CHAPTER 1

Digital Explosion

Why Is It Happening, and What Is at Stake?

On September 19, 2007, while driving alone near Seattle on her way to work, Tanya Rider went off the road and crashed into a ravine.* For eight days, she was trapped upside down in the wreckage of her car. Severely dehydrated and suffering from injuries to her leg and shoulder, she nearly died of kidney failure. Fortunately, rescuers ultimately found her. She spent months recuperating in a medical facility. Happily, she was able to go home for Christmas.

Tanya's story is not just about a woman, an accident, and a rescue. It is a story about bits—the zeroes and ones that make up all our cell phone conversations, bank records, and everything else that gets communicated or stored using modern electronics.

Tanya was found because cell phone companies keep records of cell phone locations. When you carry your cell phone, it regularly sends out a digital "ping," a few bits conveying a "Here I am!" message. Your phone keeps "pinging" as long as it remains turned on. Nearby cell phone towers pick up the pings and send them on to your cellular service provider. Your cell phone company uses the pings to direct your incoming calls to the right cell phone towers. Tanya's cell phone company, Verizon, still had a record of the last location of her cell phone, even after the phone had gone dead. That is how the police found her.

So why did it take more than a week?

If a woman disappears, her husband can't just make the police find her by tracing her cell phone records. She has a privacy right, and maybe she has good reason to leave town without telling her husband where she is going. In

* Citations of facts and sources appear at the end of the book. A page number and a phrase identify the passage.

Tanya's case, her bank account showed some activity (more bits!) after her disappearance, and the police could not classify her as a "missing person." In fact, that activity was by her husband. Through some misunderstanding, the police thought he did not have access to the account. Only when the police suspected Tanya's husband of involvement in her disappearance did they have legal access to the cell phone records. Had they continued to act on the true presumption that he was blameless, Tanya might never have been found.

New technologies interacted in an odd way with evolving standards of privacy, telecommunications, and criminal law. The explosive combination almost cost Tanya Rider her life. Her story is dramatic, but every day we encounter unexpected consequences of data flows that could not have happened a few years ago.

When you have finished reading this book, you should see the world in a different way. You should hear a story from a friend or on a newscast and say to yourself, "that's really a bits story," even if no one mentions anything digital. The movements of physical objects and the actions of flesh and blood human beings are only the surface. To understand what is really going on, you have to see the virtual world, the eerie flow of bits steering the events of life.

This book is your guide to this new world.

The Explosion of Bits, and Everything Else

The world changed very suddenly. Almost everything is stored in a computer somewhere. Court records, grocery purchases, precious family photos, pointless radio programs.... Computers contain a lot of stuff that isn't useful today but somebody thinks might someday come in handy. It is all being reduced to zeroes and ones—"bits." The bits are stashed on disks of home computers and in the data centers of big corporations and government agencies. The disks can hold so many bits that there is no need to pick and choose what gets remembered.

So much digital information, misinformation, data, and garbage is being squirreled away that most of it will be seen only by computers, never by human eyes. And computers are getting better and better at extracting meaning from all those bits—finding patterns that sometimes solve crimes and make useful suggestions, and sometimes reveal things about us we did not expect others to know.

The March 2008 resignation of Eliot Spitzer as Governor of New York is a bits story as well as a prostitution story. Under anti-money laundering (AML) rules, banks must report transactions of more than $10,000 to federal regulators. None of Spitzer's alleged payments reached that threshold, but his bank's computer found that transfers of smaller sums formed a suspicious pattern. The AML rules exist to fight terrorism and organized crime. But while the computer was monitoring small banking transactions in search of big-time crimes, it exposed a simple payment for services rendered that brought down the Governor.

Once something is on a computer, it can replicate and move around the world in a heartbeat. Making a million perfect copies takes but an instant—copies of things we want everyone in the world to see, and also copies of things that weren't meant to be copied at all.

The digital explosion is changing the world as much as printing once did—and some of the changes are catching us unaware, blowing to bits our assumptions about the way the world works.

When we observe the digital explosion at all, it can seem benign, amusing, or even utopian. Instead of sending prints through the mail to Grandma, we put pictures of our children on a photo album web site such as Flickr. Then not only can Grandma see them—so can Grandma's friends and anyone else. So what? They are cute and harmless. But suppose a tourist takes a vacation snapshot and you just happen to appear in the background, at a restaurant where no one knew you were dining. If the tourist uploads his photo, the whole world could know where you were, and when you were there.

Data leaks. Credit card records are supposed to stay locked up in a data warehouse, but escape into the hands of identity thieves. And we sometimes give information away just because we get something back for doing so. A company will give you free phone calls to anywhere in the world—if you don't mind watching ads for the products its computers hear you talking about.

And those are merely things that are happening today. The explosion, and the social disruption it will create, have barely begun.

We already live in a world in which there is enough memory *just in digital cameras* to store every word of every book in the Library of Congress a hundred times over. So much email is being sent that it could transmit the full text of the Library of Congress in ten minutes. Digitized pictures and sounds take more space than words, so emailing all the images, movies, and sounds might take a year—but that is just today. The explosive growth is still happening. Every year we can store more information, move it more quickly, and do far more ingenious things with it than we could the year before.

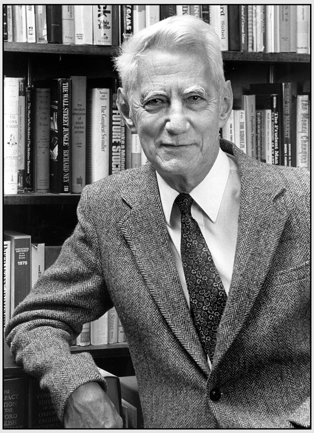
So much disk storage is being produced every year that it could be used to record a page of information, every minute or two, about you *and every other human being on earth*. A remark made long ago can come back to haunt a political candidate, and a letter jotted quickly can be a key discovery for a biographer. Imagine what it would mean to record every word every human being speaks or writes in a lifetime. The technological barrier to that has already been removed: There is enough storage to remember it all. Should any social barrier stand in the way?

Sometimes things seem to work both better and worse than they used to. A "public record" is now *very* public—before you get hired in Nashville, Tennessee, your employer can figure out if you were caught ten years ago taking an illegal left turn in Lubbock, Texas. The old notion of a "sealed court record" is mostly a fantasy in a world where any tidbit of information is duplicated, cataloged, and moved around endlessly. With hundreds of TV and radio stations and millions of web sites, Americans love the variety of news sources, but are still adjusting uncomfortably to the displacement of more authoritative sources. In China, the situation is reversed: The technology creates greater government control of the information its citizens receive, and better tools for monitoring their behavior.

This book is about how the digital explosion is changing everything. It explains the technology itself—why it creates so many surprises and why things often don't work the way we expect them to. It is also about things the information explosion is destroying: old assumptions about our privacy, about our identity, and about who is in control of our lives. It's about how we got this way, what we are losing, and what remains that society still has a chance to put right. The digital explosion is creating both opportunities and risks. Many of both will be gone in a decade, settled one way or another. Governments, corporations, and other authorities are taking advantage of the chaos, and most of us don't even see it happening. Yet we all have a stake in the outcome. Beyond the science, the history, the law, and the politics, this book is a wake-up call. The forces shaping your future are digital, and you need to understand them.

The Koans of Bits

Bits behave strangely. They travel almost instantaneously, and they take almost no space to store. We have to use physical metaphors to make them understandable. We liken them to dynamite exploding or water flowing. We even use social metaphors for bits. We talk about two computers agreeing on some bits, and about people using burglary tools to steal bits. Getting the right metaphor is important, but so is knowing the limitations of our metaphors. An imperfect metaphor can mislead as much as an apt metaphor can illuminate.



CLAUDE SHANNON

Claude Shannon (1916–2001) is the undisputed founding figure of information and communication theory. While working at Bell Telephone Laboratories after the Second World War, he wrote the seminal paper, "A mathematical theory of communication," which foreshadowed much of the subsequent development of digital technologies. Published in 1948, this paper gave birth to the now-universal realization that the bit is the natural unit of information, and to the use of the term.

Alcatel-Lucent, `http:www.bell-labs.com/news/2001/february/26/shannon2_lg.jpeg`.

We offer seven truths about bits. We call them "koans" because they are paradoxes, like the Zen verbal puzzles that provoke meditation and enlightenment. These koans are oversimplifications and over-generalizations. They describe a world that is developing but hasn't yet fully emerged. But even today they are truer than we often realize. These themes will echo through our tales of the digital explosion.

Koan 1: It's All Just Bits

Your computer successfully creates the illusion that it contains photographs, letters, songs, and movies. All it really contains is bits, lots of them, patterned in ways you can't see. Your computer was designed to store just bits—all the files and folders and different kinds of data are illusions created by computer programmers. When you send an email containing a photograph, the computers that handle your message as it flows through the Internet have no idea that what they are handling is part text and part graphic. Telephone calls are also just bits, and that has helped create competition—traditional phone companies, cell phone companies, cable TV companies, and Voice over IP (VoIP) service providers can just shuffle bits around to each other to complete calls. The Internet was designed to handle just bits, not emails or attachments, which are inventions of software engineers. We couldn't live without those more intuitive concepts, but they are artifices. Underneath, it's all just bits.

This koan is more consequential than you might think. Consider the story of Naral Pro-Choice America and Verizon Wireless. Naral wanted to form a text messaging group to send alerts to its members. Verizon decided not to allow it, citing the "controversial or unsavory" things the messages might contain. Text message alert groups for political candidates it would allow, but not for political causes it deemed controversial. Had Naral simply wanted telephone service or an 800 number, Verizon would have had no choice. Telephone companies were long ago declared "common carriers." Like railroads, phone companies are legally prohibited from picking and choosing customers from among those who want their services. In the bits world, there is no difference between a text message and a wireless phone call. It's all just bits, traveling through the air by radio waves. But the law hasn't caught up to the technology. It doesn't treat all bits the same, and the common carriage rules for voice bits don't apply to text message bits.

Verizon backed down in the case of Naral, but not on the principle. A phone company can do whatever it thinks will maximize its profits in deciding whose messages to distribute. Yet no sensible engineering distinction can be drawn between text messages, phone calls, and any other bits traveling through the digital airwaves.

Exclusive and Rivalrous

Economists would say that bits, unless controlled somehow, tend to be *non-exclusive* (once a few people have them, it is hard to keep them from others) and *non-rivalrous* (when someone gets them from me, I don't have any less). In a letter he wrote about the nature of ideas, Thomas Jefferson eloquently stated both properties. *If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of every one, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it.*

Koan 2: Perfection Is Normal

To err is human. When books were laboriously transcribed by hand, in ancient scriptoria and medieval monasteries, errors crept in with every copy. Computers and networks work differently. Every copy is perfect. If you email a photograph to a friend, the friend won't receive a fuzzier version than the original. The copy will be identical, down to the level of details too small for the eye to see.

Computers do fail, of course. Networks break down too. If the power goes out, nothing works at all. So the statement that copies are normally perfect is only relatively true. Digital copies are perfect only to the extent that they can be communicated at all. And yes, it is possible in theory that a single bit of a big message will arrive incorrectly. But networks don't just pass bits from one place to another. They check to see if the bits seem to have been damaged in transit, and correct them or retransmit them if they seem incorrect. As a result of these error detection and correction mechanisms, the odds of an actual error—a character being wrong in an email, for example—are so low that we would be wiser to worry instead about a meteor hitting our computer, improbable though precision meteor strikes may be.

The phenomenon of perfect copies has drastically changed the law, a story told in Chapter 6, "Balance Toppled." In the days when music was distributed on audio tape, teenagers were not prosecuted for making copies of songs, because the copies weren't as good as the originals, and copies of copies would be even worse. The reason that thousands of people are today receiving threats from the music and movie industries is that their copies are perfect—not just as good as the original, but identical to the original, so that even the notion of "original" is meaningless. The dislocations caused by file sharing are not over yet. The buzzword of the day is "intellectual property." But bits are an odd kind of property. Once I release them, everybody has them. And if I give you my bits, I don't have any fewer.

Koan 3: There Is Want in the Midst of Plenty

Vast as world-wide data storage is today, five years from now it will be ten times as large. Yet the information explosion means, paradoxically, the loss of information that is not online. One of us recently saw a new doctor at a clinic he had been using for decades. She showed him dense charts of his blood chemistry, data transferred from his home medical device to the clinic's computer—more data than any specialist could have had at her disposal five years ago. The doctor then asked whether he had ever had a stress test and what the test had shown. Those records should be all there, the patient explained, in the medical file. But it was in the *paper* file, to which the doctor did not have access. It wasn't in the *computer's* memory, and the patient's memory was being used as a poor substitute. The old data might as well not have existed at all, since it wasn't digital.

Even information that exists in digital form is useless if there are no devices to read it. The rapid progress of storage engineering has meant that data stored on obsolete devices effectively ceases to exist. In Chapter 3, "Ghosts in the Machine," we shall see how a twentieth-century update of the eleventh-century British Domesday Book was useless by the time it was only a sixtieth the age of the original.

Or consider search, the subject of Chapter 4, "Needles in the Haystack." At first, search engines such as Google and Yahoo! were interesting conveniences, which a few people used for special purposes. The growth of the World Wide Web has put so much information online that search engines are for many people the first place to look for something, before they look in books or ask friends. In the process, appearing prominently in search results has become a matter of life or death for businesses. We may move on to purchase from a competitor if we can't find the site we wanted in the first page or two of results. We may assume something didn't happen if we can't find it quickly in an online news source. If it can't be found—and found quickly—it's just as though it doesn't exist at all.

Koan 4: Processing Is Power

The speed of a computer is usually measured by the number of basic operations, such as additions, that can be performed in one second. The fastest computers available in the early 1940s could perform about five operations per second. The fastest today can perform about a trillion. Buyers of personal computers know that a machine that seems fast today will seem slow in a year or two.

For at least three decades, the increase in processor speeds was exponential. Computers became twice as fast every couple of years. These increases were one consequence of "Moore's Law" (see sidebar).

> **MOORE'S LAW**
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> Gordon Moore, founder of Intel Corporation, observed that the density of integrated circuits seemed to double every couple of years. This observation is referred to as "Moore's Law." Of course, it is not a natural law, like the law of gravity. Instead, it is an empirical observation of the progress of engineering and a challenge to engineers to continue their innovation. In 1965, Moore predicted that this exponential growth would continue for quite some time. That it has continued for more than 40 years is one of the great marvels of engineering. No other effort in history has sustained anything like this growth rate.

Since 2001, processor speed has not followed Moore's Law; in fact, processors have hardly grown faster at all. But that doesn't mean that computers won't continue to get faster. New chip designs include multiple processors on the same chip so the work can be split up and performed in parallel. Such design innovations promise to achieve the same effect as continued increases in raw processor speed. And the same technology improvements that make computers faster also make them cheaper.

The rapid increase in processing power means that inventions move out of labs and into consumer goods very quickly. Robot vacuum cleaners and self-parking vehicles were possible in theory a decade ago, but now they have become economically feasible. Tasks that today seem to require uniquely human skills are the subject of research projects in corporate or academic laboratories. Face recognition and voice recognition are poised to bring us new inventions, such as telephones that know who is calling and surveillance cameras that don't need humans to watch them. The power comes not just from the bits, but from being able to do things with the bits.

Koan 5: More of the Same Can Be a Whole New Thing

Explosive growth is exponential growth—doubling at a steady rate. Imagine earning 100% annual interest on your savings account—in 10 years, your money would have increased more than a thousandfold, and in 20 years, more than a millionfold. A more reasonable interest rate of 5% will hit the same growth points, just 14 times more slowly. Epidemics initially spread exponentially, as each infected individual infects several others.

When something grows exponentially, for a long time it may seem not to be changing at all. If we don't watch it steadily, it will seem as though something discontinuous and radical occurred while we weren't looking.

That is why epidemics at first go unnoticed, no matter how catastrophic they may be when full-blown. Imagine one sick person infecting two healthy people, and the next day each of those two infects two others, and the next day after that each of those four infects two others, and so on. The number of newly infected each day grows from two to four to eight. In a week, 128 people come down with the disease in a single day, and twice that number are now sick, but in a population of ten million, no one notices. Even after two weeks, barely three people in a thousand are sick. But after another week, 40% of the population is sick, and society collapses

Exponential growth is actually smooth and steady; it just takes very little time to pass from unnoticeable change to highly visible. Exponential growth of anything can suddenly make the world look utterly different than it had been. When that threshold is passed, changes that are "just" quantitative can look qualitative.

Another way of looking at the apparent abruptness of exponential growth—its explosive force—is to think about how little lead time we have to respond to it. Our hypothetical epidemic took three weeks to overwhelm the