to the thicket of networks everywhere else.

It used to be that we kept our data on our (actual) desks, but as we’ve increasingly given up that local control to far-off professionals, the “hard drive”—that most tangible of descriptors—has transformed into a “cloud,” the catchall term for any data or service kept out there, somewhere on the Internet. Needless to say, there is nothing cloudlike about it. According to a 2010 Greenpeace report, 2 percent of the world’s electricity usage can now be traced to data centers, and that usage is growing at a rate of 12 percent a year. By today’s standards, a very large data center might be a 500,000-square-foot building demanding fifty megawatts of power, which is about how much it takes to light a small city. But the largest data center “campus” might contain four of those buildings, totaling more than a million square feet—twice the size of the Javits Center in New York, the same as ten Walmarts. We’ve only just begun building data centers, and already their accumulated impact is enormous.

I know this intuitively, because a lot of this data is mine. I have gigabytes of email storage in a data center in Lower Manhattan (and growing every day); another sixty gigabytes of online backup storage in Virginia; the cumulative traces of countless Google searches; a season’s worth of episodes of *Top Chef* downloaded from Apple; dozens of movies streamed from Netflix; pictures on Facebook; more than a thousand tweets and a couple

hundred blog posts. Multiply that around the world and the numbers defy belief. In 2011, Facebook reported that nearly six billion photos were uploaded to the service every *month*. Google confirms at least one billion searches per day—with some estimates tripling that number. All that has to be processed and stored somewhere. So where does it all go?

I was less interested in the aggregate statistics than in the specifics, the parts of all this online detritus that I could touch. I knew that data centers which once occupied closets had expanded to fill whole floors of buildings; that floors had grown into subdivided warehouses; and that warehouses have transformed into purpose-built campuses, as in The Dalles. What had before been afterthoughts, physically speaking, had now acquired their own architecture; soon, they’d need urban planning. A data center was once like a closet, but now was more like a village. The ever-increasing size of my own appetite for the Internet made it clear why. What was less clear to me was where. What were these enormous buildings doing way up on the Columbia Plateau?

The Internet’s efficiency at moving traffic—and the success of exchange points at serving as hubs for that traffic—has left the question of where data sleeps remarkably open-ended. When we request information over the Internet, it has to come from somewhere: either another person or from the place where it’s being stored. But the everyday miracle of the Internet allows all that data to, in theory, be stored anywhere—and still the stuff will find its way back to us. Accordingly, for smaller data centers, convenience rules: they are often close to their founders or their customers, or whoever finds a need to visit them to tweak the machines. But as it happens, the bigger a data center gets,

the thornier the question of location becomes. Ironically for such massive, factory-like buildings, data centers can seem quite loosely connected to the earth. But still they cluster.

Dozens of considerations go into locating a data center, but they almost all come down to making it as cheap as possible to keep a hard drive—much less 150,000 of them—spinning and cool. The engineering of the building itself, especially how its temperature is controlled, has a huge impact on its efficiency. Data center engineers compete to design buildings with the lowest “power usage effectiveness,” or “PUE,” which is sort of like the gas mileage in a car. But among the most important external variables in a good PUE is a building’s location. Just as a car will get better gas mileage in a flat, empty place compared with a hilly city, a data center will run more efficiently where it can draw in outside air to cool its spinning hard drives and powerful computers. But because data centers *can* be anywhere, seemingly small differences become amplified.

Siting a data center is like the acupuncture of the physical Internet, with places carefully chosen with pinpoint precision to exploit one characteristic or another. As competitive companies thrust and parry for advantage, it becomes clear that some places are better than others, and the result is geographic clusters. The largest data centers begin piling up in the same corners of the earth, like snowdrifts.

Michael Manos has built more data centers than perhaps anyone—by his count around a hundred, first for Microsoft and later for Digital Realty Trust, a major wholesale developer. He is a big, fair-skinned, good-humored guy and he talks a mile a minute, like John Candy playing a commercial real estate agent.

That suits the data center game, which is about finding a deal and driving your stake. When he joined Microsoft in 2005, the company had about ten thousand servers spread out in three separate facilities around the world, running their online services like Hotmail, MSN, and Xbox games. By the time Manos left four years later, he had helped expand Microsoft’s footprint to “hundreds of thousands” of servers spread around the world in “tens” of facilities—“But I still can’t tell you how many,” he told me. The number was still a secret. It was an expansion of unprecedented scale in Microsoft’s history, and one that to this day has been matched only by a handful of other companies. “Not a lot of people on the planet are dealing with these size and scale issues,” Manos said. Even fewer have scoured the world as Manos has.

At Microsoft, he built a mapping tool that considered fifty-six different criteria to generate a “heat map” indicating the best location for a data center, shaded from green (for good) to red (for bad). But the trick was getting the scale right. At the state level, a place like Oregon looked horrible—mainly because of environmental risks, like earthquakes. But when he zoomed in, the story changed: the earthquake zone is on the western side of the state, while central Oregon has the benefit of being cold and dry—perfect for cooling hard drives using outside air. Surprisingly, what got almost no weight in the equation was the cost of the land itself, or even the cost of the actual building. “If you look at the numbers, eighty-five-ish percent of your cost is in the mechanical and electrical systems inside the building,” Manos explained. “Roughly seven percent, on average, is land, concrete, and steel. That’s nothing! People always ask me, ‘Is it better to

build small and tall or big and wide?' It doesn't matter. At the end of the day, real estate and the biggest construction costs are literally not an issue for most of these buildings. All your cost is in how much gear can you stick in your box." And then, of course, how much it costs to plug it in—what data center people call "op-ex," the operating expenses. "A data center guy is always looking for two things," Manos said. "My wife used to think I was always looking at the scenery, but actually I was looking at the power lines, and for fiber hanging from those power lines." In other words, he was looking for the view outside my window in The Dalles.

Beginning in the late 1990s, the Bonneville Power Administration had begun mounting fiber-optic cables along its long-haul transmission lines, an amazing network that crisscrossed the Northwest and came together in The Dalles. It was a tricky job, often requiring helicopters to string cable on high towers in rough country, and while the power company's leaders' primary goal was improving internal communications, they saw it was only incrementally more expensive to install extra fiber—far more, in fact, than they needed for the company's own use. To the strenuous objection of the telecommunications companies, who didn't believe a government-subsidized utility should be competing with them, the BPA soon began leasing that extra fiber out. It was a big, robust communications system, a regional sweep of heavy-duty fiber protected from errant backhoes on its perch high up on the power lines—catnip for data center developers.

Microsoft tapped into it from a town called Quincy, up the road from The Dalles in Washington State. "It was the greenest spot in the United States for us," Manos said, referring to his heat

map, rather than trees or environmental considerations. Like The Dalles, Quincy was near the Columbia River and nestled in the tangle of the Bonneville Power Administration's power and fiber infrastructure. Not surprisingly, Microsoft wasn't alone for long. Soon after breaking ground on its 470,000-square-foot, 48-megawatt data center (since joined by a second building), what Manos calls the "Burger King people" showed up—the second movers, the companies who wait until the market leader has built in a particular location, and then build next to them. In Quincy, these included Yahoo!, Ask.com, and Sabey, a wholesale data center owner. "Within eighteen months, you had this massive, almost three billion dollars' worth of data center construction going on in a town that was predominantly known for growing spearmint, beans, and potatoes," Manos said. "When you drive through downtown now, it's just big, giant, open farm fields and then these massive monuments of the Internet age sticking out of these corn rows." Meanwhile, down the road in The Dalles, one of Microsoft's biggest competitors was writing its own story.

The Dalles had been a crossroads for centuries, but around 2000, at the crest of the broadband boom, it seemed as if the Internet was passing it by. The Dalles was without high-speed access for businesses and homes, despite the big nationwide backbones that tore right through along the railroad tracks, and the BPA's big network. Worse, Sprint, the local carrier, said the city wouldn't get access for another five to ten years. "It was like being a town that sits next to the freeway but has no off-ramp," was how Nolan Young, the city manager, explained it to me in

his worn office, grand but fluorescent lit like a high school principal's, inside the turn-of-the-century Dalles City Hall. Wizen and soft-spoken, with a hobbitlike pitch to his voice, Young had shrugged at the sight of my tape recorder. Like any veteran politician, he was used to nosy journalists—although more than a small town's share had been through here recently.

The Dalles had felt the brunt of the industrial collapse of the Pacific Northwest, and the Internet's neglect added insult to injury. "We said, 'That's not quick enough for us! We'll do it ourselves,'" Young recalled. It was an act of both faith and desperation—the ultimate "if you build it they will come" move. In 2002, the Quality Life Broadband Network, or "Q-Life," was chartered as an independent utility, with local hospitals and schools as its first customers. Construction began on a seventeen-mile fiber loop around The Dalles, from city hall to a hub at the BPA's Big Eddy substation, on the outskirts of town. Its total cost was \$1.8 million, funded half with federal and state grants, and half with a loan. No city funds were used.

The Dalles's predicament was typical of towns on the wrong side of the "digital divide," as politicians call poorer communities' lack of access to broadband. The big nationwide backbones were quickly and robustly built, but they often passed through rural areas without stopping. The reasons were both economic and technological. Long-distance fiber-optic networks are built in fifty-odd-mile segments, which is the distance light signals in fiber-optic cables can travel before needing to be broken down and reamplified. But even at those "regeneration" points, siphoning off the long-distance signals for local distribution requires expensive equipment and a lot of person-hours to set up.

High-capacity, long-distance fiber-optic networks are therefore cheaper to build and to operate if they zoom straight through on their path between hubs. And even if they can be induced to stop, a small town doesn't have the density of customers needed to push it up the priority list of construction projects for a national company, like Sprint. A "middle mile" network bridges that gap, by laying fiber between a town and the nearest regional hub, connecting small local networks to the long-distance backbones. Network engineers call this the "backhaul," and there's no Internet without it. Q-Life was a textbook example of the middle mile—although in The Dalles, the middle mile was actually closer to four miles, from the center of town to the Big Eddy substation, where the BPA's fiber converged.

Once Q-Life's fiber was in place, local Internet service providers quickly swooped in to offer the services Sprint wouldn't. Six months later, Sprint itself even showed up—quite a lot sooner than its original five-year timeline. "We count that as one of our successes," Young said. "One could say they're our competitors, but now there were options." But the town couldn't have predicted what happened next. At the time, few could have. The Dalles was about to become home to the world's most famous data center.

In 2004, just a year after the Q-Life network was completed, a man named Chris Sacca, representing a company with the suspiciously generic name of "Design LLC," showed up in The Dalles looking for shovel-ready sites in "enterprise zones," where tax breaks and other incentives were offered to encourage businesses to locate there. He was young, sloppily dressed, and interested in such astronomical quantities of power that a nearby

town had suspected him as a terrorist and called the Department of Homeland Security. The Dalles had a site for him, thirty acres next to a decommissioned aluminum smelter that itself once drew eighty-five megawatts of power—more than the everyday needs of a city many times its size.

As negotiations began, Sacca wanted total secrecy, and Young started signing nondisclosure agreements. The cost of the land itself wasn't much at issue (as Manos could have predicted). It was all about power and taxes. The local congressman was called in to help convince the Bonneville Power Administration to steepen its discounts. The governor had to approve the fifteen-year tax break Design LLC demanded, given the hundreds of millions of dollars of equipment it planned to install in The Dalles. But any reasonably sized community in Oregon might have come up with the power and the incentives. The ace in the hole that made Design LLC's heat map glow bright green over The Dalles was of the town's own making: Q-Life. "It was visionary—this little town with no tax revenues had figured out that if you want to transform an economy from manufacturing to information, you've got to pull fiber," Sacca later said. In early 2005, the deal was approved: \$1.87 million for the land and an option for three more tracts. But still Young had to keep the secret, even after construction began. "I had signed so many agreements that there was a point when I was standing at the site, and someone said, 'I see they're building . . . rrrggrrr . . . there.' And I said, 'What, I don't see anything!'" But the secret's out now: Design LLC was Google.

It's become a cliché that data centers adhere to the same rules

as the secret cage matches in the movie *Fight Club*: "The first rule of data centers is don't talk about data centers." This tendency toward the hush-hush often bleeds into people's expectations about the *other* types of the Internet's physical infrastructure, like exchange points—which are actually quite open. So why all the secrecy about data centers? A data center is a storehouse of information, the closest the Internet has to a physical vault. Exchange points are merely transient places, as Arnold Nipper pointed out in Frankfurt; information passes through (and fast!). But in data centers it's relatively static, and physically contained in equipment that needs to be protected, and which itself has enormous value. Yet more often the secrecy isn't because of concerns over privacy or theft, but competition. Knowing how big a data center is, how much power it uses, and precisely what's inside is the kind of proprietary information technology companies are eager to keep under wraps. (And indeed, Manos and Sacca very well might have run into each other, crisscrossing the Columbia River Valley in search of a site.) This is especially true for data centers built and owned by single companies, where the buildings themselves can be correlated to the products they offer. A culture of secrecy developed in the data center world, with companies fiercely protecting both the full scope of their operations, and the particularities of the machines housed inside. The details of a data center became like the formula for Coke, among the most important corporate secrets.

As a consequence, from a regular Internet user's perspective, where our data sleeps is often a difficult question to answer. Big web-based companies in particular seem to enjoy hiding

within “the cloud.” They are frequently cagey about where they keep your data, sometimes even pretending not to be entirely sure about it themselves. As one data center expert put it to me, “Sometimes the answer to the question ‘where’s my email?’ is more quantum than Newtonian”—a geeky way of saying it appears to be in so many places at once that it’s as if it’s nowhere at all. Sometimes the location of our data is obscured further by what are known as “content delivery networks,” which keep copies of frequently accessed data, like popular YouTube clips or TV shows, in many small servers closer to people’s homes, just as a local store keeps popular items in stock. Being close minimizes the chances of congestion, while also bringing bandwidth costs down. But generally speaking, the cloud asks us to believe that our data is an abstraction, not a physical reality.

But that’s disingenuous. While there are moments when our online life really has discombobulated, with our data broken into ever-smaller pieces to the point that it’s theoretically impossible to know where it is, that’s still the exception. It’s a quarter truth that data center owners seize upon in a deliberate attempt at directing attention away from their actual places—whether for competitive reasons, because of environmental embarrassment, or for other notions of security. But what frustrates me is that feigned obscurity becomes a malignant advantage of the cloud, a condescending purr of “we’ll take care of that for you” that in its plea for our ignorance reminds me of slaughterhouses. Our data is always *somewhere*, often in two places. Given that it’s ours, I stick to the belief that we should know where it is, how it ended up there, and what it’s like. It seems a basic tenet of today’s

Internet: if we’re entrusting so much of who we are to large companies, they should entrust us with a sense of where they’re keeping it all, and what it looks like.

Nolan Young was happy to show me his data center, good public official that he is. Without thinking too much about it, soon after The Dalles’s fiber loop was completed, Young carved out a little space in the basement of City Hall where customers could put a rack of equipment and connect to one another—like a mini-Ashburn on the Columbia. Of course I wanted to see it; it sounded like a nice little piece of the Internet. “It’s just boxes and lights, but if you want!” Young said, and he fetched the key from his assistant. The Dalles’s town court was across the hall from Young’s office, and we walked past a sullen teenager waiting outside with his mother, then down the grand staircase at the center of the building, out the front steps, and around to a little side door into the basement. There was a small vestibule, linoleum tiled and fluorescent lit. Young opened a steel door, and I was greeted by the roar of blowing air and the old familiar electric smell of networking equipment. The Dalles’s data center may have looked like a glorified closet, but it struck me as an exchange point in its purest incarnation: just a bunch of routers plugged into one another in the dark. Young cheerily pointed out the pathways: “The customers come in here, jump onto our fiber, connect to each other, do whatever else they do, then pop back on our fiber out to Big Eddy and go wherever they go! The technical end of it is beyond me. I just know all that stuff goes to one spot and then it shoots out.” This was among the smallest rooms you might

feign to call a data center—in the shadow of one of the largest. But in its homespun simplicity it was a vivid confirmation that the Internet is always somewhere.

Working with the press people at the Googleplex—“Design LLC’s” headquarters in Silicon Valley—I had arranged a visit to their massive data center that afternoon, but Young warned me not to expect much. “I can pretty much guarantee that the closest you’re going to get is the lunchroom,” he said. We said our good-byes, and I made sure Young had my email address. “I do. Now we’re connected! I’ll jump on that fiber, and there we are.”

From City Hall I drove the five minutes across town, over the interstate and into an industrial neighborhood along the banks of the Columbia, nearly at the entrance to the gorge. The vast campus was visible from a distance, sitting beside the highway. It looked like a prison, thanks to its towering security lights, loosely spaced beige buildings, and strong perimeter fence. Huge power lines hemmed the campus into the base of the mountains, whose middle reaches were still dusted with snow, and their tops obscured by fog. On the corner was an animal shelter. Across the street was a concrete plant. Every hundred yards or so I passed a white safety pylon with an orange top that said BURIED FIBER-OPTIC CABLE—Q-LIFE. I drove past a DEAD END sign and buzzed the intercom on the outside of a double gate. It opened, and I parked in front of a security building the size of a house. A sign attached to a second layer of fencing said *VOLDEMORT INDUSTRIES* in gothic script—a playful reference to the Harry Potter villain, known by the wizards in training as “He-Who-Must-Not-Be-Named.” The only clue as to who actually owned this place was the picnic table with fixed seats, each painted a primary color:

red, blue, green, and yellow, familiar from Google’s ubiquitous logo.

I had known when I contacted Google’s media relations department that seeing the inside of a data center would be a long shot, given the notoriously tight lid the company kept on its facilities. But when I stressed that I wasn’t interested in numbers (they change so fast anyway) but rather in the place itself—The Dalles and its character—they agreed to a visit. Certainly Google’s presence in The Dalles was no longer a secret. There may not have been a sign outside (except for Voldemort Industries), but the company had joined the local chamber of commerce, begun to participate in community activities, donated computers to schools, planted a garden just outside its high steel fence, and was planning a public Wi-Fi network for downtown. Granted, this all came at the end of several years of bad press, in which Google’s data center was portrayed as a poorly hidden smog-belching factory—an image incongruous with the clean white pages, friendly demeanor, and immediate access we otherwise associate with Google. Company officials had been vocal about turning over a new leaf, releasing some statistics from their data centers around the world, and even a short video tour. They seemed to agree that hiding their data centers was no longer the best policy. So the farce that came next surprised me.

Inside the security building, a pair of guards sat in front of a bank of video monitors, wearing blue polo shirts embroidered with a sheriff’s badge nestled into the first “o” in “Google.” Three visiting “Googlers” had come in ahead of me and were waiting for their security clearance, which involved having their

retinas scanned from a machine that looked like a set of sleek coin-operated binoculars.

"Employee number?" the guard asked as each one approached the counter. "Step up to the machine."

Then the scanner took over the conversation, a robotic woman's voice, like a spaceship in a sci-fi movie. "Look into the mirror. Please stand closer." Snap. "Eye scan complete. Thank you." The visiting Googlers all giggled. Then the guard issued them a warning: make sure to scan in and scan out when you enter and exit the data center, because if the computer thinks you're still on the data center floor, it won't let you back in.

I wouldn't have that problem because—just as Young suspected—not only would I not see the data center floor, I wouldn't enter any buildings except the lunchroom. I began to realize I had come to The Dalles for a tour of the parking lot. Google's first rule of data center PR was: don't go in the data center.

I was greeted by a small entourage: Josh Betts, one of the facility's managers; an administrative assistant, Katy Bowman, who had spearheaded the community outreach; and a media handler who had driven in from Portland. Things were awkward from the beginning. When I pulled out my tape recorder, the media person leaned in for a close look at it, checking to make sure it wasn't a camera. With stiff smiles, we headed out into the rain, buzzed through a gate in the fence, and set out on foot across the campus. It felt like the back of a shopping mall, with broad parking lots, loading docks, and a tiny polite nod toward landscaping. The week before, I'd spoken with Dave Karlson, who managed the data center but was going to be away on vacation. "At the

facility we'll hopefully be able to show you around what it looks and feels like to be at a Google data center," he said. But it took only a few moments of silence to make me realize that there'd be no guiding going on in this tour. Can you tell me about what we're looking at, and what these buildings do? I ventured. Betts carefully avoided looking at the media handler, pursed his lips, and stared at the pavement in front of him—an information void like a hung web page. I tried to make my question more specific. What about this building over here—a yellow warehouse-looking thing with steam drifting from a vent? Was it mostly for storage? Did it contain the computers that crawl the web for the search index? Did it process search queries? There were nervous glances back and forth. The handler skipped a couple steps to get within earshot.

"You mean what The Dalles does?" Betts finally responded. "That's not something that we probably discuss. But I'm sure that data is available internally."

It was a scripted nonanswer, however awkwardly expressed. Of course he knows what these buildings do—he manages the facility. He just wasn't about to tell me. But the march across the parking lot was an invitation to describe what I saw: There were two main data center buildings, each the shape and character of a distribution warehouse on the side of the highway. They were set on either end of an empty lot the size of a soccer field. There were two components to each of the buildings—a long low section and a taller end piece—that together formed an "L" kicking to the sky. On top of the L were the cooling towers, which gave off a hefty steam that rolled across the length of the building, like a Santa Claus beard. There were loading docks all around, but

no windows. The roofs were clean. At the rear of each building was a series of generators encased in steel cabinets and attached with thick umbilicals of cables. Up close, the buildings' particularly unpleasant shade of beige-yellow could only have been chosen for being nondescript, on sale, or to make the place look like a penitentiary. Their signage—numbers only, no names—was perfectly painted and rational, with big, easy-to-read blue letters on beige. The roads had clean sidewalks with gravel neatly landscaped to their edges. Enormous lampposts spiked the campus, each topped by a halo of silver ball lights. The empty field—soon to house a third building—was filled with pickup trucks and modular construction offices. Just behind the high fence the Columbia River flowed steadily by.

As we approached the far edge of the property, Betts called security from his cell phone, and a few moments later a guard in a gray pickup pulled up. He unlocked a pedestrian gate, and we stepped through. We all admired the small garden tilled by Googlers in their off time, although it was too early in the season to see much growth. Beside the garden was another orange-and-white plastic pole, marking the location of the Q-Life fiber underground. Then we turned around and retraced our steps.

Near the entrance to Columbia House, which housed the dining room, Betts spoke up. "So you can see for yourself the campus. We've walked the perimeter. You can see what we have to deal with and what we've got going. In terms of the future you can get a sense of it just by taking a look around." I felt as if we were playing a puzzle game—perhaps the kind Google gives its employees as job applications. What was being left unsaid? Were they speaking in code? What was I supposed to be seeing?

A bearded man pedaled by on a sky-blue cruiser bike. "I think we're ready to go in!" my handler said.

Lunch was delicious. I ate organic salmon, a mixed green salad, and a peanut butter pudding for dessert. A handful of Googlers had been invited to join us, and as they sat down, my handler prompted each of them to say a few words about how much they liked living in The Dalles and how much they liked working at Google. "Can you tell Andrew what you like about working at Google and living in The Dalles?" she asked. Betts is a data center expert, second in charge of what I can only assume was among the most innovative facilities in the world, a key component of perhaps the greatest computing platform ever created. But he was sullen—preferring to say nothing at all than to risk stepping outside the narrow box PR had inscribed for him. We talked about the weather.

I considered expressing my frustration at the kabuki going on. Wasn't Google's mission to make information available? Aren't you the best and the brightest, and eager to share what you all know? But I decided the silence wasn't their choice. It was bigger than them. Calling them out for it would have been unfair. Emboldened by my peanut butter cup, I eventually said only that I was disappointed not to have the opportunity to go inside a data center. I would have liked to have seen it. My handler's response was immediate: "Senators and governors have been disappointed too!" A guy came off the lunch line wearing a T-shirt that said PEOPLE WHO THINK THEY KNOW EVERYTHING ARE ANNOYING TO THOSE OF US WHO ACTUALLY DO.

It wasn't until I drove away that it began to sink in how strange the whole visit had been, easily the strangest visit I'd had to the

Internet. I hadn't learned anything from Google—except all the things I couldn't know. I wondered if I was being unfair, if the Orwellian atmosphere was just the side effect of Google's legitimate prerogative to maintain corporate secrets, and to protect our privacy. On its corporate website, I'd even read a little note about it (which later disappeared): "We realize that data centers can seem like 'black boxes' for many people, but there are good reasons why we don't reveal every detail of what goes on at our facilities, or where every data center is located," it said. "For one thing, we invest a lot of resources into making our data centers the fastest and most efficient in the world, and we're keen to protect that investment. But even more important is the security and privacy of the information our users place in our trust. Keeping our users' data safe and private is our top priority and a big responsibility, especially since you can switch to one of our competitors' products at the click of a mouse. That's why we use the very best technology available to make sure our data centers and our services remain secure at all times."

Google's famed mission statement is "to organize the world's information and make it universally accessible and useful." Yet at The Dalles, they'd gone so far as to scrub the satellite image of the data center on Google Maps—the picture wasn't merely outdated, but actively obscured. In dozens of visits to the places of the Internet, people I'd met had been eager to communicate that the Internet wasn't a shadowy realm but a surprisingly open one, dependent to its core on cooperation, on information. Driven by profit, of course, but with a sense of accountability. Google was the outlier. I was welcomed inside the gates, but only in the most superficial way. The not-so-subliminal message was that I,

and by extension you, can't be trusted to understand what goes on inside its factory—the space in which we, ostensibly, have entrusted the company with our questions, letters, even ideas. The primary colors and childlike playfulness no longer seemed friendly—they made me feel like a schoolkid. This was the company that arguably knows the most about us, but it was being the most secretive about itself.

On my way into The Dalles, I'd stopped at the Bonneville Dam, the massive power plant—built and still operated by the Army Corps of Engineers—that spans the Columbia River. It was a fortress. Coming off the highway, I passed through a short tunnel, with a huge iron gate. An armed guard greeted me, asked if I was carrying any firearms, and searched my trunk. Then she tipped her hat and welcomed me in. There was a big visitor's center with a gift shop, exhibits about the construction of the dam and the ecology of the river, and a glass-walled room where you could see salmon swimming up the "fish ladder," on their way upstream to spawn. It was a classic American roadside attraction, a somewhat kitschy blend of big government and big landscape, all tied up in a complicated story of technological triumph and environmental tragedy. For an infrastructure geek—much less anyone who likes watching fish—the dam was a great stop.

I couldn't help but contrast the dam with the data center. One is owned by the government, the other by a public corporation; both are proud examples of American engineering. And they are functionally intertwined: it's the Bonneville Power Administration that, in part, drew Google to the region. But where the dam was welcoming, the data center was forbidding. What if Google opened a visitor's center, with a gift shop and a viewing gallery of

all its servers? I think it would be a popular tourist attraction, a place to learn about what goes on behind Google's white screen. For now, though, the stance is the opposite. The data center is locked down, obscured.

While visiting the Internet I often felt like a pioneer, a first tourist. But the dam made me realize that might be temporary, that there'd be others behind me. So much of ourselves is in these buildings that Google's position will be tough to retain. I had gone to the Internet to see what I might learn from the visit. From Google, I hadn't learned much. Driving away, I preferred not to think about what Google knew about me.

There was another way of doing it. Google wasn't the only giant in the region. To the north was Quincy, where Microsoft, Yahoo!, Ask.com, and others all have major data centers. And just over a hundred miles due south from The Dalles was the town of Prineville, which might be as equally hard up as The Dalles but was truly off the beaten path. Yet Prineville was where Facebook had chosen to build its first ground-up data center, at a scale equal to The Dalles. That in itself struck me as an amazing testament to the advantages of central Oregon as a place to store data: four years after Google, Facebook had chosen it again.

Leaving The Dalles, a two-lane road rose up abruptly from the Columbia River Valley to the high plateau of central Oregon. Snow drifted across it in uneven streaks, crunching under my tires. There were actual tumbleweeds, blowing around like plastic bags in the city. And always there were the Bonneville Power Administration's high-tension power lines, which

marched across the green sagebrush like columns of giant soldiers.

Prineville was a hundred-odd miles away. What was the significance of that distance? Why hadn't Facebook also moved into The Dalles? Or Quincy? On the map, they looked like neighbors. By virtue of being far away, and in a place where few people visit, it was easy to see it all as one place. But underneath the huge dome of sky, slowly lapping the miles, passing through little towns and empty crossroads, it was clear that each place had its own character, history, and people with a story to tell. The Internet "cloud," and even each piece of the cloud, was a real, specific place—an obvious reality that was only strange because of the instantaneity with which we constantly communicate with these places.

Just as I'd been lulled into the landscape's incredible expanse, I became distracted by the foreground, where spiked every few hundred yards into the red dirt of the highway shoulder were white plastic posts with orange caps. Eventually, I decided to pull over for a closer look at one. The cap read WARNING. BURIED FIBER OPTIC CABLE. NO DIGGING. LEVEL 3 COMMUNICATIONS.

Denver-based Level 3 operates one of the largest global backbone networks. One of its long-haul routes is here, in the dirt, most likely several hundred strands of fiber—although only a handful are likely "lit" with signals, while the remainder are "dark," awaiting future needs. Each individual fiber is capable of carrying terabits of data. But the bigness of that number (trillions!) and Level 3's geographic reach were the opposite of what really excited me. It was the freeze frame: the momentary presence of all that in this very particular spot. When you click on a

little photo thumbnail and wait for the big image to load, those scattered pulses of light were passing beneath the edge of US 197, near the speck on the map labeled Maupin, Oregon—if only for a nearly infinitesimal fraction of a second. It is difficult to say for sure which roadside and which instant. But it is enough to remember that between here and there there's always a white-and-orange post on the side of a road. The path is continuous and true.

A few miles later I came over the top of a ridge and was rewarded with the Internet tourist's jackpot: a fiber-optic regeneration station, housing the equipment that amplified the light signals on their journey across the country. A barbed-wire fence enclosed an area the size of two tennis courts, with a gravel parking lot and three small buildings. When I got out for a closer look, the high desert wind whipped around and slammed the car door shut. Two of the buildings were steel walled, like shipping containers. The third was concrete and stucco, with multiple doors, like a self-storage locker. A zeppelin-shaped fuel tank the size of a sofa stood between them. On the fence was a white sign with red-and-black lettering: NO TRESPASSING. LEVEL 3. IN CASE OF EMERGENCY CALL. . . . Given that there was nothing around, none of the signal stopped here; all of it was merely received and re-sent by the racks of equipment inside, a necessary pit stop on the photons' journey through glass.

Directly across the road was an earlier generation's version of the same idea: an AT&T microwave site, hardened against nuclear attack, its big bunkerlike building, bigger than a house, looking sinister with its spindly antennae. The Level 3 encampment looked like the kind of sheds you'd find behind a gas sta-

tion. I remembered the same contrast in Cornwall, where British Telecom's brutalist bunker stood in stark contrast with Global Crossing's more discreet house. I thought of the tilt-up concrete buildings in Ashburn, and the corrugated steel sheds in Amsterdam. The Internet had no master plan, and—aesthetically speaking—no master hand. There wasn't an Isambard Kingdom Brunel—the Victorian engineer of Paddington Station and the *Great Eastern* cable ship—thinking grandly about the way all the pieces fit together, and celebrating their technological accomplishment at every opportunity. On the Internet there were only the places in between, places like this, trying to disappear. The emphasis wasn't on the journey; the journey pretended not to exist. But obviously it did. I climbed up on the car for a better vantage point, doing what I could to climb up into that big sky. There was nobody around, the highway was empty, and there wasn't another house in sight. It was too windy to hear the hum of the machines.

Prineville was seventy-five more miles down the road. While The Dalles is in spitting distance of Portland, Prineville is tucked away in the middle of Oregon, far from the nearest interstate, in an area so remote that it was among America's last to be inhabited—until westward settlers noticed gold stuck in the hooves of lost cattle. Prineville is still a cowboy town, home to the Crooked River Roundup, a big annual rodeo. It's a place that has always fought to get its own, right down to founding a city-owned railroad after the main line passed it by—a nineteenth-century middle-mile network Nolan Young would appreciate. The City of Prineville Railway is still in operation ("Gateway to Central Oregon"), the last municipal-owned tracks in the entire

country. But Prineville's biggest struggle came with the recent loss of its last major employer, Les Schwab Tire Centers—known for its “free beef” promotion—to Bend, a booming ski town with twelve Starbucks and a big Whole Foods, thirty miles away. Prineville fought to bring in Facebook, touting tax breaks that would save the company as much as \$2.8 million a year, as a perk of its presence in an enterprise zone on the outskirts of town. But where Google insisted on secrecy, Facebook moved into Prineville with fanfare. Driving the town's main drag, with its intact 1950s roadside architecture, I spotted a WELCOME FACEBOOK sign in a store window.

The data center sits on a butte above town, overlooking the Crooked River. Lining both sides of the wide road leading up to it are more white-and-orange fiber markers, like bread crumbs leading to the data center door. My first impression was of its overwhelming scale—long and low like a truck distribution center on the side of the highway. It was surprisingly beautiful, more visually assertive than most any piece of the Internet I'd seen, set on a shallow crest like a Greek temple. Where Google's buildings were aesthetically loose, with loading docks and appendages pointing every which way, Facebook's seemed tightly rational, a crisp human form in the sagebrush. It sits alone in the empty landscape, a clean concrete slab topped by a penthouse of corrugated steel. At the time I visited it was still under construction, with only the first large data center room finished. Three more phases extended out the back, like a caterpillar growing new body segments—the last one still showing the yellow insulating panels of endoskeleton. All together the four sections would total three hundred thousand square feet of space, the equivalent

of a ten-story urban office tower. Construction on another building the same size would begin soon, and there was room on the property for a third. Across the country in Forest City, North Carolina, Facebook had begun construction on a sister building of the same design—which also happened to be fifty miles from Google's own massive data center in Lenoir, North Carolina.

Before I visited, I was predisposed to think of these big data centers as the worst kind of factories—black smudges on the virgin landscape. But arriving in Prineville I discovered what an industrial place it was already, from the vast hydroelectric infrastructure of the region to the remnant buildings of the timber industry that dotted the town. The notion of this data center despoiling the landscape was absurd. Prineville has long been a manufacturing town—and at the moment, what it needed most of all was more industry. What amazed me was that the data center had ended up here at all. This enormous building landed in the brush was an astonishing monument to the networked world. What's here is also in Virginia and Silicon Valley—that isn't surprising—but the logic of the network led this massive warehouse, this huge hard drive, to this particular town in Oregon.

I found Ken Patchett inside, leaning back in a brand-new Aeron chair with its tags still on. He sat at his desk in the sunny, open offices, his white iPhone earbuds stuck in his ears, finishing up a conference call. Before coming to Prineville to manage the data center, he'd held the same job in The Dalles, but it was hard to imagine him at Google. “My dog had more access to me there than my family!” he said. For all the Google-bots' silence, Patchett was uncensored. He's an enormous extrovert, with a booming voice and a winking sense of humor. At six feet, four

inches, when he put his hard hat on for a walk through the building's unfinished sections, he looked like the iron workers still on the site. That fit: his job at Facebook wasn't about shaping information (at least not entirely), but the proper functioning of this huge machine.

Patchett grew up a military brat and then lived with his grandparents on their farm in New Mexico, milking cows before school. He wanted to be an iron worker or a policeman, but he dropped out of college when he couldn't play football anymore. He traveled the country for a job managing and servicing equipment at sawmills. "You want to talk about a wood chip, I am the guy to talk about a wood chip," he said. "And if your wood chips are no good, I can tell you how to make them better." The work even brought him to Prineville, where as a twenty-four-year-old he installed a chipper in the town mill for the current city manager. He had four kids and got into computers for the money. At a job fair in Seattle in 1998, he heard about a contract position at a Microsoft data center, paying \$16 an hour. When he arrived at the place, he realized he'd help build it—one summer as an iron worker. "I walked in there and was, like, hey, I've been in here before! Then I saw this fellow lumber by and I thought he was a janitor, and next thing you know he comes out and it's the guy who's going to be interviewing me." He'd taken a couple technical classes, and the guy looked over his paperwork and asked, "What does that mean? Why should I hire you?" That taught him a lesson: "I don't know nothing. I know enough to figure my way around, but what I learned from taking all these classes is I don't know enough."

A month later, Microsoft had him running a data center.

"Like any good manager, I came in and painted the walls and brought in the plastic flowers." Then Microsoft moved him into the global networking team, and he celebrated the turn of the millennium sitting on the top of the AT&T building in Seattle with a satellite phone in his hand, in case the world ended. At Google a few years later, he started out managing The Dalles but soon was promoted out and ended up building data centers in Hong Kong, Malaysia, and China. He was in Beijing the day Google pulled out in 2010. "We left some boxes in there but they're not doing anything, just blinky lights," he assured me.

As we began talking about Facebook, I told Patchett how I was interested in why this building was here, of all places, seemingly in the middle of nowhere, but he cut me off. "Just because they don't have this one thing here, does that mean you forsake the whole community?" He shook his head. "Do you say screw 'em, let them eat cake?" It would be naive to think that Facebook came to Prineville to benefit the community—and indeed, Patchett came on board long after the site was chosen. But now that Facebook was there, he was determined for Facebook to be a part of Prineville. Facebook's ethos was bringing people together—perhaps, occasionally, more than they wanted to be. That extended to the data center. "We're not here to change the culture, just to integrate and be a part of this," Patchett offered.

To some extent this was a concerted PR effort to avoid repeating the mistakes that Google made in The Dalles, and the bad press that followed. Where Google had kept everything top secret, threatening legal action against anyone who even spoke its name, Facebook was determined to be wide open to this community. But it came wrapped in a broader statement about the

openness of technology. At a press conference soon after I visited Prineville, Facebook launched the Open Compute project, where it shared the schematics of the entire data center, from the motherboard to the cooling system, and challenged others to use it as the starting point for improvement. "It's time to stop treating data centers like Fight Club," Facebook's director of infrastructure declared. But you could also look at the difference between Google and Facebook from the other angle: Facebook played fast and loose with our privacy while Google vehemently protected it. At the least, Patchett was happy to show off Facebook's data center. "Want to see how this shit really works?" he asked. "This has nothing to do with clouds. It has everything to do with being cold."

We started out in the glass-walled lobby filled with modern furniture in bright colors and photos of old-time Prinevillians on the wall. Facebook had hired an art consultant to poke around the town archives and choose images to decorate the place. (It made sense to me: If you're going to spend half a billion on hard drives, why not a few thousand on art?) Patchett leaned in close to one. "Look at the people—how'd you like to make her angry? And look at the hats. Everybody has their own hat," he said. "They all have their own style." He winked—that was a Facebook joke.

We passed the conference rooms named for local beers and entered a long, wide hallway with cavernous ceilings, like the stockroom of an IKEA. The overhead lights went on as we walked. Patchett swiped us through another doorway and into the first data center room, still in the process of being turned on. It was spacious and shiny, as big as a hotel ballroom, brand-new

and uncluttered. On either side of an open central corridor were narrow aisles formed by high racks of black servers. In scale and shape, and with the concrete floors, the place felt like the underground stacks of a library. But in place of books were thousands of fluttering blue lights. Behind each light was a one-terabyte hard drive; the room contained tens of thousands of them; the building had three more rooms this size. It was the most data I'd ever seen in one place—the Grand Canyon of data.

And it was important stuff. This wasn't the dry database of a bank or government agency. Somewhere in here was stuff that was at least partly mine—among the most emotionally resonant bits around. But even knowing that, it still felt abstract. I knew Facebook as the thing on the screen, as a surprisingly rich medium for delivering personal news—of friends' new babies and jobs, health scares and vacations, first days of school and heart-wrenching memorials. But I couldn't avoid the breathtaking obviousness of what was physically in front of me: A room. Cold and empty. It all seemed so *mechanical*. What had I handed over to machines—these machines in particular?

"If you blew the 'cloud' away, you know what would be there?" Patchett asked. "*This*. This is the cloud. All of those buildings like this around the planet create the cloud. The cloud is a building. It works like a factory. Bits come in, they get massaged and put together in the right way, then packaged up and sent out. But everybody you see on this site has one job, that's to keep these servers right here alive at all times."

To minimize energy usage, the temperature in the data center is controlled with what amounts to a swamp cooler, rather than normal air conditioners. Cool outside air is let into the build-

ing through adjustable louvers near the roof; deionized water is sprayed into it; and fans push the conditioned air down onto the data center floor. "When the fans aren't on, and the air isn't being sucked through here—it's like a real cloud, dude," Patchett said. "I fogged this whole place up." Given Prineville's cold and dry climate, most of the year cooling is free. We stood beneath a broad hole in the ceiling, almost big enough to call an atrium. Daylight was visible along its upper edges. "If you stand right here and look up, you can see the fan bank," Patchett said. "The air hits this concrete floor and roils left and right. This whole building is like the Mississippi River. There's a huge amount of air coming in, but moving really slowly."

We left out the far end of the huge room and came into another wide hallway. "Here's my own personal storage room for stuff I don't really need," Patchett said. "And here's a bathroom I had no idea was back here until they put that sign on it." Behind another door was the second large data center space, a match to the one we'd just crossed but filled with server racks in various states of assembly. Behind this room would be two more like it—phases A, B, C, and D, ready for growth. Equipment had been arriving by the truckload every day. "We swarm on it like little server fairies, and by the morning, whhheeeee, there's all the blinky lights arranged in a nice order," Patchett said.

"But you've got to understand what your growth curve looks like. You want to make sure you don't overbuild. You want to be 10 percent ahead, although you're always 10 percent behind. But I'd rather be 10 percent behind than have a half a billion dollars of data center space sitting there." That reminded me that Patchett had the keys to Facebook's biggest single line item. The social

network had recently raised a billion and a half dollars through a controversial private offering, orchestrated by Goldman Sachs. A significant fraction of that ended up in the back of a semitruck, chugging up this hill. But Patchett had been around long enough to be wary. "The Internet is a fickle thing," he said. "She's a crazy lady! So don't spend everything you've got up front because you may or may not use it. People get a swinging dick complex. Google built these monstrous data centers that are empty, you know why? Because it's fucking cool!"

After lunch, we climbed into Patchett's huge pickup truck and drove out on a dirt road through the woods behind the data center. Above us was the spur power line that Facebook had built off the main branch—a onetime expense that would pay for itself many times over. At a wide spot in the road, I could see the main lines running off into the northwest in the direction of The Dalles—and Portland, Seattle, Asia. At the edge of a bluff, we got out of the truck and looked out over the town of Prineville and toward the Ochoco Mountains. Immediately below us was an old sawmill, with a new power cogeneration plant built a decade ago but never used. "I think it's important to think about locally significant stuff when you're here," Patchett said. "What if when we're all grown up and ready to do something, what if we help get that back up and deliver twenty megawatts of power?" It wasn't a real plan, only a dream. In fact, Facebook had come under fire from Greenpeace for relying too heavily on coal power. But for Patchett, it was tied up in a broader vision about the future of data centers, and America. "If you lose rural America, you lose your infrastructure and your food. It's incumbent for us to wire everybody, not just urban America. The 20

percent of the people living on 80 percent of the land will be left behind. Without what rural America provides to urban America, urban America couldn't exist. And vice versa. We have this partnership." If in Oregon that was once about timber and beef, it now extended to data, of all things. The Internet was unevenly distributed. It wasn't everywhere at all—and the places where it wasn't suffered for it.

We climbed back in the truck and bounced back toward the data center, which emerged out of the woods like an oceanliner. Patchett was fiddling with his iPhone as he drove along the rutted road. "I just got an email," he said. Testing on the data center was done. "We are *live* on the Internet right now."

Epilogue

As everyone from Odysseus on down has pointed out, a journey is really only understood upon arriving home. But what did that mean when the place I was coming home from was everywhere?

The morning I left Oregon, I'd opened my laptop in the airport lounge to write some emails, read a few blog posts, and do the things I always do while sitting in front of the screen. Then, even more strangely, I did the same thing on the plane, paying the few bucks for the inflight Wi-Fi, flying above the earth but still connected to the grid. It was all one fluid expanse, the vast continent be damned—on the Internet's own terms, at least.

But I hadn't traveled tens of thousands of miles, crossed oceans and continents, to believe that was the whole story. This may not have been the most arduous of journeys—the Internet settles in mostly pleasant places—but it was a journey nonetheless. The science fiction writer Bruce Sterling voiced a popular sentiment when he wrote, "As long as I've got broadband, I'm perfectly at ease with the fact that my position on the planet's surface is

Notes

Prologue

- 3 **In the F. Scott Fitzgerald story:** F. Scott Fitzgerald, *My Lost City: Personal Essays 1920–1940*, ed. James L. W. West III (Cambridge: Cambridge University Press, 2005), p. 115.
- 5 **Senator Ted Stevens of Alaska described the Internet:** The comments were made in the Senate Commerce, Science, and Transportation Committee's hearings for the "Communications, Consumers' Choice, and Broadband Deployment Act of 2006" on June 28, 2006. The full audio can be downloaded at <http://www.publicknowledge.org/node/497>.
- 5 **The *New York Times* fretted:** Ken Belson, "Senator's Slip of the Tongue Keeps on Truckin' Over the Web," *New York Times*, July 17, 2006 (<http://www.nytimes.com/2006/07/17/business/media/17stevens.html>).
- 6 **"The cyborg future is here":** Clive Thompson, "Your Outboard Brain Knows All," *Wired*, October 2007 (http://www.wired.com/techbiz/people/magazine/15-10/st_thompson).
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- 7 **Sure enough, one stepped forward:** Lic. Mara Vanina Oses "The Internet Mapping Project," June 3, 2009 (<http://psiytecnologia.wordpress.com/2009/06/03/the-internet-mapping-project/>).
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1: The Map

My education in mapping the Internet, as well as many basics of the Internet's geography, came thanks to the patience of the excellent people at TeleGeography, including Markus Krisetya, Alan Maudlin, Stephan Beckert, Bonnie Crouch, Roxanna Tran, Nicholas Browning, and former employee Bram Abramson—who also fished TeleGeography's first Internet report from the depths of his files and mailed it to me. In Milwaukee, Dave Janczak gave a great tour of the Kubin-Nicholson printing floor and filled in the company's history; Dr. Steven Reyer of the Milwaukee School of Engineering—and keeper of the "Milwaukee Architecture" website—rounded out some historical details about the building. I'm especially grateful to Jon Auer for opening up his particularly vivid piece of the Net. At the Oxford Internet Institute, Mark Graham helped my understanding of the challenges of mapping cyberspace.

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2: A Network of Networks

A shelfful of books helped me to understand the Internet's history; I've listed them below. At UCLA, I'm grateful to Leonard Kleinrock who gave the better part of an afternoon to sharing stories. My understanding of the murky history of MAE-East was thanks to Steve Feldman, Bob Collet, and Rob Seastrom. On Tysons Corner, Paul Ceruzzi's book *Internet Alley* was indispensable. And out of nowhere, Matt Darling sent me the 1980 ARPANET directory, which he'd pulled out of the trash twenty years before.

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3: Only Connect

From the earliest stages of this project, Eric Troyer at Equinix was a constant source of information and guidance; I couldn't have understood the Internet without his expertise. Also at Equinix, Aaron Klink, Dave Morgan, and Felix Reyes were generous with their time on both coasts; David Fonkalsrud at K/F Communications opened the door. And I'm grateful to Jay Adelson for the day he spent going down memory lane—and the faster ride, to the future, in his electric roadster.

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4: The Whole Internet

In the complicated and nuanced realm of Internet peering, I was grateful for the hours many people spent helping me to understand, in particular: Anton Kapela, Martin Levy of Hurricane Electric, Joe Provo, Ren Provo, Jim Cowie of Renesys, Jon Nistor, Josh Snowhorn, Daniel Golding of DH Capital, Sylvie LaPerrière, Michael Lucking, Rob Seastrom, Jay Hanke, Pat-

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5: Cities of Light

At Brocade, Greg Hankins quickly arranged a visit, and Par Westesson was the ideal guide inside the machine. In New York, Ilissa Miller and Jaymie Scotto opened many doors, and I was especially grateful for their introduction to the inimitable Hunter Newby, who happily shared his insight and gave a great walking tour of Lower Manhattan. Michael Roark and Tesh Durvasula turned the lights on in some dark corners of the city's Internet. Victoria O'Kane and Ray La Chance happily accommodated my interest in seeing fiber-optic cables being laid, while Brian Seales and Eddie Diaz made it a fun night on the streets. John Gilbert at Rudin Management keeps the history alive at 32 Avenue of the Americas. In London, I'm grateful for the time and assistance of Tim Anker of the Colocation Exchange; Pat Vicary at Tata; John Souter, Jeremy Orbell, and Colin Silcock at the London Internet Exchange; Nigel and Benedicte Titley; Dionne Aiken, Michelle Reid, and Bob Harris at Telehouse; and Matthew Finnie and Mark Lewis at Interoute. James Tyler and Rob Coupland at Telecity spent the better part of a day showing off their impressive pieces of the Internet.

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6: The Longest Tubes

In human terms, the world of undersea cables is an intimate one, and many people happily shared their knowledge and opened their facilities. At Global Crossing—now Level 3—Kate Rankin championed my interest to her colleagues, who collectively spent days answering my questions. In Rochester, Jim Watts, Mary Hughson, Louis LaPack, Mike Duell, and Nels Thompson provided the background info. Then in Cornwall, Jol Paling shared his beautiful part of the world. The Porthcurno Telegraph Museum is an invaluable resource for the history of undersea cables; archivist Alan Renton became a friend in the valley. At Hibernia Atlantic, Bjarni Thorvardarson welcomed me in and Tom Burfitt gave a great tour. At Tata Communications, Simon Cooper allowed everything to happen, most especially the chance to watch a cable land on the beach; his colleagues Janice Goveas, Paul Wilkinson, Rui Carrilho, and Anisha Sharma made it work. At TE Subcom, Courtney McDaniel arranged fascinating and hugely informative visits with Neal Bargano in Eatontown and Colin Young in Newington. Tom Standage's *The Victorian Internet* (New York: Walker, 2007) and John Steele Gordon's *A Thread Across the Ocean* (New York: Walker, 2002) filled in the fascinating history, while Richard Elliott at Apollo brought it up to the present. And every word written about this topic owes a debt to Neal Stephenson's epic 1996 article for *Wired*, "Mother Earth Mother Board" (available at <http://www.wired.com/wired/archive/4.12/ffglass.html>).

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7: Where Data Sleeps

Any journalist who has waded into the world of data centers quickly learns that the gold standard for coverage is Rich Miller's blog, *Data Center Knowledge*. His posts were a constant source of news and context, and I'm grateful for his friendly support of this project. At Facebook, Ken Patchett told me everything

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