THE THIRD LINK

Six Degrees of Separation

IN 1912, JUST AS ANNA ERDŐS DISCOVERED she was pregnant with her third child, Paul, the streets of Budapest were abuzz with talk about a new collection of poems and prose by the best Hungarian and international writers. The first edition had sold out before the literary critics could even get to it, and the second printing was also disappearing when the first serious reviews appeared in newspapers around the country. By then Anna Erdős had entered the hospital, given birth to Paul, and gone home, only to discover that her two older daughters were the victims of a scarlet fever epidemic that was tearing through Budapest.

Despite the city's many personal tragedies, enthusiasm for the new literary phenomenon was unabating. The book's popularity was rooted in a minor detail: All the poems and short stories were fake. In *Igy irtok ti*, or *This Is How You Write*, Frigyes Karinthy, a twenty-five-year-old virtually unknown poet and writer, invented what he called *literary caricature*. The volume is a collection of poems and short stories that appear to be written by a who's who of world literature. If you were familiar with the authors, you could easily recognize their styles. Each piece is a cunning parody that, like a distorting mirror, keeps the mimicked author recognizable while changing all the proportions. Karinthy applied his vitriolic and annihilating humor with equal ease on deceased giants and close friends. And his arrow was often deadly: The authors he most venomously parodied are known to us only through his book; their actual works are lost in the unforgiving sink of literary taste and history.

Igy irtok ti is one of the most read books in Hungarian history. It made Karinthy an instant celebrity. Never again did he have to wait for the bus in the bus station—he simply waved to it from wherever he was, and the drivers, with wide smiles, stopped for him. He wrote most of the time behind the expansive glass windows of the Central Café in the heart of Budapest. Passersby often performed a strange dance. As they walked by the window, they suddenly stopped, turned, and peered through the window at the working writer, as if he were an exotic species in a new aquarium.

Almost two decades after *Igy irtok ti*, in 1929, at about the same time that the seventeen-year-old Erdős was lecturing about the Pythagorean theorem in the shoe store a few streets away from the Central Café, Karinthy published his forty-sixth book, *Minden masképpen van (Everything Is Different)*, a collection of fifty-two short stories. By now he was recognized as the genius of Hungarian literature. Everyone, however, was still waiting for "The Book," the novel that would define Karinthy and guarantee his place among literature's immortals. The critics openly voiced concern that Karinthy was selling out his unique talent by writing short stories that drew quick bucks. Karinthy, whose incredibly disordered and chaotic life was spent between coffeehouses and a hectic and noisy home, failed to deliver the long awaited tome. The short story collection was a critical failure and soon sank into obscurity. It has been out of print ever since. I have visited most bookstores and antiquaries in Budapest and cannot find a trace of it. But there is one story, entitled "Láncszemek," or "Chains," that deserves our attention.

"To demonstrate that people on Earth today are much closer than ever, a member of the group suggested a test. He offered a bet that we could name any person among earth's one and a half billion inhabitants and through at *most five* acquaintances, one of which he knew personally, he could link to the chosen one," writes Karinthy in "Láncszemek." And indeed, Karinthy's fictional character immediately links a Nobel prizewinner to himself, noting that the Nobelist must know King Gustav, the Swedish monarch who hands out the Nobel prize, who in turn is a consummate tennis player and plays occasionally with a tennis champion who happens to be a good friend of Karinthy's character. Remarking that linking to celebrities is easy, Karinthy's character demands a more difficult assignment. Next he tries to link a worker in Ford's factory to himself: "The worker knows the manager in the shop, who knows Ford; Ford is on friendly terms with the general director of Hearst Publications, who last year became good friends with Árpád Pásztor, someone I not only know, but is to the best of my knowledge a good friend of mine—so I could easily ask him to send a telegram via the general director telling Ford that he should talk to the manager and have the worker in the shop quickly hammer together a car for me, as I happen to need one." Though these short stories have been neglected, Karinthy's 1929 insight that people are linked by at most five links was the first published appearance of the concept we know today as "six degrees of separation."

1.

Six degrees was rediscovered almost three decades later, in 1967, by Stanley Milgram, a Harvard professor who turned the concept into a much celebrated, groundbreaking study on our interconnectivity. Amazingly, Milgram's first paper on the subject occasionally reads like an English translation of Karinthy's "Láncszemek" rewritten for an audience of sociologists. Milgram, perhaps the most creative practitioner of experimental psychology, is best known for a series of highly debated experiments probing the conflict between obedience to authority and personal conscience. But his intellect was wide-ranging, and he soon became interested in the structure of our social network, a topic that was frequently discussed by sociologists at Harvard and MIT during the late sixties.

Milgram's goal was to find the "distance" between any two people in the United States. The question driving the experiment was, how many acquaintances would it take to connect two randomly selected individuals? To get started, he first chose two target persons, the wife of a divinity graduate student in Sharon, Massachusetts, and a stock broker in Boston. He picked Wichita, Kansas, and Omaha, Nebraska, as starting points for the study because "from Cambridge, these cities seem vaguely 'out there,' on the Great Plains or somewhere." There was little consensus about how many links it would take to connect people from these remote areas. Milgram himself pointed out in 1969, "Recently I asked a person of intelligence how many steps he thought it would take, and he said that it would require 100 intermediate persons, or more, to move from Nebraska to Sharon."

Milgram's experiment entailed sending letters to randomly chosen residents of Wichita and Omaha asking them to participate in a study of social contact in American society. The letter contained a short summary of the study's purpose, a photograph, and the name and address of and other information about one of the target persons, along with the following four-step instructions:

HOW TO TAKE PART IN THIS STUDY

1. ADD YOUR NAME TO THE ROSTER AT THE BOTTOM OF THIS SHEET, so that the next person who receives this letter will know who it came from.
2. DETACH ONE POSTCARD. FILL IT OUT AND RETURN IT TO HARVARD UNIVERSITY. No stamp is needed. The postcard is very important. It allows us to keep track of the progress of the folder as it moves toward the target person.
3. IF YOU KNOW THE TARGET PERSON ON A PERSONAL BASIS, MAIL THIS FOLDER DIRECTLY TO HIM (HER). Do this only if you have previously met the target person and know each other on a first name basis.
4. IF YOU DO NOT KNOW THE TARGET PERSON ON A PERSONAL BASIS, DO NOT TRY TO CONTACT HIM DIRECTLY. INSTEAD, MAIL THIS FOLDER (POSTCARDS AND ALL) TO A PERSONAL ACQUAINTANCE WHO IS MORE LIKELY THAN YOU TO KNOW THE TARGET PERSON. You may send the folder

to a friend, relative or acquaintance, but it must be someone you know on a first name basis.

Milgram had a pressing concern: Would any of the letters make it to the target? If the number of links was indeed around one hundred, as his friend guessed, then the experiment would likely fail, since there is always someone along such a long chain who does not cooperate. It was therefore a pleasant surprise when within a few days the first letter arrived, passing through only two intermediate links! This would turn out to be the shortest path ever recorded, but eventually 42 of the 160 letters made it back, some requiring close to a dozen intermediates. These completed chains allowed Milgram to determine the number of people required to get the letter to the target. He found that the median number of intermediate persons was 5.5, a very small number indeed—and coincidentally, amazingly close to Karinthy's suggestion. Round it up to 6, however, and you get the famous "six degrees of separation."

As Thomas Blass, a social psychologist who has devoted the last fifteen years to in-depth research on the life and work of Stanley Milgram, pointed out to me, Milgram himself never used the phrase "six degrees of separation." John Guare originated the term in his brilliant 1991 play of that title. After an extremely successful season on Broadway, the play was made into a movie with the same title. In the play, Ousa (played by Stockard Channing in the movie), musing about our interconnectedness, tells her daughter, "Everybody on this planet is separated by only six other people. Six degrees of separation. Between us and everybody else on this planet. The president of the United States. A gondolier in Venice. . . . It's not just the big names. It's anyone. A native in a rain forest. A Tierra del Fuegan. An Eskimo. I am bound to everyone on this planet by a trail of six people. It's a profound thought. . . . How every person is a new door opening up into other worlds."

Milgram's study was confined to the United States, linking people "out there" in Wichita and Omaha to "over here" in Boston. For Guare's Ousa, however, six degrees applied to the whole world. Thus a myth was born. Because more people watch movies than read sociology papers, Guare's version has prevailed in popular thought.

Six degrees of separation is intriguing because it suggests that, despite our society's enormous size, it can easily be navigated by following social links from one person to another—a network of *six billion* nodes in which any pair of nodes are on average *six* links from each other. Perhaps we should be surprised that there *is* a path between any two people. Yet we saw in the previous chapter that being connected requires very little—barely more than one social link per person. As we all have many more than one link, each of us is a part of the giant network that we call society.

Stanley Milgram awakened us to the fact that not only are we connected, but we live in a world in which no one is more than a few handshakes from anyone else. That is, we live in a *small world*. Our world is small because society is a very dense web. We have far more friends than the critical one needed to keep us connected. Yet is six degrees something uniquely human, tied somehow to our desire to form social links? Or do other kinds of networks look the same? Answers to these questions surfaced only a few years ago. We now know that social networks are not the only small worlds.

2.

"Suppose all the information stored on computers everywhere were linked. . . . All the best information in every computer at CERN and on the planet would be available to me and anyone else. There would be a single global information space." This was the dream of Tim Berners-Lee in 1980 while working as a programmer at the European Organization for Nuclear Research, commonly known by its French acronym, CERN, in Geneva, Switzerland. To turn his dream into reality, he wrote a program that allowed computers to share information—to link to each other. By inventing the links, Berners-Lee released a genie whose existence had been unknown to us. In less than ten years the genie turned into the World Wide Web, one of the largest ever human-made networks. It is a virtual network whose nodes are Webpages that have it all: news, movies, gossip, maps, pictures, recipes, biographies, and books. If it can be written, drawn, or photographed, chances are there is already a node on the Web containing it in some form.

The power of the Web is in the links, the uniform resource locators (URLs) that allow us to move with the click of a mouse from one page to another. They allow us to surf, locate, and string together information. These links turn the collection of individual documents into a huge network spun together by mouse clicks. They are the stitches that keep the fabric of our modern information society together. Remove the links, and the genie would spectacularly vanish. Huge inaccessible databases would be left behind, the contemporary ruins of an interconnected world.

How large is the Web today? How many Web documents and links are out there? Until recently no one knew for sure—there's no single organization to keep track of all the nodes and links. It was Steve Lawrence and Lee Giles, working at the NEC Research Institute at Princeton, who took up this unique challenge in 1998. Their measurements indicated that in 1999 the Web had close to a billion documents—not bad for a virtual society born less than a decade earlier. Considering that it grows much faster than human society, chances are that by the time this book is published there will be more Web documents than people on Earth.

But the real issue isn't the overall size of the Web. It's the distance between any two documents. How many clicks does it take to get from the home page of a high-school student in Omaha to the Webpage of a Boston stockbroker? Despite the billion nodes, could the Web be a "small world"? The answer to this question is not irrelevant to anybody who surfs the Web. If Webpages are thousands of clicks from each other, it is hopeless to find any document without a search engine. Finding that the Web was not a small world would also indicate that the networks behind society and the online universe were fundamentally different. If that were the case, to fully understand networks we would need to understand why and how this difference emerges. Therefore, at the end of 1998 I set out with Réka Albert, a Ph.D. student, and Hawoong Jeong, a postdoctoral associate—both working at that time in my research group at the physics department at the University of Notre Dame—to grasp the size of the world behind the Web.

Our first goal was to obtain a map of the Web, essentially an inventory of all Webpages and the links connecting them. The information contained in such a map would be truly unparalleled. If we were to construct a similar map for society, it would have to include each person's professional and personal interests and chart everyone she or he knew. It would make Milgram's experiment seem clumsy and obsolete by allowing us to find, in seconds, the shortest path to any person in the world. It would be a must-use tool for everyone from politicians to salespeople and epidemiologists. Of course, such a social search engine is impossible to build, since it would take at least a lifetime to interrogate all 6 billion people on the earth to learn about their friends and acquaintances. Yet there is something magical about the Web that sets it apart from society: We can navigate its links instantaneously. It is just a matter of clicks.

Unlike our current society, the Web is digital. This allows us to write a piece of software that downloads any document, finds all the links on it, then visits and downloads the documents to which they point, continuing until all pages on the Web are captured. If you let such a program loose, in theory it will return a complete map of the Web. In the computer world, this software is called a *robot* or *crawler* because it crawls through the Web without human supervision. The big search engines, such as Alta Vista or Google, have thousands of computers running numerous robots that constantly look for new documents on the Web. Our little research group clearly could not compete on their scale. So Jeong created a robot to accomplish a more modest goal. First it gave us a map of the nd.edu domain by mapping about 300,000 documents within the University of Notre Dame, a rather eclectic collection containing everything from philosophy course Web pages to Irish music fan sites. But we were not concerned about the content of the pages. We were interested only in the links that told us how to travel from one page to another. With such a map at hand, we could then measure the distance between any two pages within the university.

Just as Milgram saw some of his letters reaching the target person in two steps while others took as many as eleven, our results indicated lots of variability in the distances between Web documents. For example, my graduate students have links to my Webpage; thus they are one click away from me. Yet going from my Webpage to the homepage of a philosophy major would often require twenty clicks. What was astonishing, however, is that, taken together, these paths were not as long as the vastness of the Web would suggest. The measurements indicated that pages were on average eleven clicks away from each other. Paraphrasing Guare's title, we could say there are eleven degrees of separation at Notre Dame.

However, the Webpages within our university, the nd.edu domain, represent only a tiny subset of the World Wide Web. The full Web in 1999 was at least 3,000 times larger. Would this mean that the distance between two randomly selected nodes on the World Wide Web was also 3,000 times longer than the eleven clicks our measurements indicated? That is, would it take a full 33,000 clicks to get from one page to another on the Web? To answer this question we needed a map of the full Web. The problem was that nobody had one. Even the largest search engines that tirelessly scan the Web with thousands of computers have managed to cover less than 15 percent of the Web's full size. Could we determine the separation for the full Web without such a map? The answer was yes. But we had to use a method commonly employed in statistical mechanics—the field of physics that regularly deals with random systems with unpredictable components or outcomes.

Our approach had a simple premise: If the Web is too large to fit into our computer, then we should study many smaller pieces of it that do fit. For example, we took a small portion of the Web, with only 1,000 nodes, and calculated the separation between any two nodes on this tiny sample. Next we took a slightly larger piece, with 10,000 nodes, and determined the separation again. We repeated this for the largest systems our computer allowed us to use and looked for trends in the obtained node-to-node distances. The results indicated that the average separation between the nodes increased much more slowly than the number of documents, following a very simple and reproducible expression.[1] This finding allowed us to predict the separation on the

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1. We found the separation to be proportional to the logarithm of the number of nodes in the network. That is, if we denote d to be the average separation between the nodes on a Web of N Webpages, then this separation followed the equation $d = 0.35 + 2\log N$, where $\log N$ denotes the base-10-logarithm of N.

full Web as long as we know the total number of documents out there. That number was provided by the NEC group. They estimated the size of the publicly indexable Web to be around 800 million nodes at the end of 1998. Thus our expression predicted that the diameter of the Web was 18.59, close to 19. As Guare might say: nineteen degrees of separation. While surfing might give you a different impression, in reality the Web is a small world. Any document is on average only nineteen clicks away from any other.

3.

Taken together, Milgram's six degrees and the Web's nineteen degrees suggest that behind the short observed distances there is something more fundamental than humanity's desire to spread social links all over the globe. This suspicion was confirmed by subsequent discoveries which demonstrated that small separations are common in just about every network scientists have had a chance to study. Indeed, species in food webs appear to be on average two links away from each other; molecules in the cell are separated on average by three chemical reactions; scientists in different fields of science are separated by four to six coauthorship links; and the neurons in the brain of the *C. elegans* worm are separated by fourteen synapses. In fact, it appears that the Web holds the absolute record at nineteen degrees, as all other networks studied so far display a separation between two and fourteen.

Nineteen degrees may appear to be drastically far from six degrees. This is not the case, however. What is important is that huge networks, with hundreds of millions or billions of nodes, collapse, displaying separation far shorter than the number of nodes they have. Our society, a network of six billion nodes, has a separation of six. The Web, with close to a billion nodes, has a separation of nineteen. The Internet, a network of hundreds of thousands of routers, has a separation of ten. Seen from this perspective, the difference between six and nineteen is negligible.

The natural question is: Why? How do networks achieve such a uniformly short path despite consisting of billions of nodes? The answer lies in the highly interconnected nature of these networks. In the previous chapter, we saw that random networks require only one link per node to form a giant cluster. The question is, what if, as usually happens in real networks, nodes have many more links than that? At the critical point when the average connectivity is around one per node, the separation between nodes could be rather large. But as we add more links, the distance between the nodes suddenly collapses. Consider a network in which the nodes have on average k links. This means that from a typical node we can reach k other nodes with one step. There are, however, k^2 nodes two links away and roughly k^d nodes exactly d links away. Therefore, if k is large, for even small values of d the number of nodes you can reach can become very large. Within a few steps you have reached all nodes to be found, which explains why the average separation is so short in most networks.

These arguments can be easily turned into a mathematical formula that predicts the separation in a random network as a function of the number of nodes.[2] The origin of the small separation is a logarithmic term present in the formula. Indeed, the logarithm of even a very large number is rather small. The ten-based logarithm of a billion is only nine. For example, if we have two networks, both with an average of ten links per node, but one 100 times larger than the other, the separation of the larger net will be only two degrees higher than the separation of the smaller one. The logarithm shrinks the huge networks, creating the small worlds around us.

4.

One of the most absentminded people of his generation, Karinthy was well-known for forgetting meetings he had arranged ahead of time. Dezső Kosztolányi, Karinthy's close friend and literary rival, once remarked, "I have got to run home because Karinthy promised that he would visit us, and perhaps he forgot that he promised, and he will indeed come." Interestingly, six degrees appears to follow a very Karinthyan path: forgotten,

2. If we have N nodes in the network, k^d must not exceed N. Thus, using $k^d = N$, we obtain a simple formula that works well for random networks, telling us that the average separation follows the equation $d = \log N / \log k$.

reformulated, and rediscovered in the popular press and scientific texts alike. I have no idea who originally discovered the six degrees concept. The earliest written account that I know of comes from Karinthy. But how did he get it? Did he think of it by himself? In view of his unparalleled intellect and fondness for unexpected and unconventional ideas, it is not inconceivable. Or did he hear about it from others in the coffeehouse, as his short story suggests? We will perhaps never have an answer. But it is interesting to speculate on the subsequent turn of events.

Karinthy's short story was published in 1929, when Erdős, also living in Budapest, was seventeen years old. As even unsuccessful books of Karinthy's were literary events, it is not unlikely that Erdős read or heard of the "Chains" story, in which Karinthy postulates that all people on the earth can be connected by a chain of five acquaintances. The same conjecture could even be made about Alfred Rényi, who, though only nine years old when "Chains" appeared, had a unique affinity for literature. Indeed, he was known to have been good friends with many writers, including Karinthy's son, Ferenc, a well-known writer himself.

Erdős teamed up with Alfred Rényi in 1959 to write their famous string of eight papers on random networks. The papers do contain the expression giving the network's diameter as a function of the number of nodes. Should either of them have cared, they could have easily shown that Karinthy's intuition was correct, since the many social links we have shrink even gigantic webs into truly tiny worlds. They never mention this application in their papers, however, and we will probably never know if they amused themselves with the idea while taking breaks between proofs and theorems. But the links do not stop there. Stanley Milgram published his experiments uncovering the 5.5 links in 1967, four decades after Karinthy's five-link conjecture and almost a decade after Erdős and Rényi introduced the random network theory. He did not seem to have been aware of the body of work on networks in graph theory and most likely had never heard of Erdős and Rényi. He is known to have been influenced by the work of Ithel de Sole Pool of MIT and Manfred Kochen of IBM, who circulated manuscripts about the small-world problem within a group of colleagues for decades without publishing them, because they felt they had never "broken the back of the problem." Incidentally, Milgram is a child of a Hungarian father and Romanian mother who immigrated to the United States and settled in the Bronx. Could his father or uncles, who often visited, have been aware even anecdotally of Karinthy's five degrees? Could his real interest in the problem have been rooted in stories he overheard as a child? This again is something that we will never know, but it certainly suggests some interesting paths in the evolution of the idea of six degrees.

5.

The six/nineteen degrees phrase is deeply misleading because it suggests that things are easy to find in a small world. This could not be further from the truth! Not only is the desired person or document six/nineteen links away, but so are all people or documents. In other words, six—or ten or nineteen—can either be a very small number or a very large one, depending on what you're trying to do. Since the average number of links on any given Web document is around seven, this means that while we can follow only seven links from the first page, there are 49 documents two clicks away, 343 three clicks away, and so on. By the time we reach the nodes that are exactly nineteen degrees away, in principle we would have checked 10^{16} documents, 10 million times more than the total number of pages on the Web. This contradiction has an easy resolution: Some of the links we meet along the road will point back to pages that we have seen before. Thus they are not "new" links. But even if it takes only one second to check a document, it would still take over 300 million years to get to all documents that are nineteen clicks away! Nevertheless, despite the abundance of choices, we sometimes find documents rather quickly, even without search engines.

The trick, of course, is that we do not follow all links. Rather, we use clues. Indeed, if we are looking for information on Picasso and are faced with three choices on a given Webpage, we are more apt to follow the modern art link than either the link for a famous wrestler or a frog's love life. By *interpreting* the links, we avoid having to check all the pages within nineteen degrees and can zero in on the desired page within a few clicks. While this method seems to be the most efficient, it almost always fails to find the shortest path. Indeed, it is always possible that the wrestler whose Webpage we bypassed balances his tough guy image with a link to the best Picasso site. But most people looking for Picasso would ignore the wrestler's link and eventually follow a longer path to the destination. The computer, having no taste or bias (yet), will chew through with equal excitement the wrestler, modern art, and frog's love life pages, pragmatically following the links to all of them. By trying all the possible paths, it will inevitably locate the shortest one, independent of the content of the intermediate pages.

Finding Picasso on the Web highlights a fundamental problem with six degrees: Milgram's method overestimated the shortest distance between two people in the United States. Six degrees is really an upper limit. There is an enormous number of paths with widely different lengths between any two people. Milgram's subjects were never aware of the shortest path to their target. This is like being lost in a huge maze where we can see only the corridors and doors next to us. Even if we have a compass and we know that the exit is toward the north, finding it could be woefully inefficient and time-consuming. With a map of the maze in hand, we could be out in five minutes. Similarly, Milgram's letters would have followed the shortest path between Omaha and Boston only if all participants had had a map that compiled the social links of all Americans. Lacking such a map, they forwarded the message to those that they *thought* were most likely to take it in the right direction. For example, if you wish to be introduced to the president of the United States, you would try to think of somebody who knows the president. Most likely you would settle on your senator or representative. As most of us do not know our senator on a first name basis, we would try to find somebody who does and who would be willing to broker a meeting with the president. That would take at least three handshakes. In the meantime, you might have no clue that the gentleman you sat next to a few days earlier at a dinner party went to school with the president. Thus in reality you are only two degrees away from the president. Similarly, the paths recorded by Milgram's experiment were invariably longer than the shortest possible. Thus, the real separation in society was clearly overestimated. It must be shorter than six—perhaps shorter than Karinthy's five. We don't have a social search engine, so we may never know the real number with total certainty.

6.

Six degrees is the product of our modern society—a result of our insistence on keeping in touch. It is aided by our relatively newfound ability to communicate over great distances—often over thousands of miles. The global village we've grown used to inhabiting is a new reality for humans. The ancestors of most Americans lost contact with those they left behind in the old country. From the cattle herds on the prairies or the gold mines of the Rocky Mountains it was impossible to reach loved ones separated by oceans and continents. No postcards, no phone calls. In the subtle social network of those days, it was rather difficult to activate the links that had been broken when people moved. That changed in this century as the mail system, the telephone, and then air travel demolished barriers and shrank physical distances. Today immigrants to America can choose to maintain their links to the people they leave behind. We can and do keep in touch. I keep track of my relatives and friends even if they are as far away as Korea or eastern Europe. The world has collapsed irreversibly in the twentieth century. And it is undergoing yet another implosion right now, as the Internet reaches to every corner of the world. Though we are nineteen clicks away from everybody on the Web, we are only one click away from our friends. They might have hopped three cities and five jobs since we last met in person. But no matter where they are, we can usually find them on the Internet if and when we wish to do so. The world is shrinking because social links that would have died out a hundred years ago are kept alive and can be easily activated. The number of social links an individual can actively maintain has increased dramatically, bringing down the degrees of separation. Milgram estimated six. Karinthy five. We could be much closer these days to three.

"Small worlds" are a generic property of networks in general. Short separation is not a mystery of our society or something peculiar about the Web: Most networks around us obey it. It is rooted in their structure—it simply doesn't take many links for me to reach a huge number of Webpages or friends. The resulting small worlds are rather different from the Euclidean world to which we are accustomed and in which distances are measured in miles. Our ability to reach people has less and less to do with the physical distance between us. Discovering common acquaintances with perfect strangers on worldwide trips repeatedly reminds us that some people on the other side of the planet are often closer along the social network than people living next door. Navigating this non-Euclidean world repeatedly tricks our intuition and reminds us that there is a new geometry out there that we need to master in order to make sense of the complex world around us.