THE
GOLDEN AGE
OF INNOVATION

Mark J. Barrenechea

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"I am everywhere" – Lucy

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OpenText CEO and CTO

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Mark J. Barrenechea serves as Chief Executive Officer (CEO) and Chief Technology Officer (CTO) at OpenText (NASDAQ: OTEX, TSX: OTC), and as a member of the board. He joined OpenText in January 2012. Under Mr. Barrenechea's direction, the company has grown both organically and through strategic acquisitions into a $2B company. Through its commitment to innovation and customer-centricity, OpenText has successfully realigned its products to transform itself into a leader in the Enterprise Information Management (EIM) market.

Before joining OpenText, Mr. Barrenechea was President and CEO of Silicon Graphics International Corporation (SGI), where he also served as a member of the board. During his time at SGI, he led the company's strategy and execution. Prior to SGI, Mr. Barrenechea served as Executive Vice President and CTO for CA, Inc. (CA), (formerly Computer Associates International, Inc.) and as a member of the executive management team. Mr. Barrenechea was also Senior Vice President of Applications Development at Oracle Corporation, responsible for managing a multi-thousand member global team. He has also held a number of other positions, including Vice President of Development at Scopus, a software applications company, and Vice President of Development at Tesseract, where he was responsible for reshaping the company's line of human capital management software.

Mr. Barrenechea holds a Bachelor of Science degree in Computer Science from Saint Michael's College. He currently serves as a member of the Board and Audit Committee of Dick's Sporting Goods. He also serves as a member of the Board of Hamilton Insurance.

Mr. Barrenechea has authored several books about the evolution of the enterprise software industry, including: *On Digital, Digital: Disrupt or Die, e-Government or Out of Government, Enterprise Information Management: The Next Generation of Enterprise Software, eBusiness or Out of Business,* and *Software Rules: How the Next Generation of Enterprise Applications Will Increase Strategic Effectiveness.*

ACKNOWLEDGEMENTS

We Choose to Go to the Moon!

"We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people. For space science, like nuclear science and all technology, has no conscience of its own **[well, not so fast!]**. Whether it will become a force for good or ill depends on man, ... I do not say that we should or will go unprotected against the hostile misuse of space any more than we go unprotected against the hostile use of land or sea, but I do say that space can be explored and mastered without feeding the fires of war, without repeating the mistakes that man has made in extending his writ around this globe of ours.

…

We choose to go to the Moon! … We choose to go to the Moon in this decade and do the other things, *not* because they are easy, *but because they are hard;* because *that goal* will serve to organize and measure the best of our energies and skills, because *that challenge* is one that we are willing to accept, one we are unwilling to postpone, and *one we intend to win* …"

<div align="right">

− John F. Kennedy,
Rice University, Houston, Texas,
September 12, 1962

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Is the Microphone Working?

Testing, one, two, three. Testing, one, two three. Can you hear me? Is the microphone working? Testing (tapping on the mic a few times).

By all accounts, we are entering the Golden Age of Innovation, which many are calling the Fourth Industrial Revolution. This seems like a very appropriate label as we will explore in this book.

Some of the early innovations of the Fourth Industrial Revolution are visible in consumer and personal use cases, such as gaming, shopping, and entertainment. But the vast majority of these innovations—like software, Artificial Intelligence (AI), medicine, robotics, and transportation—have yet to impact society or productivity. When they do, their effects will be exponential and staggering.

Right now, we are in the midst of a technology boom. Over the last decade, the top 20 U.S. technology firms have created over $1 trillion USD in value. U.S. venture investment topped $60 billion USD in 2016.[1] Software is now contributing over $1 trillion USD in Gross Domestic Product (GDP) to the global economy.[2] And there are 4.5 million professional software developers in North America alone—more than ever before.[3]

Innovation drives progress. Software and hardware innovation accounts for nearly 15% of all R&D, pharmaceuticals for almost 10%.[4] In 2015, U.S. patent applications hit a record high, topping over 600,000.[5] Half of the world's best-known brands are now platform companies.

We all need to be software companies. The ability to innovate at scale needs to transcend nations, cultures, and people. Many cultures find it difficult to innovate. My experience suggests there are three key ingredients to innovation: access to talent, access to capital, and an entrepreneurial spirit.

All industries will be transformed over the next 10 to 20 years by technology. These transformations will vastly impact us as individuals, as a society, as businesses and governments, and will change how we live, work, govern, keep the peace, and wage wars. We will explore this in coming chapters.

But what will be the ultimate measure of this transformation: is it profit, peace, quality of life, or a new form of conscious capitalism? The Organization for Economic Co-operation and Development (OECD) Better Life Index ranks Norway, Australia, Denmark, Switzerland, Canada, Sweden, New Zealand, Finland, United States, and Iceland as the top 10 countries for wellbeing.[6]

The United States would rank in the top three if not for: community, civic engagement, and work-life balance. I am not one to lecture on work-life balance. But democracy is not easy, and the great American experiment has invested deeply in a government of, by, and for the people, yet only 50% of eligible American citizens vote or experience civic engagement.[7] This is shameful. In regards to community, despite progress over the last 100 years, 15% of Americans still live in poverty, which is completely unacceptable.[8]

My grandfather was born before planes, cars, televisions, telephones, and electricity were commonplace. He lived for 98 years (smoked for 60 of those and ate bacon and eggs every morning). He also worked on his farm every day until he passed, and left America only once to sail across the Atlantic to France to join the Allied Liberation Forces in WWI. There were many phenomenal aspects to my grandfather, but let me highlight the incredible human spirit of adaptability that led him to transition from horses to planes, from whale oil to electricity, from dirt roads to a nationwide transportation network. He also lived to see the first personal computer, and his grandson earn a computer science degree.

As a software engineer, I have never seen a more gilded time to positively impact society and humanity through technology.

This is the Golden Age of Innovation: And so begins the Fourth Industrial Revolution and our individual responsibilities for creating a better future.

Testing, one, two, three. Is the microphone loud enough?

2

Revolutions. Industrial or Otherwise.

The Fourth Industrial Revolution (4IR) changes everything. Although it has many names—Industry 4.0, Digitalization, the Singularity, the Internet of Things (IoT), Connected World, Smart Home, Cognitive, etc.—it will be known as the Fourth Industrial Revolution, or 4IR. And it will be driven by vast technology advancements in software, analytics, AI, machine learning, quantum advances in hardware, robotics, material science, 3-D printing, medicine, connectivity, and transportation. The Fourth Industrial Revolution will change the nature of wealth, health and happiness, how we live, work, relate to one another, as well as how governments engage, regulate, serve, and protect.

By 2025, 50% of the world's GDP will be derived from digital (a process that is completely automated by machines, which does not require human intervention).[9] This will have profound implications.

The First Industrial Revolution (1750 – 1840) was powered by water and steam to mechanize production. Inventions such as the steam engine, iron working, textiles, cement, and railroads terraformed our landscape as humans migrated from rural (agrarian) to urban (city) settings in massive population shifts. Language and reading skills increased with the printing press and so our civilization advanced. Great libraries of the world were built and opened to the public. Revolutions ensued in America and France with Napoleon conquering most of Europe. The very fabric of society changed. Voltaire, Paine, and Rousseau agreed that society should be organized according to rules based on rational thought rather than

religious ideology. Indeed, most western advances are based on rational thought, behavior, and market dynamics. This is changing in our time.

The Second Industrial Revolution (1840 – 1969) was driven by electronic power to create mass production and predicated inventions such as the car, the plane, the television, the telephone, the submarine, the typewriter, and even the hydrogen bomb. It was the great age of iron, steel, rail, electrification, petroleum, chemicals, engines, telecommunications, and modern business management. It demonstrated the greatest increase in economic growth in the shortest period ever, introduced by mass production and modern manufacturing. The foundations of globalization were laid and great western populations rose up out of poverty while many deadly commonplace diseases, such as measles, mumps, polio and more, were eradicated. Civil war defined America, Germany rose to power, and two world wars were fought.

The Third Industrial Revolution (1969 – 2000) was enabled by Information Technology to automate production. Inventions included the integrated circuit, the personal computer, smartphones, the Internet, space exploration technologies, and the laser. In 1988, Kodak had 170,000 employees and sold 85% of the world's paper. Within a few years, their business model disappeared and they went bankrupt.[10] Yes, digital technologies replaced film, but what Kodak failed to realize was the disruptive force around them, its opportunities, and the appropriate investment in them (thus, the defining

"Kodak Moment"). In the year 2000, the Third Industrial Revolution gave way to the Fourth, which ushered in great technological advancements, along with wage stagnation and income inequality.

The Fourth Industrial Revolution (2000 – present) not only digitizes production, but also "intelligence-based tasks," which previously could only be handled by the human mind. This revolution is of a scope, scale, velocity, and complexity unlike anything else we have faced. Its effects will impact all of humankind, all industries, all countries, every facet of every glorious element of our society—revolutionizing business models, reshaping the world, and even redefining our very existence. As Kennedy observed in his famous "We choose to go to the Moon" speech, the technological opportunities presented by this revolution will be unlimited and challenging, having the power to create and the power to destroy; and as we say in Vermont, any fool can burn down a barn.

The Cretaceous-Paleogene extinction event (i.e., the meteor that wiped out the dinosaurs) decimated some 75% of the plant and animal species on Earth. The last ice age only ended about 10,000 years ago, and you can still travel the Moraine line today (which I have done from California to New York). Extinction events happen. Present possible extinction events include meteor, nuclear, climate change, and some now add sentient machines and the Singularity—or the point at which a machine can think and act at or beyond human capability (thereby rendering us redundant)—to this list.

The vast majority of this book will highlight the power to create inherent in the 4IR as the Golden Age of Innovation, but it is important to note the perils that are equally present.

3

The Fourth Industrial Revolution

What makes the 4IR different from the Third Industrial Revolution (3IR)? Well, everything.

It is marked by exponential thinking where linear solutions no longer apply. The digital version replaces the analog version. Knowledge and invention are cumulative. Evolution is just the re-encoding of information, after all. Every person, culture, industry, and country is affected. All forms of production, management, systems, and governments will be transformed.

The opportunities are unlimited: faster prototyping and time-to-market with 3-D printing and production, conquering disease and illness with nanotechnology, micro-financing using robo-advisors and advanced algorithms, more efficient and affordable connected homes, safer and more convenient travel with autonomous vehicles. Not to mention other improvements made in human longevity, energy, material sciences, entertainment, consumerism—the list goes on and on. All of these advances will be predicated by developments made in AI, machine learning, algorithms, massively large data sets, and robotics.

But as the opportunities flourish, so will the perils: identity theft, cyber-crime, espionage, new definitions of conflict and war, de-humanization, a widening of the digital divide, automation anxiety, radicalization, propagandizing. Last year, my identity was stolen and I only discovered this because the Internal Revenue Service (IRS) rejected my tax return saying that I had already filed. Sixteen months later, I am still dealing with the aftereffects.

The 4IR is delineated from the 3IR by three main concepts: extreme connectivity, extreme computing power, and extreme automation.

Extreme Connectivity: Cell phones currently connect almost 5 billion people.[11] By 2025, this number will be 6 billion.[12] Today, a smartphone costs $150 a month. By 2025, it will cost $150 a year.[13] Further, it is easy to follow the curve to attaining 1 trillion connected devices (machines) over the Internet (cars, phones, homes, machinery, airplanes, trucks, ships, soda machines, etc.). Six billion connected people, 1 trillion connected machines—this is extreme connectivity.

Extreme Computing Power: Today, you can rent almost endless processing power from Microsoft Azure or Amazon's AWS. Enter quantum computing and the Qubit. Quantum computing will become a reality in the 4IR. Humans can no longer beat a computer at chess. The world's Go champion is also a computer; the alpha male is replaced by Google's AlphaGo.[14] This is nothing compared to the capabilities of quantum computing and the Qubit. Quantum computing has already reached 128 Qubits of processing capacity for a single system. At 1024 Qubits of quantum processing power, all the world's traditional encryption codes can be unlocked by a machine in near real time. All doors are instantly opened, from banks, to vaults, to personal accounts, to weapons systems. It would be a world without doors and locks. This is extreme computing power.

Extreme Automation: With extreme connectivity and extreme computing power, the exponential opportunities for automation are revealed (truths are revealed, never created): cognitive, AI, machine learning, 3-D printing (prosthetics, cloths, and machine parts), algorithms, and methods at hyper-scale. Five billion Google searches a day[15], 200 million daily orders on Alibaba[16], and 2 billion worldwide Facebook subscribers.[17] Automation will drive cars, cure cancer, replace entire labor pools, reduce underwriting risk, fight wars, and entertain us. Ultimately, it will create a new class of sentient beings with artificial consciousness. This is extreme automation.

4

The Impact on Business

The 4IR is presently servicing new market needs while simultaneously disturbing existing products and services. New business models and value chains are emerging, and in some cases, supply and demand cycles are being slammed together to become one.

In almost all cases, new entrants have an advantage over incumbents. New entrants have vast access to capital, have no legacy infrastructure to transition into the future, innovate at the speed of thought and without political or organizational boundaries, and investors are more interested in grabbing subscribers and market share than generating profits in the early years of the 4IR.

Even more important than all of this is the ability to conceptualize in the 4IR, perhaps because the new inventors are borne of an age with a maniacal focus on the customer experience, transparency of their services, and a reinvention of how products and services are conceived, designed, delivered, marketed, sold, and supported.

Business leaders need to transform their thinking along fundamental lines to break synchronous orbit and achieve exponential thinking. How do we deliver solutions that are more customer-centric, faster, at greater scale, and are disruptive and thus provide higher barriers to entry?

In the 4IR, I see a new business codex:

- It is more important to be fast than perfect

- We need less data and more insight

- Conduct less planning, and encourage more experimentation (and at scale)

- Be customer-led, versus merely customer aware

- Talent, in many cases, is more important than capital

- The skills of critical thinking and creativity are more important than interpersonal and organizational skills

- Innovation is real time, iterative, and not a linear waterfall

- Experiment at hyper-scale

- It is one world; build one company

- Do for machines what we did for humans

There is a new latticework for the 4IR.

5

New Business Models Emerge

New business models have emerged in the 4IR that distinguish themselves from "the way business was conducted" in the 3IR. A common theme that has been applied to these new methods is disruption. Let us look beyond disruption and consider the distinguishing characteristics of these new models:

From Analog to Digital: This is perhaps the most obvious. Every analog version of a product or service has a digital version. The quest to eliminate every piece of paper often requires the rethinking of a process. It could be the "Kodak Moment," the elimination of the wallet and cash, removing a lockbox process, challenging a title process, redefining intellectual property, or going wireless with headphones. Challenge every analog process or product you have, even the very notion of being human.

From Partners to Disintermediation: One of the distinguishing elements in the 4IR is disintermediation, or the removal of the middle person or partner, going direct, direct to the customer, buyer or supplier. We see disintermediation occurring in all industries. Direct in retail. Direct in software. Direct in insurance. The ownership of the customer or consumer is a new battleground for trust, brand, and share of wallet. If the intermediary does not add value, it will be destroyed.

From Transactional to Subscription Economy: In the 3IR we purchased products or services to own them. In the 4IR, we will subscribe to products or services. This will change relationships and processes from one time to recurring.

Customers and consumers will desire more agility and flexibility. But do the math. There are breakeven models of owning versus renting. I find the answer to many of life's questions is 42 (as in *The Hitchhikers Guide to the Galaxy* by Douglas Adams). In the case of owning versus renting, the breakeven point is usually 42 months. After 42 months, you are better to own.

From Me to We: The Sharing Economy: The sharing economy, as it is called, is all about asset utilization. How do I utilize non-working labor or an idle car? Uber. How do I utilize an unoccupied room or house? Airbnb. How do I utilize programmers with available time? Code sourcing. How do I utilize the collective energy of a group of individuals? Crowdsourcing. And so on.

These new business models are rooted at the nexus of the extreme changes in technology (connectivity, computing power, and automation) and a generational or societal change. Millennials are changing the way we do business. Millennials are not shackled to tradition or location, they do not believe in the value of face time, they are impatient learners and seek immediacy, they prefer to learn through experiences, and they believe in life, not a work-life balance.

Technology reflects life. This drives innovation, such as on-demand, public SaaS, Cloud, a sharing economy, subscription services, and disintermediation. After all, you can run your life today only using one finger on an iPad.

6

Industries are Transformed

Every industry will be transformed by new technologies, a new workforce (Millennials), new business models, new supply/demand chains, new value chains, and new buyer expectations. Over the next 10 to 20 years, this will come to fruition due to extreme connectivity, extreme automation, and extreme computing power.

At the end of the day, all businesses will become software and analytics companies. Uber, after all, is just software; they do not own any cars or have many employees, yet they are becoming the world's largest logistics company. Bitcoin is just software called cryptocurrency. Money will soon be software too—in fact, most of it already is.

In 2001, in my book *eBusiness or Out of Business*, I wrote "you banish software, you banish the world." Let us consider how software will transform a number of industries over the next 10 to 20 years:

Financial Services and Banking: The wallet will go away and be replaced by your phone. Cash will also be eliminated. Processing will be instant for account creation, credit, and money transfer. In 1990, 90% of all NASDAQ volume was driven by humans. By 2025, 95% of all NASDAQ volume will be driven by machines. A handful of algorithmic trading firms will capture the vast majority of equity value creation—after all, it will be a zero-sum game and the person with the largest computer will win.

Automotive: Self-driving cars will appear on the road and the automotive industry will be disrupted. Automated cars will be summoned using your phone, show up at your location, and drive you to your desired destination. Parking will be coordinated by software and cameras. You will pay only for the distance traveled and be productive in the process. With autonomous cars, will our children even need a driver's license? Cities will be transformed as cars are reduced by 75%. Car accidents will drop by 90%, saving millions of lives each year. The engineers at Daimler, VW, and Audi are already reeling at the advances being made with driverless and electronic cars by Tesla, Google, and Apple. Traditional car companies as we know them today will disappear. Each car will be powered by over 150 million lines of software code, more than is currently required by Windows Vista, Google Chrome, the Mars Curiosity Rover, or an F-22 Raptor. Did I mention cars will be electric?

Insurance: The average age of an insurance agent in the U.S. is 59 years old.[18] Agents will be replaced with direct relationships between customers and insurance companies as they fortify their franchises. Data companies will emerge that have a digital sequence of the person or a property, eliminating the need for applications or consumer-supplied information. Algorithms in massive computer farms will be applied to instantly measure risk profile, underwriting needs, and the required premium for each specific policy. As cars become autonomous, accident rates will plummet and the car insurance market will disappear. The day of digital reckoning is quickly approaching for the unprepared insurer as extreme

computing, online data, and mobility reach critical mass. Know the person or the property (or its digital sequence), and you know the risk.

Agriculture: Enter the agricultural robot, or agbot. Agbots will bring efficiencies and benefits to agriculture, eliminating physical, back-breaking tasks with everything from lettuce bots to wine bots and even the modern-day Marlborough Man as drones herd cattle. When the price of an agbot falls below $1,000 USD, farmers will transition from working in their fields to working as managers of their fields. In many ways, this is still analog thinking; in the future, we may not even need livestock farms. Agbots will change the world and the future of food production by optimizing land use and eliminating a dependency on livestock. Nearly 60% of all ag-lands are used for beef production.[19] A single cow takes up nearly two acres[20] of land and 441 gallons of water[21] for one pound of beef. That same cow produces the methane equivalent of four tons of carbon dioxide a year[22] (a significant percentage of all greenhouse gases). The need for beef will be diminished by innovative approaches like substituting insect protein for meat or in-vitro (synthetic) meats designed to taste like grade-A5 Kobe beef. Are you ready for your veal created in a petri dish?

Legal: Law school graduate unemployment has hit a record high. What was once a future-proof degree will see 80% of its work eliminated by supercomputers. Within seconds, computers will be able to produce legal advice with 90% accuracy compared to 75% human accuracy. Though perhaps there will always be a need for human specialists.

Retail: I liken transformation in this industry to an iceberg, with 20% visible above the surface, and 80% hidden from view, below the surface. There are the must do's above the surface for extreme automation of operations, customer-centricity, omni-channel experiences, two-hour delivery, and technology augmentation for every sport, for every age (from team scheduling to fantasy sports to golf-swing analysis). The transformative technology is 3-D printing. Take a high-scan image of your head and get a custom helmet. Take a high-scan image of your hand and get a custom glove. Take a high-scan image of your foot and get the perfect athletic footwear. When raw materials, suppliers, supply chains, distribution, and logistics are all transformed, the end result will be perfect, bespoke, high-performance products for the consumer. A China-based company is 3-D printing homes. They can print 10 homes a day at a cost of $5,000 per home.[23]

Energy and Electricity: Renewables win. Electricity will become cheap and clean. We are now installing more solar energy than fossil fuel-based systems. The price of solar will drop so much that it will force coal companies out of business.

In 2014, Ontario, Canada eliminated coal production.[24] With cheap electricity comes cheap transportation and abundant water. The average consumer could save $2,000 USD a year.[25] Producing water from desalination will cost less than running your toaster for a year. Water is not scarce, potable water is. Imagine a world where potable water is abundant.

Healthcare: Big data will create cures for cancer, turning clinical specialization (a single doctor's knowledge through experience) into globally available protocols. Nanotechnology will change drug delivery and targeted therapy. The cyber-knife will become widely available. Genome editing could eliminate mutations and deliver enhanced humans (H+). Three-dimensional printing will make prosthetics affordable and liberating. Life expectancy now exceeds 80 years of age.[26] Living to be 100 years old is well within reach.

Education: Billions will have access to the Internet and a basic laptop and/or smartphone. Younger generations will have access to education like never before, without even leaving their homes. Education will become democratized, despite threats from terrorist groups or governments controlling or limiting access to education—especially for young women. Gender will no longer be a roadblock to access to education and educated young women will become educated mothers, ensuring generational access to education.

7

New Skills are Required

Over the last decade, we can say with confidence through research and direct experience that much attention has been applied to a handful of skills for the professional worker. This is about the future of jobs, skills, and workforce strategy. To date, emphasis has been placed on some key skills: people management, coordinating with others, negotiating, and active listening. These are all good skills, and in many ways, are table stakes for a modern workforce.

But what skills will change the most and what is required for the 4IR?

As we look to the future of jobs and the most important skills required to succeed, these top three skills emerge: creativity, critical thinking, and complex problem solving.

With new products, new technologies, and new ways to work, both employees and employers will have to be more creative to make businesses function cohesively. Disruption will drive more critical thinking and new business models will require more complex problem solving.

Think of a taxi driver. They require two skills: driving and the ability to read a map. Both of these skills are being replaced by self-driving cars and online map services. In airports, you order your meals on an iPad. Grocery stores have moved from self-service checkout to monitoring your activity and just billing you.

I have always believed in this formula, and as time passes, I become more convinced:

Killer Product = Function {Knowledge + Idea + Innovation}

Turning an idea into a killer product is insanely hard and the success rate is abysmally low.

Turning an idea into a killer product is a function of knowledge and innovation. Knowledge is the accumulation of facts and information, with new methods applied: Innovation. The plus ("+") is the human, our talent pool, requiring new skill sets in the 4IR.

Is Angry Birds (product) a function of cumulative knowledge (Sesame Street characters) plus a new idea (a sling shot) added to the innovation of mobile technologies? It may look simple, but developing the concept is insanely hard.

Product = Function { **Knowledge** + **Idea** + **Innovation** }[27]
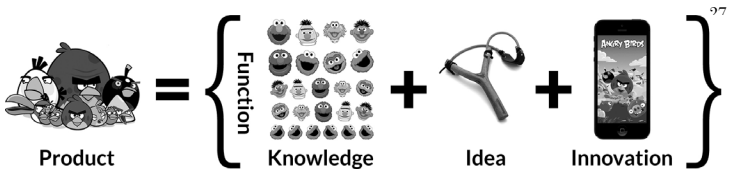
Conventional thinking is a hurdle that must be overcome to free up creativity for true innovation to happen. When I travelled throughout Asia speaking about the 4IR and this Golden Age of Innovation, Fredrik Härén gave a presentation on ideas and the impossible. During this talk he asked members of the audience to imagine achieving the impossible and to write down their top three or four answers. His findings were incredibly revealing.

The majority of people wrote down the same answers: flying, walking on water, time travel, immortality, space travel, world peace, the ability to teleport, invisibility, discovering a cure for cancer, and proving the existence of God or even to be godlike.

If we asked a child the same question, their answers would be imaginative, limitless, and truly impossible: "I want to hold an elephant in the palm of my hand."

Products are a function of knowledge plus innovation. The skill sets required for the future of work has changed. Generation Xers need to redefine their thinking about what is impossible.

8

The Rise of the Machine
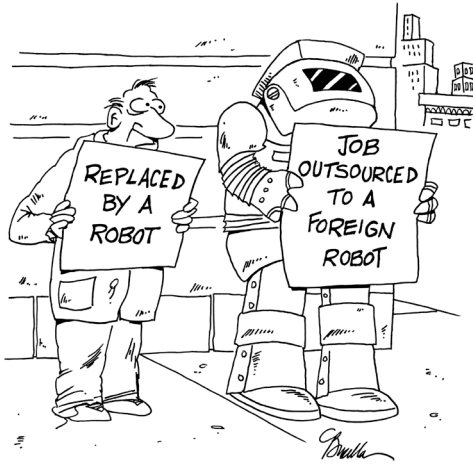
It is happening so fast it cannot be stopped. From Oxford to MIT to Harvard to the World Economic Forum, they all say the same thing: The 4IR will automate up to 47% of all jobs in the U.S. over the next 20 years.[28] This will motivate a labor migration greater than that of the Great Depression. Even at the lower end of this range, it will be a rude awakening in what some call "a world without work." I am a believer that it will be a full-on technological revolution for robots, machines, and cognitive systems (incorporating analytics, AI, and machine learning).

Extreme connectivity, extreme computing power, and the new economics of automation are driving the rise of the machine.

For an employer, the cost of an employee (including salary, healthcare, and other benefits) can total $45,000 USD a year.

A robot can do exactly the same work for much less and be more "reliable" in the process, requiring maintenance rather than benefits (robots don't take sick days). It can also produce the same product or service at the same (or faster) rate in exactly the same way every time.

Jobs that are labor-intensive are at risk, especially when the cost of a robot is significantly lower than a human salary. The more human incomes increase and benefit costs soar, the wider the crossover point grows, or if you will, the alligator jaws widen. This is the economic argument, not the moral one. The two arguments need to be solved, conjunctively.

Agbots will transform the way the world is fed.

Drones can do dangerous tasks, from building inspections to putting out wildfires to monitoring borders.

Robots can explore our universe (there are now a total of six robots and satellites exploring Mars).

Machine-to-machine communication is driving vast increases in asset utilization and efficiency, more accurate information, and greater safety. For example, by the end of 2020, there will be approximately 53 million smart meters throughout the U.K.[29] Will it make sense, or even be feasible, for a human to be dispatched four times a year to read and record the information and hand this to another human only to be correct 80% of the time?

Engine monitoring—planes, trains, and automobiles—is a great advancement. Sensors in various locations can gather information about the engine. Fuel consumption, engine performance, irregularities, preventative maintenance, and more—all of this information is sent in real time to the operator for correction, or to machines for analysis, or to ground crews to ensure parts and labor are immediately available to get the asset performing again.

The same goes for robotic handling, welding, assembly, dispensing, and processing. Over the last 10 years, the prevalence of industrial robots in welding has grown by nearly 100%.[30] At the same time, U.S. manufacturing jobs have fallen 15%.[31] In the auto industry today, one robot is employed for every 10 humans.[32]

Numbers are reaching critical mass. Researchers predict that by 2025, Japan will have 1 million industrial robots installed[33] and there will be more than 7 million unmanned aircraft (or "civilian drones") flying the U.S. skies.[34] Over the next 10 years, there will be 60 million robots in the world.[35] That's the equivalent of the entire U.K. population!

The rise of machines is real and reaching scale and the future of employment is being redefined. The business, ethical, and policy questions on how we treat a machine versus a human need to enter public discourse. As machines get smarter, more perceptive, better at manipulation, more creative and socially intelligent, more jobs become vulnerable.

Here I am talking to a robot while checking in for a flight from Tokyo to San Francisco. The robot was useless. I tried to use one of those passport scanners and it could not read my passport, so I ended up speaking to a human and printing my ticket.

9

The Impact on the Person

The "Physical" Self

The 4IR is expected to accelerate knowledge like never before. As I mentioned previously, technology will advance with artificial intelligence, resulting in medical breakthroughs. As a leukemia survivor, I carry three DNA sets and, thanks to a third-party donor, replaced my stem cell production. I guess that makes me not a cyborg, but a *chi*borg (chimerism + technology). (And yes, I just coined a new term.) Medical advancements like these will redefine what it means to be human. Nanotechnologies in the medical field will drastically change how we deliver drugs, kill microbes, repair cells, and perform surgery—all on a nano-scale that is more targeted and more accurate than previous medical methods and practices.

As a result of breakthrough technologies, life expectancy should increase as we finally slow—or even reverse—the effects of aging and decay at a cellular level. In addition, body parts that have failed will be replaced with parts grown from stem cells, cultivated and harvested by nanorobots or with biomechatronic body parts, or perhaps even 3-D printed organs. More humans will become cybernetic organisms (cyborgs), like Motoko Kusanagi in *Ghost in the Shell*, a movie in which much of humanity is connected to a vast electronic network through cybernetic bodies ("shells") which possess their consciousness and give them superhuman abilities.

In addition to increasing life expectancy, technologies such as genome editing will provide us with the tools for human enhancement, including genetic engineering to produce designer babies. Genome editing is also crucial to gene therapy, or replacing defective genes or modifying immune cells to fight diseases, such as HIV, Alzheimer's, or cancerous cells. As technology advances exponentially, so too must our civil, moral, and spiritual motivations to accommodate and adapt to the 4IR.

The 4IR will, therefore, change our fundamental understanding of our physical selves—that we were born to die *naturally*. The introduction of designer babies, cyborgs, and veritable immortality will shift how we view our physical self and how we fundamentally organize ourselves. Our traditional concept of the family might cease to exist. The way we appropriate resources might also shift as designer babies have the potential to outsmart and outwork the now older, yet stronger cyborg population that might not die.

Cogito ergo sum

Descartes' famous assertion that "I think, therefore I am" has guided modern western philosophy and ontology for centuries. The notion of self is based on humankind's ability to think and acquire knowledge. This ontological concept of the self will be challenged during the 4IR. Machine learning and interconnectedness, along with the advancement of AI, will eventually produce an intelligence that is sentient and may potentially trigger the Singularity. A self-thinking and self-improving machine would transcend our notion of

self because if a machine is self-thinking, does that make it *human* or does it simply make it *sentient*? Would you consider Dolores in *Westworld* to be human or merely a sentient machine? If we were to consider these androids to be humans, what changes would we need to make to our society to accommodate these increasingly powerful and smarter "humans"?

On the other hand, with the advance of cybernetics and a vast network of connectedness, can humans also attain the same level of knowledge as a sentient machine? Imagine again Kusanagi in *Ghost in the Shell*, where her *self* inhabits a shell and connects to everything. Is she still a human? Or would transhumanism (H+) take over and advance the human race?

Humans could start to control machines through synchronization to accomplish tasks no machine or human could accomplish alone (like the large fighting machines in *Evangelion* controlled by teenagers). Or maybe, humans would possess so much knowledge that an omnipotent, Lucy-like person could exist. Finally, humans could potentially tap into our stardust memories to unlock the inner universe's power within us, like Akira did.

The 4IR will advance machine intelligence and sentience while also ushering in transhumanism. Thinking will no longer be sufficient in defining who we are.

Disappearance of the Self or Enhancement of the Self?

The 4IR will connect everything—all networks, all things, all selves. Everything will have access to every datum, available for access in real time. Robots with AI will roam among humans. Humans will have cyborg bodies and their selves digitally copied, stored, and continually backed up in multiple locations, like the horcruxes of the Harry Potter universe. Transhumanism will be a reality.

Will the notion of the self disappear, whether physically or ontologically? If everyone is connected and doesn't die, would humans as a race be the only self that is left—a collective self and mind? Would all humans merge into this self and become a godlike creature, rivaled only by the equally godlike AI?

Or will humans retain their individuality and personality, remaining connected to others as an enhancement of their own selves? The 4IR will not only accelerate technological revolutions and knowledge acquisition, it will challenge the most fundamental understanding of what it is to be human and the notion of the self. Philosophers, ethicists, and thinkers should not delay in addressing this issue, because without a proper foundation of the notion of the self, mass hysteria might ensue when humans can no longer identify or distinguish themselves based on outdated notions or characteristics.

10

The Digital Self

Just as our analog notion of self (flesh and blood) consists of RNA and DNA, our digital sequence—let us call it the "Digital Self"—consists of code. Each day, we are creating massive and permanent data trails that contain essential attributes of encoding, decoding, and expressions of our genes (or self). We do this both consciously and explicitly, and subconsciously and indirectly.

Consider the behaviors that you produce every day, stored permanently in "Digital Land": your psychological profile, your physical profile, your consciousness and belief profiles, your emotions and character, and your net worth. Billions of us have actually submitted our own definition of our Digital Self into various social networking sites (name, address, age, marital status, education, employment, friends, likes, dislikes, political views, etc.). We volunteer this information!

Think of your gene expressions every day in Digital Land: You search the web, you read ebooks, watch movies, post videos, tweet, list your friends, order food, and complete online transactions. Imagine storing rock solid patterns of your behavior—sharing your movements via wearable technology, updates to your medical records, bank records, birth records, employment history, education, driving information, purchase history, and online articles that you read. It is all there, a complete record of your digital RNA, DNA, and behaviors. Permanent, indefatigable, revealed truths, one digital bread crumb at a time, uploaded to the Cloud—sounds like heaven.

Now suck all this information into a computer, every minute of every day. Run an algorithm against that data, and a digital sequence of you is created. Perhaps multiple sequences are created. You could use a CRISPR and have a super-digital sequence of yourself. Then pump that into an artificial intelligence or learning machine, and suddenly your Digital Self is "alive."

Science fiction or a revealing truth?

A friend recently told me a story where he received a call from his granddaughter who was in jail. She was locked in a cell, being treated poorly, and surrounded by threatening cellmates. She needed a $2,500 wire transfer to post her bail and get out of jail, but she wasn't able to ask her parents for help. This was her one call and it was being recorded by the police, so she needed to keep it short. "Granddad, can you help?" Of course he could! And he did. He wired the money, but it turned out that the call was a scam.

The bad actor in this case reproduced a digital self of the granddaughter, right down to the voice and behaviors, and perpetrated the petty crime of stealing funds using digital payments.

What does this mean for the person, for business, for governments and society?

For the person, if we dismantle the notion of the self, the societal, spiritual, and religious impacts are profound. Your Digital Self lives on, ever collecting knowledge, and is in all places at once. To quote the movie *Lucy*: "I am everywhere." We all become Brahma (the creator) and Shiva (the destroyer).

Facebook is buying data to "fill in the profiles" of their almost 2 billion subscribers; rounding out their digital selves without the users' explicit consent.[36]

For business, the Digital Self will be exploited to deliver better ads, provide better recommendations, drive purchasing decisions, and reduce risk. Consumer businesses will know what you need before you even need it. A perfect and persistent personal assistant.

Governments will be obliged to protect the rights of our Digital Selves. Does the Digital Self become like a corporation, thus serving as a new shareholder in the definition of a Corporate Self?

Ultimately, one has to "opt in" to this new Digital Land, the digerati, and leave the Flat Land, the land of the Luddites. For those who opt out, can they function in society, or are they a new super-culture or subculture?

The British television series *Black Mirror* features an episode that addresses this notion of a Digital Self being created, captured, and exploited. It is a modern-day *Twilight Zone*, with sharp undertones of an expectant and emerging reality.

It is so much an emerging reality that it is already happening in Shanghai with the recent release of the app, Honest Shanghai. In an effort to make Shanghai a global city of excellence, the government is using apps like Honest Shanghai to reward residents for their honesty, morality, and integrity. Using facial recognition software, the app aggregates some 3,000 items of personal data collected by the government—creating a digital copy of Shanghai residents—to generate "public credit" scores that range from "very good" to "good" to "bad" (imagine your government rating you). Users with a higher score can reap the benefits in the form of discounts, lower loan rates, better positions in lines, travel discounts, and more—while those with a bad score may have to deal with declined loan applications or inferior seats on planes.

There goes a little honest graft.

We need to harness the transformative aspects of the 4IR to change the world, and obsessively but thoughtfully conquer the perils. For me, I am all in.

11

The Impact on Government

"Good enough" as a measure for government work is no longer good enough. The changing nature of the citizenry (Millennials and subsequent generations) will massively raise the bar for government.

Citizens want to engage with their governments. They want to voice opinions, coordinate their activities, and in some cases, circumnavigate their officials. Citizens want full transparency and automated services. Why do we need to file a tax return? If all of our transactions are digital, we should simply be emailed a check or a bill. If the wallet disappears, will our need for a passport, ID card, or a driver's license persist? Or will we be provided with a digital identity in the form of a digital fingerprint or retina scanner?

The revolutionary wave in 2011 known as Arab Spring highlighted the power of social media; the U.S. election of 2016 weaponized its capabilities.

Governments will have more data and massive controls over people via their information and behaviors, obtained through pervasive surveillance. Governments can also do good with their data, and set agendas for Open Data, to unlock the value of data sets to spur innovation and invention. Imagine the emergence of educational institutions using the billion dollar infrastructures of NASA and the Departments of Energy or Agriculture to drive innovation.

It will be a battle over privacy and citizens must never relent on the protection of their information. Data corrupts, absolute data corrupts absolutely.

The very nature of conflict and war will be redefined in the 4IR. Mobilizing troops, engaging in gunfire, bombing power plants, and blowing up dams will be replaced with hacking systems and shutting down power grids. These will be the new acts of war.

A new playbook will be required to counterbalance the black-hats, to protect our way of life, and to ensure the analog version of war is minimized and avoided.

Just as the rules of war will change, so too will governments. They will need to conform to the theory of global governance epitomized by transgovernmentalism (G+)—as administrators of the collective good, purveyors of the ultimate surveillance program (such as PRISM), and as power centers competing with other governments. At the end of the day, governments will need to re-think how they protect citizen workers in the 4IR as labor is displaced at scale.

12

How Will We Measure our Golden Age?

"Let us not seek the Republican answer or the Democratic answer, but the right answer. Let us not seek to fix the blame for the past. Let us accept our own responsibility for the future."

— John F. Kennedy

Industrial revolutions tend to benefit the rich more than the poor, initially. They all begin with great inequality. In unequal societies, life expectancies and trust levels are lowered. They tend to be more violent, experience greater levels of mental illness, and have higher rates of incarceration. In the U.S., one in 50 adults are on community supervision, probation, or parole.[37] One in 50!

As it stands today, the future is not evenly divided. The richest 1% of the population now owns 75% of all household wealth and 8 individuals control more assets than the poorest 3.6 billion people combined—or half of the world's population.[38]

The anxiety over automation, the growing digital divide, is real, is present, and is the greatest moral question of our time. Reports vary in their quantum, with some at the low end (25%) and others at the high end (47%)[39], but they all agree that the human workforce of the future is shrinking as more and more jobs are automated out of existence.

This increasing anxiety, divide, and inequality will create instability and security concerns for both citizens and states—a general state of unrest. The unrest can manifest itself from within—witness the BREXIT vote—or externally, with bad state-sponsored actors. The transformation is real and it will impact jobs and equality.

The strategic space for conflict is changing and new battlegrounds are emerging. In the future, power plants will not be bombed, they will be turned off. Leaders will not be assassinated, they will be toppled by propaganda, data leaks, and fake news. This has already happened in Iran with Stuxnet[40] when Hackers made Iran's nuclear computers blast AC/DC's song Thunderstruck in the middle of the night, and even with the 2016 United States Presidential election.

The 4IR also goes deeply into who we are as a people, as a species, and speaks directly to our identity and our communities.

Beyond the transformation of all industries, beyond the new winners and losers and the creation of new "Kodak Moments," how will we measure our new Golden Age of Innovation?

I have a series of modest proposals:

Personal Responsibility: We each need to take personal responsibility and be a driving force for positive change. We choose and instigate our own actions and we each need to be morally accountable, and thus, drive a common purpose of humanity in our new world, one leader at a time.

Education: Education is a game-changer. It creates a happier and more stable life, raises income levels, and creates more equality. It has the power to create independence and turn aspirations into a reality. A more educated world is more tolerant, safer, peaceful, and surely, more economically prosperous. Educational equality is a dual-track system, supporting vocational and academic advancement, and

ultimately, equality. The world needs skilled electricians, plumbers, roofers, carpenters as much as we need doctors, programmers, and lawyers.

Youth Sports: I am a product of public education and youth sports. Athletics have a positive, life-long impact. They instill in children the value of teamwork, personal discipline and healthy competition, and teach youths how to recover from setbacks. Sports help children to develop their cognitive and motor skills, provide positive influences and inspiration, and keep kids out of trouble. There is no other activity that affords the opportunity to impart so many positive qualities in children. In the U.S., youth sport participation is declining. Roughly 40% of American youth participates in a regular team sport.[41] There is a direct correlation between youth sport participants and a more productive future, so we must increase participation to ensure a better future.

Technology Everywhere: Technology needs to find its way into the poorest communities and countries. Getting fees for a smartphone and rural connectivity down to $150 a year is still too expensive. For many, this represents a large portion of their annual income. A billion smartphones in underdeveloped countries like Africa would raise not just a community or a country, it would carry the entire continent into the 4IR.

Raising Humanity Out of Poverty: Enough with technology driving my car, having a "Like" button, or delivering a real-time movie—these comforts are meaningless when you consider that much of the world is still living in poverty. Circa 1800, 95% of the world lived in poverty. Today, 50% of the world still lives in poverty.[42] Fifty percent!!! While many view this as an improvement, I believe we can do better. The greatest injustice in this world is poverty. There is no structural reason why we cannot radically change the world— and technology can be the enabler for this.

Our Age of Innovation will be truly golden if we can raise the world's citizens above the poverty line in our lifetimes and perfect conscious capitalism.

Testing, one, two, three. Is this microphone working? Can you hear me?

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