An excerpt from

FutureHype
The Myths of Technology Change

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Introduction:
Leveling the Exponential Curve

The further backward you look, the further forward you can see.
—Winston Churchill

THE GAME OF CHESS DATES back to India fourteen hundred years ago. Legend says that the local ruler was so delighted by the game that he offered its inventor the reward of his choice. The inventor's request was defined by the game board itself: a single grain of rice for the first chess square, two for the next, four for the next, and so on, doubling with each square through all sixty-four. Unaccustomed to this kind of sequence, the ruler granted this seemingly trivial request. Little did he realize that the rice begins to be measured in cups by square fourteen, sacks by square twenty, and tons by square twenty-six. The total comes to about three hundred billion tons—more rice than has been harvested in the history of humanity.

Like the king in the chess story, most of us are inexperienced in this kind of exponential increase. Let's look at a present day example. In 1971, Intel introduced the 4004, its first microprocessor, with a performance of 0.06 MIPS (million instructions per second). Intel's Pentium Pro was introduced in 1995 with 300 MIPS, a five-thousand-fold performance increase in twenty-four years—about one doubling every two years. A car making the same speed increase would now have a top speed of about Mach 700. Give it another twenty-four years at the same rate of increase, and its top speed would exceed the speed of light.

Moore's Law, named after Intel cofounder Gordon Moore, predicts this exponential rise in computer performance: every two years, microprocessor speed doubles. Again. This law has been startlingly accurate for three decades, and the progress it predicts is expected to continue, at least for the near future. Because there is no precedent for this rapid performance improvement, we tend to view computers and their rapid change with wonder.

My own career of twenty-five years as a digital hardware designer and a programmer and software architect has been tied to Moore's Law. Ever since my high school years in the 1970s, I've been immersed in computer technology and have been an energetic cheerleader for technology in general. I was in awe of the change it brought about and was delighted to be a small part of that change. Change was exciting. And it was all around us—I grew up with the space program and jumbo jets, nuclear power and skyscrapers, *Future Shock* and *Megatrends.* Exponential change seemed to be everywhere we looked.

To make sure we're all clear what exponential change looks like, figure 1 shows the differences between *no change, linear change,* and *exponential change.* The vertical axis is unlabeled—it could represent transistors in microprocessors, dollars for compound interest, the number of bacteria grown in a petri dish, or the grains of rice in the chess story. While they may start out slowly, exponential curves eventually snowball.

As I gained experience, I came to realize that change for its own sake wasn't as desirable for the software user as the software developer imagined. Users wanted new software to answer to bottom-line demands. Who would have guessed? Coolness alone was no longer enough—users demanded that software pull its weight, as they would for any other purchase.

They were right, of course. New software must provide sufficient additional benefits to outweigh the cost and aggravation of adopting it.

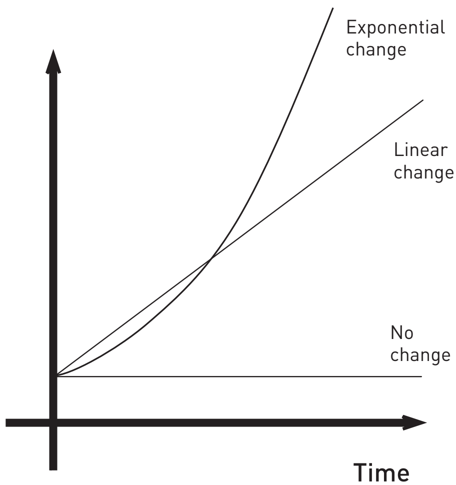

Figure 1. Exponential change contrasted with linear change and no change. The exponential curve doubles every time period. It might double every day if measuring bacteria growth or every decade if measuring number of miles of railroad track.

This is also true for other consumer products. The consumer might think: I like that digital camera, but it uses a new type of memory card. Will it become a standard or an unsupported dead end, like so many other products? Should I make MP3 copies of my favorite songs or keep them on CD? Is HDTV (High-Definition TV) really here, or is the current hype another false alarm? In general, is the latest hot product something that will last, or is it just a fad? The early adopters are quick to make this leap, but the chasm must be narrowed considerably for the majority of us. Change for its own sake wasn't as delightful as I'd thought, and I came to see things more from the user's perspective.

The high failure rate of new products challenges the inevitability of exponential change. A bigger challenge came as I studied high-tech products from the past, looking for precedents against which to compare my own projects. I wondered, why were these old products successful? and how could I apply what I learned to my own work? As I learned more about the history of technology, I was surprised to find examples that the exponential model could not explain. I gradually realized that there was a different way—a more accurate way—to look at such change.

The exponential model as a universal explanation for and predictor of technological change is at best an approximation and at worst a delusion. We can sustain it only by selecting just the right examples and ignoring all the rest. Technology does not always continuously improve. For example, commercial airplane speeds increased steadily for a while but halted when airlines realized that expensive supersonic travel didn't make business sense. Highway speed limits increased steadily but also hit a ceiling. Record heights for skyscrapers increased rapidly during the first third of the twentieth century but have increased only moderately since then. Use of nuclear power has peaked, and manned space exploration halted after we reached the moon.

Specific areas of technology advance at different rates and come to the fore at different times. Cathedral building emerged during the 1200s while other technologies languished. Printing underwent dramatic change in the late 1400s, then surged again in the early 1800s as mechanized presses provided cheap books and magazines. Steam power and mills had their heyday; later, it was electricity and electrical devices. There are dozens of examples of a specific technology surging forward and then maturing and fading back into the commonplace.

Perhaps the most venerable use of the exponential model has been to represent world population growth, but even here it's an imperfect metaphor. In the 1960s and '70s, experts warned that the world's population was growing exponentially, and crowding would quickly get worse. Famine was just around the corner. Though dramatic, the model was inaccurate: world population growth is slowing and is expected to peak midcentury, and the populations of dozens of countries are already *falling* in population (not counting immigration).

Despite the common perception, the impact of technology on society today is comparatively gentle. To see a truly serious example of the collision of technology and society, look at Britain during the Industrial Revolution almost two centuries ago. In 1811, armed gangs of Luddites smashed the textile machines that displaced their handmade crafts. Several years and over ten thousand men were required to put down the rebellion. The unrest spread to the Continent, where the word "sabotage" was coined—from the French word *sabot,* the wooden shoes used by workers to smash or jam machines. In the space of a generation, independent work on farms had given way to long six-day weeks in noisy and dangerous factories. Our own technological growing pains seem minor by comparison.

It's easy to focus on the recent at the expense of the old, but doing so can lead to a distorted view of our current situation. New products loom disproportionately large, often simply because they're new. The image of previous generations of Americans living quiet, static lives is fiction; they dealt with disruptions caused by technological innovations every bit as challenging and exciting as our own: the telegraph and electricity, the car and railroad, anesthesia and vaccines, concrete and steel, newspapers and mail. And if we go even further back, we see the fundamental developments on which society is based: agriculture, metallurgy, the beginnings of engineering, writing, textiles, transportation, timekeeping, basic tools and weapons, and so on. Are today's products really so amazing compared to those on which they were built? Too often we mistake a new technology for an important one.

Part of the problem is a narrow definition of *technology.* Obviously, the Internet, computer, and cell phone fit into this category. These are in the news and in our awareness. But this book will use a very broad definition of technology, including these new technologies as well as older and less glamorous ones mentioned above. Metallurgy, textiles, and all the rest were high tech at one point, they are still important to society, and examples from these older technologies will be liberally used in this book to illustrate that today's issues have, in fact, been around for a long time.

Sometimes the prevailing view of reality is an oversimplification. For example, small children are often taught that "All ocean creatures are fish." Though incomplete, it's a step in the right direction. When the children are a little older, we might teach them that all ocean creatures are fish—except whales and dolphins. When they are older still, we teach them that all ocean creatures are fish except marine mammals (like whales and dolphins), crustaceans (like crabs and lobsters), bivalves (like oysters and scallops), cephalopods (like nautilus and squid), and so on.

We frequently hear that the nature and rate of change in today's technologies are unprecedented. But like the fish simplification for children, this tells far less than the whole story; it helps explain some of what we see, but is inaccurate—and dangerously so. Leave behind the children's version of technology change, and explore how it is really affecting society and how it will impact us in the future.

> *We live in a technology-dense world. . . . We are terrifyingly naked without knowing elementary things about how [technologies] work.*
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> —John Lienhard, *The Engines of Our Ingenuity* (2000)