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[Exponential Technologies]

Preparing for the Exponential Technology Revolution

By Mark Michaelis | November 2019

The world you know is about to change in profound and radical ways. A historic confluence of emerging technologies, powered by ubiquitous connectivity and advances like artificial intelligence (AI), are poised to complement and catalyze each other to change the way we work, play, relate and live.

Right about now, you probably know this isn't going to be your usual MSDN Magazine article. While the magazine remains committed to code-level guidance for developers, this final issue offers an opportunity to ponder the future and how today's technology will shape and inform it. We stand at an inflection point in technology evolution, and we need to understand that it involves exponential change that will yield a world very different from the one we know. But it's a chance, also, to explore the role and responsibility that we as developers will have as we engage with and enable the coming tide of innovation. There are moral and ethical choices ahead of us, also, and grappling with them will be a core challenge of the coming age.

Needless to say, readers of MSDN Magazine are uniquely impacted by the accelerating technological forces changing our world. Developers like you right now are writing the code that drive the systems that will shape our future. In this, the final issue of MSDN Magazine, I can think of no more fitting topic for exploration.

Understanding Exponential Technologies

To grasp the coming technology revolution, it's necessary to understand the concept of an exponential technology. Consider for example the graph in **Figure 1**, which tracks the growth in the number of photos taken annually worldwide. Since 2000, the emergence of digital cameras,

and then camera-equipped cell phones, has driven skyrocketing growth. In 2000, about 86 billion photos were taken. Twelve years later, that number was 380 billion.
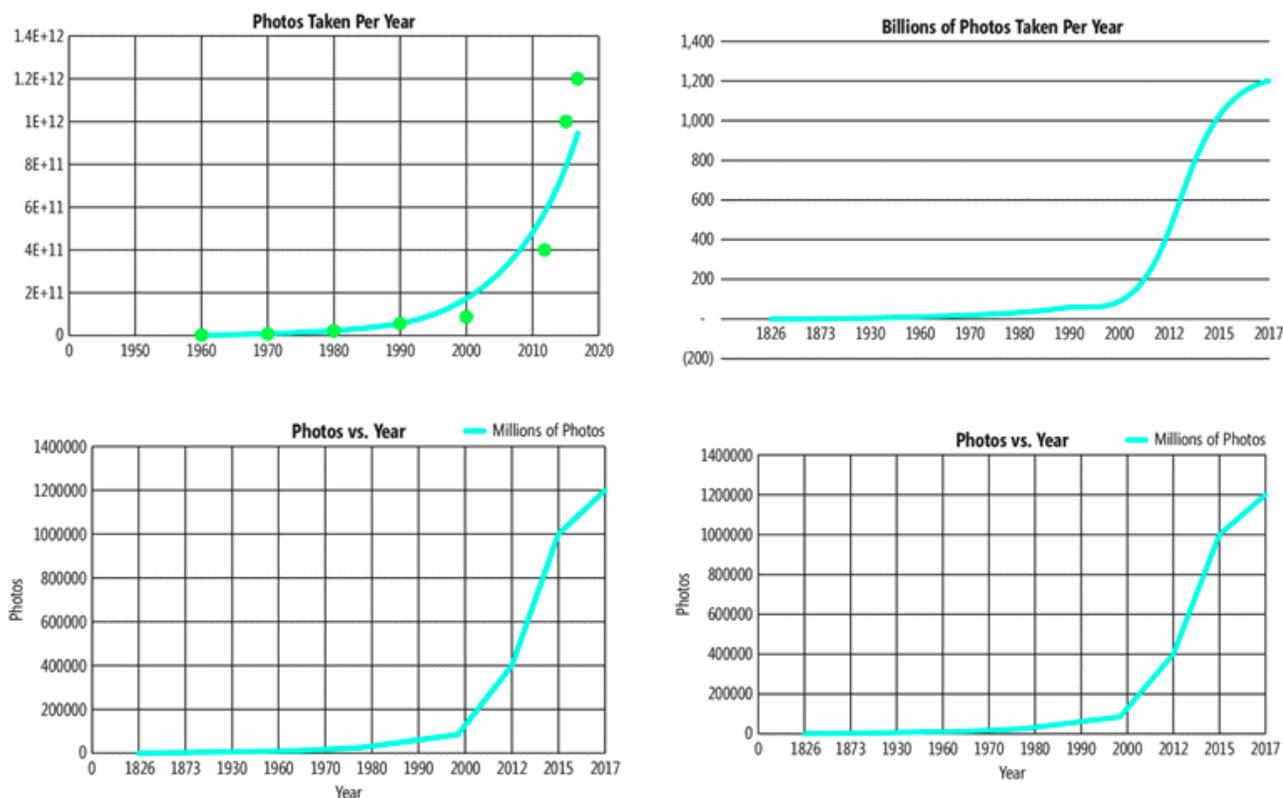
Figure 1 The Exponential Growth of Photography

The problem with charts like this, and the numbers underlying them, is that they illuminate exponential trends in hindsight, only after they've already happened. Forecasting exponential growth is difficult because we're tuned for linear thinking—we struggle to grasp the magnitude of exponential trends.

To recognize exponential trends early—when growth still looks linear—you need to identify the key technology improvement that drives it. In the case of digital photography—and many other exponential technologies—that driver is digitization.

Digitization is closely associated with exponential technology because it tends toward zero cost. The more digital photos you take, the closer the cost per photo approaches free. Even digital storage isn't far from a zero-cost item—there are numerous cloud providers offering storage that's close to free (especially if the provider is licensed to advertise or mine the information posted).

Another key characteristic of exponential technologies is democratization—making the technology ubiquitous. In the case of photography, this occurred because of the parallel

adoption of mobile phones—another exponential technology. (For more on this dynamic, consider exploring the work of Salim Ismail and Steven Kotler, who both identify characteristics to look for in identifying exponential technologies.)

Figure 2 offers a small sample of some of today's exponential technologies. As with photography and mobile phones, what's amazing is that each is likely exponential on its own, but together they amplify each other, making the doubling time even shorter.

Figure 2 Exponential Technology Areas

⟦ ⟧ **Expand table**

Material Science	Energy Storage	Autonomous Transportation (cars/trucks, drones, etc.)
Internet of Things (IoT)	Quantum Computing	Nanotechnology
Artificial Intelligence/Machine Learning	Blockchain	Bio-Technology/Medicine
Robotics	Computers	Virtual Reality
3D Printing	Cloud Computing	Neuroscience

The breadth of even the short list in **Figure 2** is almost shocking. And when you consider the impacts of all these technology areas converging at once, it raises the question: Are we experiencing another industrial revolution?

Industrial Revolution or Inflection Point

Historically, industrial revolutions are characterized by changes in labor—the way we work. Whether it was the First Industrial Revolution (steam and mechanization), the Second Industrial Revolution (electric power and mass production) or the Third Industrial Revolution (digitization and information technology), they all involved a radical change in labor.

Today, the news about labor is peppered with concerns about AI and autonomous robots (in which I include autonomous transportation) and how these technologies will replace today's work force. Research by the McKinsey Global Institute predicts that 45 percent of current work

activities could be automated by existing technology right now. It also finds that about one-third of the tasks in 60 percent of existing jobs can be performed by computers. These are premonitions of dire unemployment.

Of course, similar predictions occurred with the previous industrial revolutions, and all proved inaccurate with time. While work was radically affected in all cases, especially when the technology was democratized, the technology that triggered each industrial revolution generally enabled people to move on to better jobs overall. In short, labor improved. Is today's technology any different?

Staying with the labor theme, consider the profits of companies delivering exponential technologies. For a company like Amazon the number of employees doesn't correlate to an increase in sales, which may increase exponentially while employment only increases linearly. Likewise, companies in exponential markets can see net income per employee (NIPE) increase exponentially. Consider, for example, the NIPE of the top four tech companies in 2018, as reported by CSIMarket, shown in **Figure 3**. By contrast, the average NIPE in 1990 for the top three automobile manufactures was just less than $60,000, when adjusted for inflation.

Figure 3 Net Income Per Employee for Top Tech Firms

⌐⌐ **Expand table**

	No. of Employees	Net Income Per Employee
Facebook	25,105	$634,694.00
Apple	92,600	$393,097.00
Microsoft	118,000	$171,000.00
Alphabet (Google)	53,861	$158,057.00

At the same time, companies are favoring independent contractors over full-time employees. (This dynamic may change as employment law steps in to protect workers, such as the recently passed Assembly Bill 5 in California, which requires that app-based companies treat their contractors like employees.) Regardless, the breadth of disruption across major industries such as print media, music, television, transportation, hotels, banking and agriculture is breathtaking.

These are all significant changes in labor, but are they enough to credit this decade with the

introduction of a fourth industrial revolution, as suggested by Klaus Schwab, head of the World Economic Forum and author of the book, "The Fourth Industrial Revolution" (Penguin Group, 2017)? Or are these trends simply a continuation of the the digital revolution? That is, perhaps, a question best left to historians to answer, but today's technology revolution does present some important differences from past cycles. Consider:

- The quantity, concurrency and fusion of exponential technologies as they potentially amplify each other. Example: Energy storage amplifies drones technology.
- The exponentially increasing adoption of cyber physical devices connected to the Internet. Example: home automation devices.
- The core value of data mined from technology, be it via devices, online services or other technologies. Example: The McKinsey report estimates revenue from data mined and monetized from connected cars could reach $750 billion in 2030.
- The exponential velocity of change. Example: The incredibly rapid acceptance and ubiquitous adoption of smartphones and soon after cloud services.

In fact, we're seeing transformative change for entire systems and industries, such as in transportation, travel and purchasing. What's more, these paradigm shifts are changing us, both as individuals and as communities and nations. Smartphones, for instance, have already revolutionized personal interaction and relationships.

Confronting Questions

Whether we identify the current decade as the Fourth Industrial Revolution, or simply an inflection point in the digital revolution, there are significant questions to confront. And as programmers, we're in the unique position of implementing the software that will ultimately control the exponential technologies.

First, there are the obvious ethical questions about many of the innovations in the offing—genetic engineering is an easy example. While I'm surprised and concerned by how few organizations employ ethicists on their teams, the fact is any employee can fill that role simply by raising ethical questions. And there have been some employee protests in recent years that reflect this commitment.

Second, we can't innovate without considering the issue of governance. How do we regulate exponential technologies that may be used for good or ill? You can use facial recognition to tag your personal photo collection just as easily as governments can use it to track and control populations. Similarly, drones can be used to carry medicines to the sick following a hurricane,

but they can be equally effective as weapons.

Almost any technology can be used for good or evil, but the challenge of exponential technology is the potential for exponential consequences. Whether companies self-regulate or the law provides boundaries, either approach will struggle to keep pace with rapid change. Autonomous driving, social media propaganda and ethnic/gender bias in machine learning have already emerged as immediate challenges.

Finally, we should consider what motivates our innovation. Capitalism was a core driver of the industrial revolutions of the past and it yielded profound progress, but it also produced troubling inequities. Now, as we step forward into a world reshaped by exponential technologies, we have the opportunity to improve humanity and to ensure the economic and social benefits of our advances are felt by all.

Next Steps

When you consider the pace and breadth of technology advancement, it's clear we live in a time like no other. As software developers, we're in a unique position to influence the future. Whether you're engaged with exponential technologies in the physical sciences (medicine, energy storage, bio engineering) or in the computer sciences (AI, cloud, Big Data, blockchain), you have opportunities to have an impact. And for those not yet leveraging these technologies, you should be urging your organizations to catch up. Organizations that fail to engage exponential technologies early in the curve alongside their competitors court the risk of being left exponentially behind.

Now is the time to explore opportunities to digitize your product. Research how to information-enable your offerings so the data becomes a profit center. At the same time, evaluate the cloud and at a minimum move there for Platform-as-a-Service (PaaS) implementations. "Get thee to the cloud" is obviously advice you've heard before, but it becomes imperative if you hope to capitalize on the exponential growth happening in cloud technologies. And nowhere is this growth more dramatic than in the field of AI and machine learning.

Finally, don't be afraid to think big. Look beyond leveraging existing technologies and budget time to ideate about your next pivot. Instead of Uber replacing taxi drivers, think of autonomous driving replacing drivers entirely. Consider forming an ideation team within your company that allocates time each week to complain about frustrations and concoct solutions.

In summary, capture the potential of today's exponential technology, focus on how you can

leverage or even surpass it to make the world a better place, and then—just do it.

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